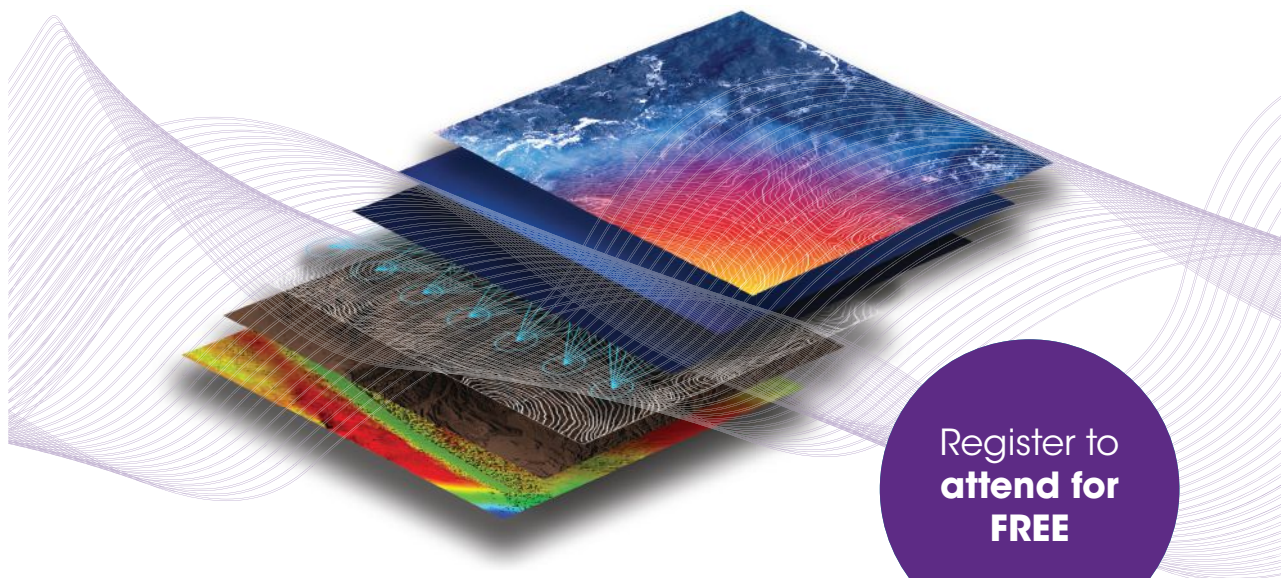


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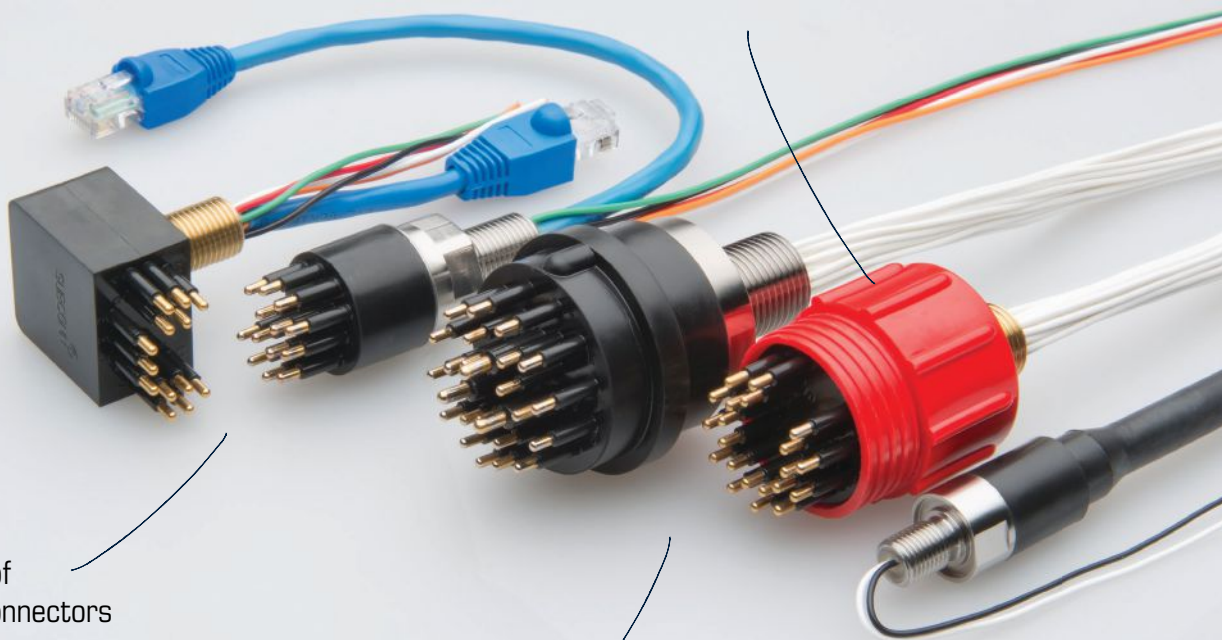
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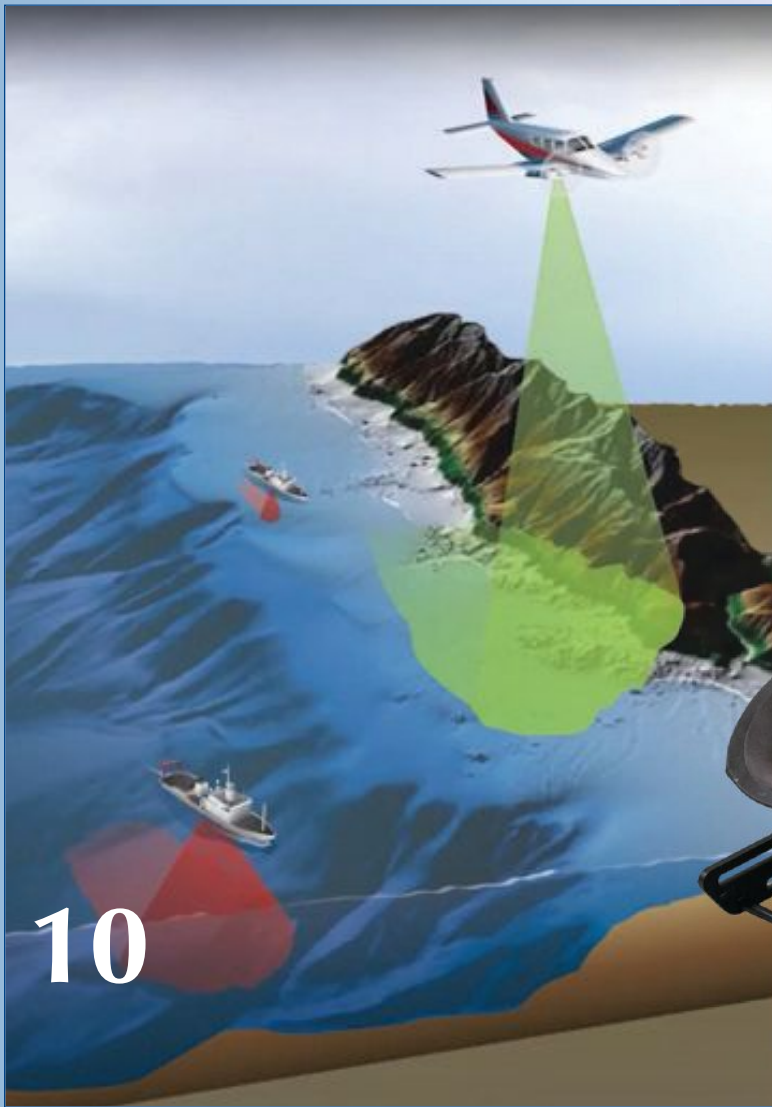
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Classic seismograph



Source: Yamaguchi先生, CC BY-SA 3.0

Networked digital seismometer
(land-based)



Dart buoy



Source: NOAA

Pressure and temperature
sensors

Accelerometers



New SMART submarine cables

Distributed acoustic
sensing

State of polarization
analysis



Source: TeleGeography

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COVER IMAGE

SY *Eugen Seibold* launching a HYDRO-BIOS titanium MultiNet customized for this research vessel. The 72-ft.-long sailing yacht is designed for contamination-free analyses of seawater, plankton and air. Here, the scientific team of Max Planck Institute for Chemistry (MPIC) operates the MultiNet in the Madeira Basin in the Amazon. (Credit: MPIC, Mainz)

NEXT MONTH

Carbon Intensity Indicator solutions for various ship types ... Calculating vessel emissions by analyzing fuel consumption ... Advanced navigation in the Arctic ... AI-powered cameras to monitor, detect events on board ... Cloud-based geospatial data management compatible with electronic navigation charts.

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)) Apply for NOIA Safety in Seas Awards. NOIA is accepting nominations through February 24, 2023 for the NOIA Safety in Seas (SIS) Awards. NOIA has held the SIS Awards competition annually since 1978 to recognize those who contribute to improving the safety of the offshore energy industry. The awards are sponsored by Compass Publications, the publisher of *Sea Technology* magazine. The Safety in Seas Awards are the industry standard for recognizing relentless dedication to safety and for celebrating the women and men who are at the forefront of safety performance and durable improvement. The Culture of Safety Award honors overall organizational immersion in and commitment to safety, which has resulted in remarkable, measurable and sustained safety performance over a prolonged period of time. The Safety Practice Award recognizes specific technologies, approaches, methods or projects with direct and demonstrable impacts on improving safety. The winners of the Safety in Seas Awards are determined by an independent selection committee. The awards are presented each spring in Washington, D.C. Learn more at: www.noia.org/sis.

)) UNESCO Selects 25 MPAs for Biodiversity Pilot. UNESCO has established a global biodiversity snapshot of marine species across 25 marine World Heritage sites located around the world for an initial pilot phase. Analysis of these samples will help us understand how biodiversity hotspots are shifting due to climate change and where to focus conservation efforts in the future. Today, marine protected areas (MPAs) around the world help safeguard vital species. But as ocean temperatures rise, species are increasingly forced to leave their natural homes in search of cooler waters. In the long term, the protected areas may no longer match the places where species live. This requires regular assessment of the situation. In combination with rising temperature projections, the UNESCO initiative will help visualize and detect changes using environmental DNA (eDNA). eDNA sampling identifies the species that live in an area by analyzing just a couple of liters of water. It's a cost-effective, early-detection tool for changes and is noninvasive to local wildlife. The UNESCO method combines science and education by working with local schools. Hundreds of students are being trained to participate in the eDNA expeditions to collect ocean data. This active involvement by citizens is key to raising awareness about biodiversity loss and fostering a love of science in the leaders of tomorrow. Once collected, the samples are analyzed in the laboratory, and all results are made publicly available through the UN Ocean Biodiversity Information System. Sampling began in September 2022.

)) Collaboration on Marine Energy Microgrid Projects. Schneider Electric and ORPC have signed a memorandum of understanding to collaborate on microgrid projects to advance marine energy as a commercially viable renewable energy source. ORPC and Schneider Electric will install microgrid systems that include Schneider Electric's energy storage and smart microgrid controllers integrated with ORPC's RivGen power systems to provide communities worldwide with highly predictable baseload electricity in renewable energy form, enabling the global transition toward net-zero societies. This paves the way to establish marine energy as a commercially viable solution in the renewable energy mix. Nearly 1 billion people globally have no access to electricity, and another 700 million rely on diesel-fueled off-grid systems. These communities pay up to 15 times more for electricity than grid-connected areas, and deal daily with the noise, poor air quality and environmental risk resulting from diesel fuel use. Schneider Electric and ORPC are already working on implementing this solution in partnership with the remote tribal community of Igiugig, Alaska. When this project is completed in summer 2023, the integrated system will form the grid for the community, moving the existing diesel generators to backup and enabling the village to operate without diesel 60 to 90 percent of the time. In Igiugig, ORPC's RivGen has successfully operated through three winters in temperatures as low as -40° C. As a result of environmental monitoring of the Igiugig project, comprising hundreds of hours of data, not a single injury or mortality to marine or aquatic life has been observed. Schneider Electric supplied the battery energy storage system (BESS) with EcoStruxure Microgrid Operation to enable use of the RivGen for diesel reduction. This is achieved by leveraging the grid-forming capability of the Schneider Electric BESS.

)) Commercial Recycled Ocean Plastic Pellets. Plastic Ocean Legacy, a Canadian nonprofit with the goal to end ocean plastic pollution, has produced the first commercially available plastic pellet in North America, called Legacy Plastic (www.legacyplastic.ca). Legacy Plastic is made from high-grade, 100 percent post-consumer-processed, recycled plastic recovered during ocean, shoreline and marine equipment cleanups. With Legacy Plastic, companies can use recycled marine plastics in their products, continuing to close the loop on plastic management systems. Legacy Plastic consists of recovered marine gear, such as fishing ropes, buoys, floats, oyster trays and other anthropogenic plastic debris collected from cleanup activities and reprocessed for use in the manufacturing of new durable products. Legacy Plastic is sourced from diverse channels within Ocean Legacy's network of plastic and debris recovery operations with community partners, as well as its own recovery efforts. Legacy Plastic is establishing itself in the marketplace via a new partnership with Full Circle Plastics in Alberta, Canada, a specialist in plastic lumber for commercial, industrial and residential construction. Legacy Plastic enables companies to meet their sustainability goals to manufacture products using high-quality, post-consumer recycled content resins that have a relatively lower carbon footprint when compared to virgin plastic production. **ST**

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Lewes, DE 19958
Tel: (302) 569-0019 (M)
rmahrjr@gmail.com

WESTERN U.S.A. & CANADA

John Sabo
Barbara Sabo
Gregory Sabo
John Sabo Associates
447 Herondo St. #305
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bsabo@jsaboassoc.com

EUROPE

John Gold
John F. Gold & Associates
"Highview"
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Int'l: +44-20-8641-7717
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We Need a Global Network To Observe Ocean Changes

The ocean takes up circa 25 percent of the CO₂ we emit to the atmosphere via fossil fuel combustion, land use change and cement production. This is how the ocean is slowing climate change and giving us more time to put in place mitigation and adaptation measures to avoid the worst consequences of climate change.

We know this percentage due to the network of shipboard sensors that measure ocean surface CO₂ levels, mainly on board commercial vessels known in the scientific community as "ships of opportunity." Because this CO₂ uptake is highly variable in both space and time, to study it thoroughly requires a dense set of measurements across the ocean. That is difficult to achieve because commercial traffic tends to avoid large areas of the Southern Hemisphere.

For this reason, there is an intense effort to develop autonomous technologies that can survive in the harshest ocean conditions, particularly in the inhospitable Southern Ocean winter environment, while maintaining the ability to measure and return quality climate data to researchers in order to estimate the ocean carbon sink.

An optimal measuring array would likely include a combination of high-precision instruments on surface platforms, calibrated directly to primary standards and linked to the World Meteorological Organization standards. These platform-mounted instruments would work together within a network of float-based technologies that have the ability to survive for many years in the open ocean.

Observations are also crucial in coastal regions, which will probably be where ocean-based solutions to climate change are first deployed. These technologies are unlikely to be an instant solution and are certainly not a substitute for emission reductions. However, they may form an important component of some coastal states' path to reduce emissions as per the Paris Agreement. There is currently an active debate on how to monitor, report and verify carbon dioxide removal efforts, and it seems that ocean-based technologies on a variety of platforms will be key here.

Currently, the efforts to measure and monitor ocean carbon uptake are somewhat ad hoc and uncoordinated. As a step toward more cohesion, continental-scale networks are being established. One of the first ones is ICOS, the Integrated Carbon Observation System, which is supported by multiple European states. ICOS provides information to large international databases, such as the SOCAT (Surface Ocean CO₂ Atlas), that form the basis of annual estimates of ocean carbon uptake that are reported to the global climate negotiations at the UN COP through the Global Carbon Project.

These activities are part of a value chain comprising observations at sea, databasing, synthesis and reporting. This chain is largely based on ad-hoc, bottom-up actions and is fragile at key points, with a level of resilience way below what is required to deliver the information society desperately needs to manage climate change.

In the future, the need for a robust observation network will probably be addressed via a World Meteorological Organization initiative to build an international greenhouse gas monitoring system, which would incorporate observations of ocean and land carbon uptake, as well as atmospheric accumulation. This will require strong collaborations between ocean scientists, technologists and the ocean business community, as it is only by working together that we can provide the data that society requires to quantify the role of the ocean in regulating climate and the mitigation solutions needed. **ST**

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APRIL

Offshore Technology/Alternative Energy & Ocean Engineering

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EDITORIAL CONTACT: Aileen Torres-Bennett, oceanbiz@sea-technology.com

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Laser Mapping the Coast

Airborne LiDAR Bathymetry Improves Coastal Zone Management

By Charles de Jongh

Airborne LiDAR bathymetry (ALB) is a surveying technique that uses laser light to measure water depths from an airborne platform, e.g., an aircraft. ALB is particularly effective for surveying shallow areas that are difficult or impossible to access with other methods, such as vessel-based multibeam sonar.

ALB is notable for its accuracy, speed, and cost-effectiveness and has the unique ability to simultaneously map both underwater elevations and topographic elevations on land, creating a seamless elevation model of the coastal zone.

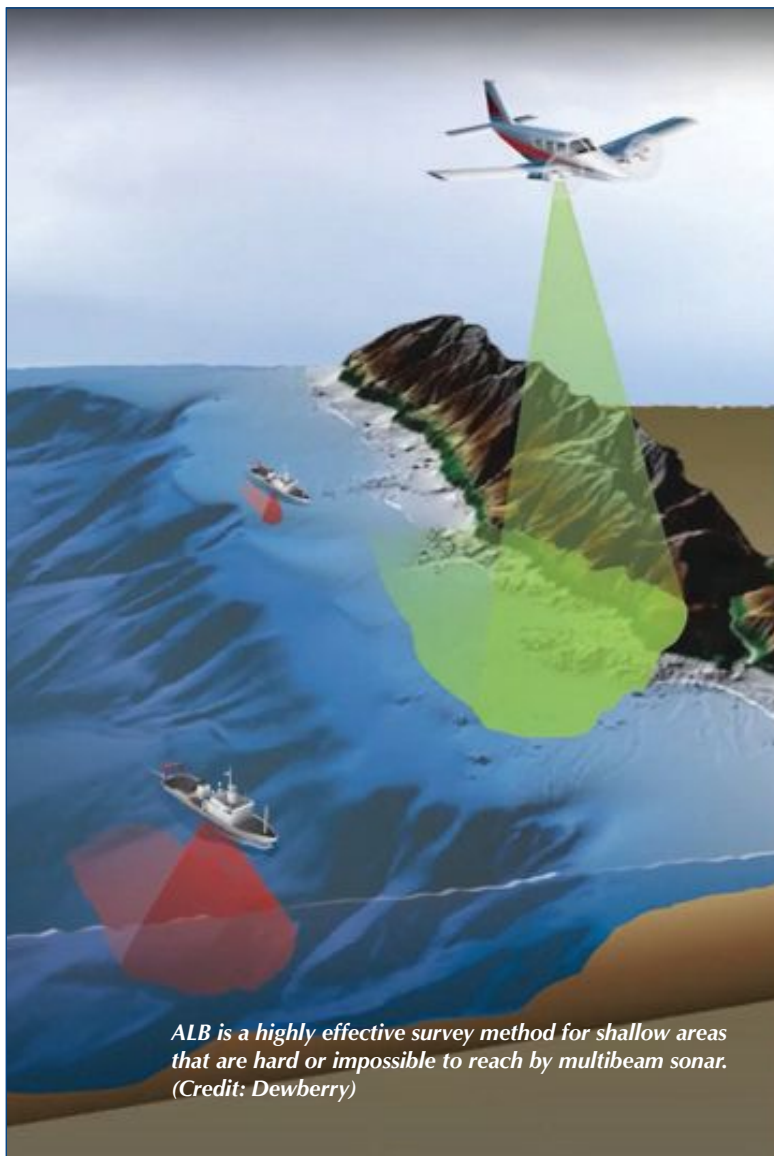
While ALB is a niche market within the hydrographic survey industry, demand for it is growing due to the maturity of the technology and the increasing global need for better coastal zone mapping.

All around the world the coastal zone is a vital area for economic activity, human habitation and biodiversity, making it important for governments and other stakeholders to understand and manage it effectively. An accurate geospatial elevation model, which ALB can provide, is crucial for this purpose.

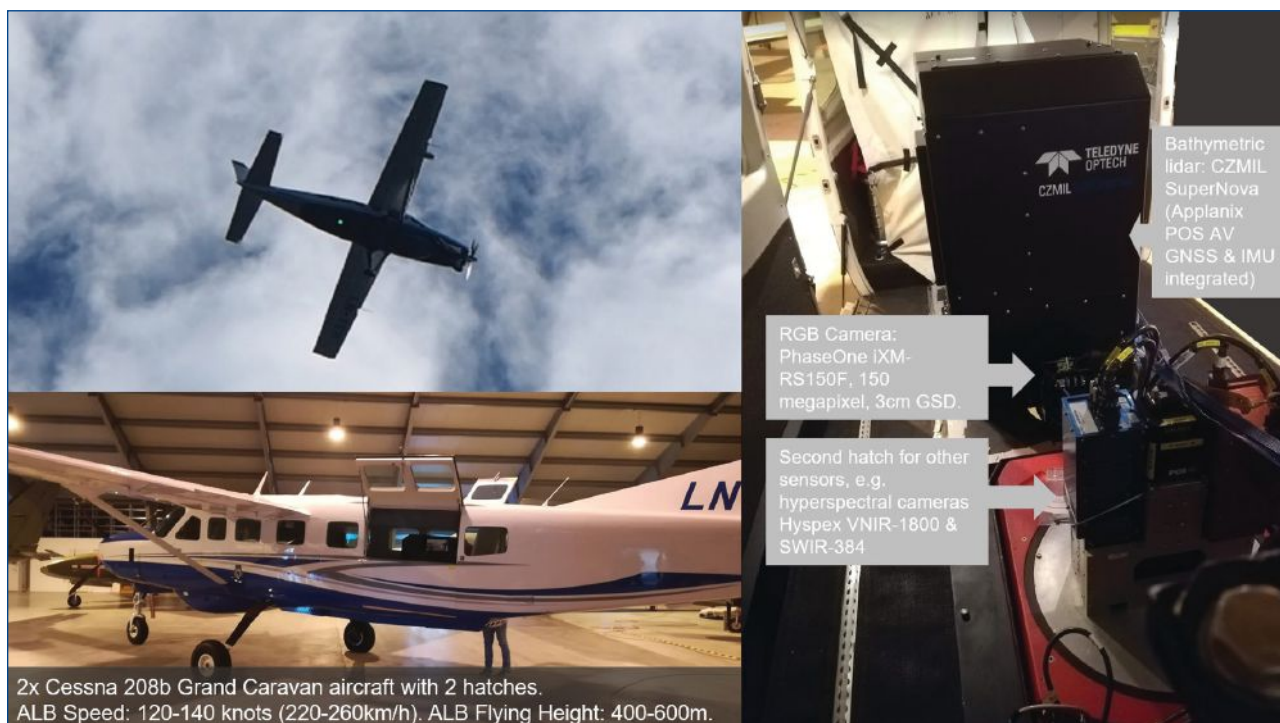
Furthermore, ALB can also be effectively used to map other shallow bodies of water, such as rivers and lakes.

The Process

ALB typically uses a green laser with a wavelength of 532 nanometers (nm), as this wavelength can best penetrate the water. Laser pulses are emitted from the sensor in the airborne platform, hit the water surface, pass through the water column, and reflect off the bottom back to the sensor in the airborne plat-



ALB is a highly effective survey method for shallow areas that are hard or impossible to reach by multibeam sonar. (Credit: Dewberry)



Field equipment for ALB surveys.

form. An additional near-infrared (NIR) signal at 1,064 nm is often used as well to improve the water surface detection and to augment the topographic point density.

The sensor digitizes and counts the returning light photons, which results in a waveform. “Bumps” in the waveform indicate the time the light hits the water surface and the water bottom. The difference in time between these two can be measured to define the water depth, based on the speed of light through air and water.

Current ALB sensors can send out and digitize tens of thousands of laser pulses per second, and the result, when combined with precise positioning information, is a geospatial point cloud with high density and accurate topographic elevation and bathymetric depth measurements.

What needs to be taken into account with an ALB survey is that not all the light photons that are shot out from the laser will actually return to the sensor in the aircraft. In very turbid water with a lot of suspended particles or algae and a muddy bottom, most of the laser light is absorbed or scattered in the water and does not reach the sensor. In these conditions, the sensor may not be able to detect the bottom beyond a few meters, even with the most advanced ALB sensors.

On the other hand, in optimal conditions with a strong laser, transparent water and a highly reflective bottom (e.g., in the Caribbean), the sensor may be able to detect the bottom at depths over 50 m.

In general, ALB is a technique that's very complementary with multibeam sonar. While ALB is most effective in shallow areas, multibeam sonar can be used in deeper areas where ALB is less effective or doesn't reach.

CZMIL SuperNova

Field is a Norwegian geodata collection and analysis

company that specializes in ALB surveys. The bathymetric LiDAR sensor that Field uses is called the CZMIL SuperNova, where CZMIL is an acronym for coastal zone mapping and imaging LiDAR.

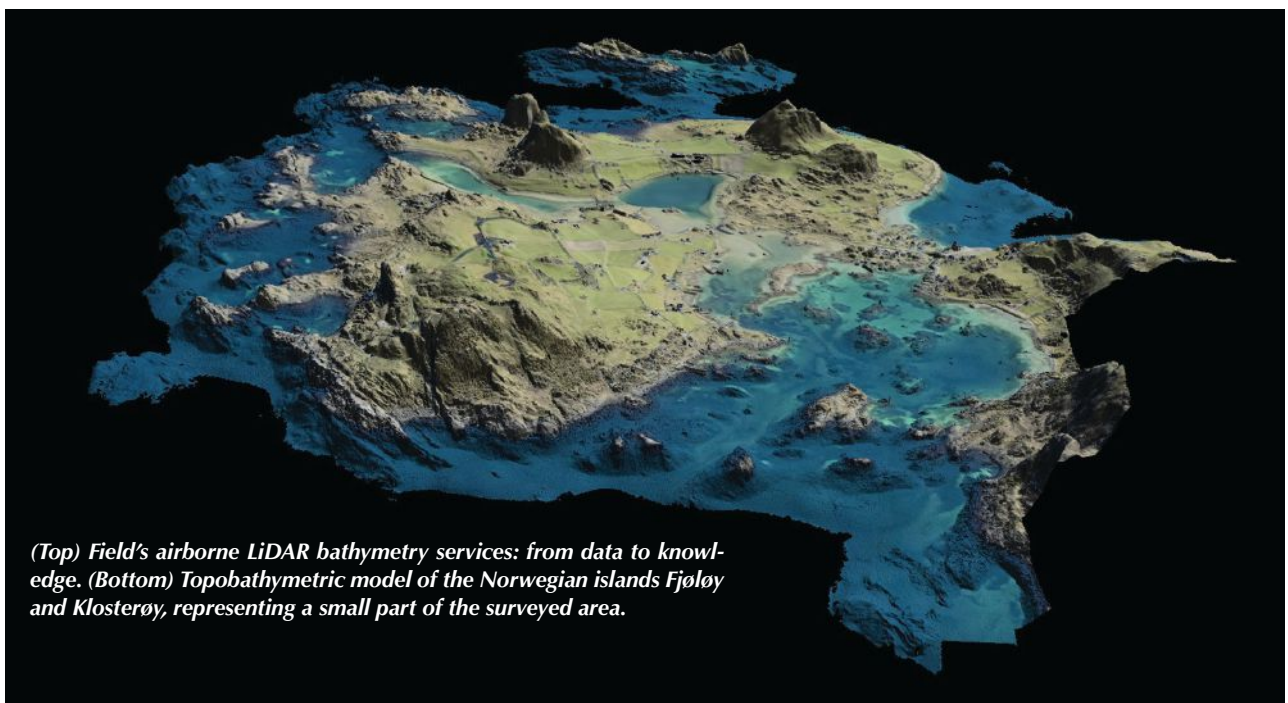
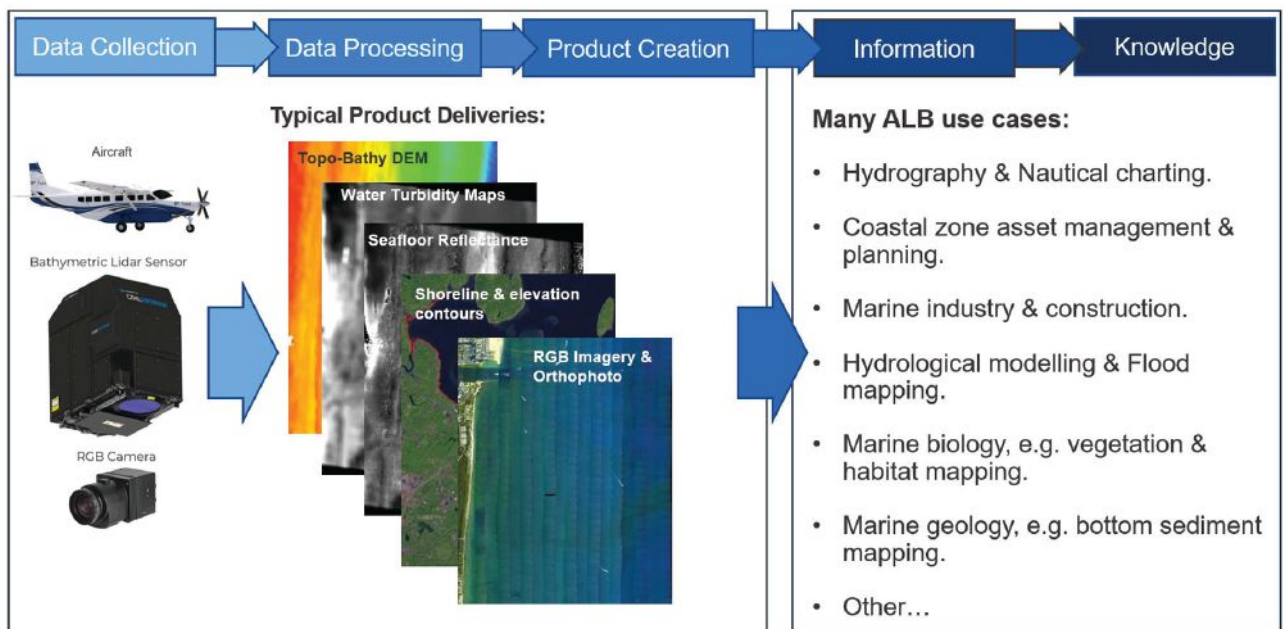
The CZMIL was developed by Teledyne Optech (now Teledyne Geospatial) in cooperation with the U.S. Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX). Teledyne Optech has worked with bathymetric LiDAR since the 1970s, so the company has 50 years of experience with this technique.

The CZMIL has been in use by the U.S. Army Corps of Engineers (USACE) and the U.S. Navy (both JALBTCX team members), as well as other government mapping agencies around the world since 2012. The product was upgraded to the CZMIL Nova in 2015, with a subsequent further upgrade to SuperNova in 2021.

Most of the U.S. coastline and the Great Lakes have been mapped with the CZMIL. According to USACE, compared with traditional surveying techniques, using the CZMIL saves around \$18,000 and 12 days of surveying per mile of coastline.

The SuperNova is the third generation of the CZMIL, with many improvements. Thanks to a variable pulse frequency, SuperNova has over double the point density of the Nova (around 8 points per m²). It is the ALB sensor with the best depth penetration for deep and turbid waters on the market. Furthermore, due to improved digitizer technology, the survey accuracy is within International Hydrographic Organization Special Order for the seven shallow channels that are a feature of the system.

Teledyne Geospatial's CARIS software and algorithms are used for the processing of the data, including new deep learning tools for land-water classification and LiDAR noise classification, which greatly assist with data processing.



Field is the first owner of the CZMIL SuperNova and the only European company that has such an advanced bathymetric LiDAR sensor available. Field owns two Cessna Grand Caravan aircraft in which the SuperNova can be installed, along with an integrated Applanix POS AV inertial measurement unit (IMU) and GNSS receiver for precise positioning.

The CZMIL SuperNova also has an integrated Phase One 150-megapixel RGB camera, and with the 50-mm Rodenstock lens the image resolution is approximately 3 to 4 cm (from the default 400-m altitude). The dynamic range of the camera provides excellent imagery and a detailed view of the seafloor when conditions allow.

The workflow from data collection to knowledge products is as follows: After data collection, the sensor

data are processed at Field's office. The basic product, after processing is finished, is a clean and classified geospatial point cloud, with X, Y and Z coordinates indicating topographic elevations and bathymetric depths with high accuracy. Note that the data also contain many other meaningful attributes, for example, information about bottom reflectance and position uncertainties of individual points.

Depending on the client's requirements, many different types of geospatial products can be created. Based on these products, there are many potential use cases for the bathymetric LiDAR data. Examples include: nautical charting, marine construction, marine geological/biological research, hydrological modeling and all sorts of coastal zone management applications. Therefore, the

“The survey area can be visualized by combining the digital elevation model of the ALB-acquired land elevations and bathymetry depths, together with aerial imagery acquired during the same survey.”

ALB data, which are collected once, can be useful for several stakeholders for different use cases and, as such, have significant economic and scientific value.

Norwegian Marine Base Maps Project

One of the projects that Field participated in was to survey the Stavanger region on the west coast of Norway using bathymetric LiDAR in combination with high-resolution RGB and hyperspectral imagery. This was part of the Marine Base Maps project, a three-year pilot project executed by the Norwegian Hydrographic Service, together with the Geological Survey of Norway and the Institute of Marine Research. The goal of this project was to better and more efficiently map the Norwegian coastal zone, and bathymetric LiDAR was one of the main techniques that was being tested.

After Canada, Norway has the longest coastline in the world, with a length of more than 100,000 km, including all the fjords and islands. Good geospatial data of the Norwegian coastal zone is scarce, though, as it has historically been an area hard to survey. To improve management of the coastal zone, better data are required, so the Norwegian authorities plan to set up a national coastal zone mapping program. By using ALB to map the 0- to 10-m-depth area, they hope to significantly reduce the project cost compared to using vessel-based surveys.

The pilot project area of about 100 km² was surveyed in two days, and the resulting data were very impressive, with maximal depth returns of over 30 m and a generally high point density and full coverage almost everywhere in the required survey area.

The survey area can be visualized by combining the digital elevation model of the ALB-acquired land elevations and bathymetry depths, together with aerial imagery acquired during the same survey. This is a truly seamless topobathymetric elevation model, which was not possible to acquire by other means.

It's worth emphasizing the efficiency of ALB here. A relatively small part of this survey area had been covered previously with multibeam sonar by the Norwegian Hydrographic Service, which took eight days. The same area was surveyed with ALB in less than 2 hr., providing full coverage of both land and water at the same time.

Regarding the accuracy of the data, the Norwegian Mapping Authorities have compared the bathymetric LiDAR data with accurate multibeam data from the same area, and in general the two data types fit very well with each other, with average vertical differences at centimeter level, so they are very satisfied with the results.

What is interesting as well is that, with ALB, you do not only map the water bottom but the whole water column, as objects within the water column also reflect laser



Mapping marine vegetation using a sensor fusion of ALB and RGB/hyperspectral imagery.

“With ALB, you do not only map the water bottom but the whole water column, as objects within the water column also reflect laser light.”

light. This makes it possible to also map marine vegetation or other objects in the water.

Furthermore, information from the LiDAR data can be combined with aerial imagery from RGB and/or hyperspectral imagery, giving a high-resolution multiple wavelength view of the water column. This enables a further quantification of the amount of marine vegetation, and potentially even vegetation types, based on spectral signatures. The fusion of these sensors provides a treasure trove of information, which can be interesting not only for hydrographers and nautical charting but also for many other economic and scientific purposes.

Other Projects

In addition to the Marine Base Maps project in Norway, Field has completed several other marine survey projects in Europe using the new CZMIL SuperNova sensor. For various clients and purposes, the company has surveyed harbors, lakes and rivers, and has also participated in surveys for marine construction projects, including an offshore wind farm and a cable-laying project.

With respect to coastal zone mapping specifically, Field has used the SuperNova to map the entire coastal zone of Catalonia in Spain and is currently starting a project to map the full coastline of Northern Ireland. These projects highlight the demand for improved coastal zone data and demonstrate the efficiency and cost-effectiveness of using ALB to survey shallow areas.

Looking forward, Field will continue to use ALB technology to improve coastal zone management and protection around the world. **ST**

Charles de Jongh has an M.S. in cartography and geographical information science. He has 20 years of experience in the marine geospatial field, including several roles at the software company CARIS (now Teledyne Geospatial), where he provided services to hydrographic agencies globally. Currently, he is based in Oslo, where he works for the company Field, specializing in the provision of airborne bathymetric LiDAR services.



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High-Resolution Modeling

3D Recon Sensor Supports Structural Integrity Management

By Christina Land

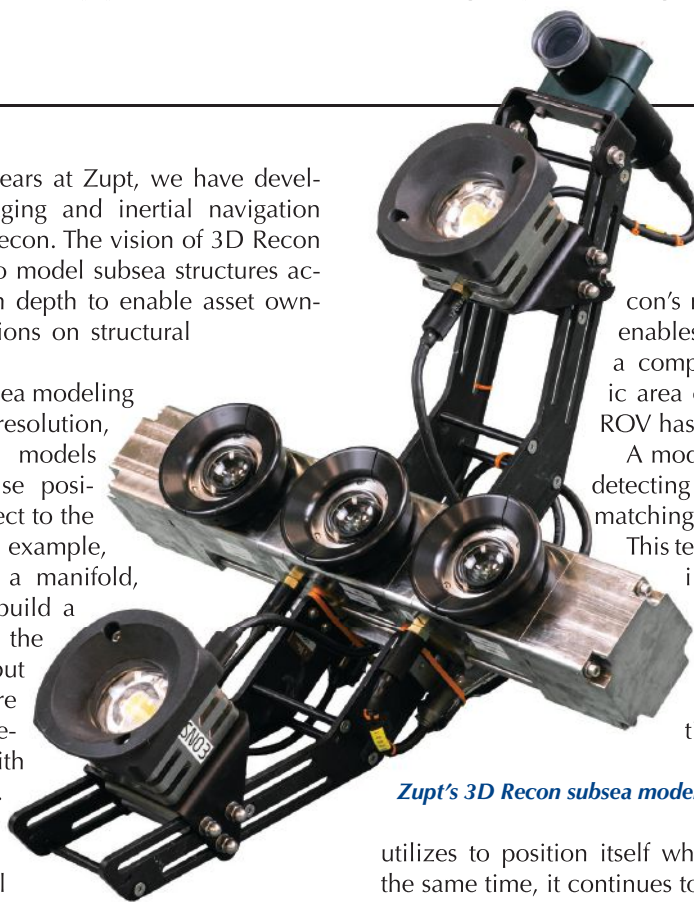
Over the last several years at Zupt, we have developed integrated imaging and inertial navigation solutions, one being 3D Recon. The vision of 3D Recon was born from the need to model subsea structures accurately down to 4,000-m depth to enable asset owners to make critical decisions on structural integrity.

3D Recon is Zupt's subsea modeling sensor that delivers high-resolution, geospatially correct 3D models while generating a precise position in real time with respect to the structure it is imaging. For example, if you are flying around a manifold, not only will 3D Recon build a low-resolution model of the manifold in real time, but it will also tell you where the sensor is located in relation to the manifold with a precision of 1 to 2 cm. Any flying leads (electrical or hydraulic) seen in the manifold model will also be accurately positioned in three-dimensional space.

3D Recon was initially developed for integrity management purposes, and applications have evolved for additional subsea positioning and model generation, including jumper/spool metrology, pipeline out-of-straightness surveys, mooring chain link inspection, hull inspection and more.

Design

3D Recon contains global shutter machine vision cameras with unique lenses, coupled with a high-specification MEMS IMU inside a 4,000-m-rated subsea housing. 3D Recon can be manipulator held for short-term



Zupt's 3D Recon subsea modeling sensor.

deployments, or fixed to the front of an ROV with an optional hydraulic actuator to change 3D Recon's relative viewing angle. This enables 3D Recon to model either a complete structure or a specific area of a structure to which the ROV has access.

A model is built by automatically detecting features in the images and matching them between cameras.

This technique demands balanced illumination over the cameras' entire field of view, so we developed unique lights for 3D Recon.

Simultaneous localization and mapping (SLAM)

is one of the

algorithms

3D Recon

utilizes to position itself while building the model. At the same time, it continues to develop knowledge of the environment through feature detection/description and global map matching.

3D Recon Painter

Early in the development of 3D Recon, we realized the need to plan data acquisition to ensure that complete data sets are collected as efficiently as possible. We built a tool that allows you to import a CAD model of the subsea structure and then configure the proposed trajectory for the ROV. This trajectory is based on operator-selected line spacing and along-track speed. The data collection sequence is then simulated based on a built-in model of 3D Recon. The output from this simulation shows the actual achievable coverage on the specific structure.

This planning tool is called 3D Recon Painter. Its main benefits are the ability to plan precisely how a structure will be modeled in advance, estimate the project timing, and assess the data volume (storage) needed for the project. Additionally, during offshore data acquisition, the tool is used to paint the sparse point cloud in real time onto the CAD model for quality control to ensure complete structural coverage.

To plan the most efficient route around the CAD model, you input data such as the line spacing and along-track speed, and the tool is pre-configured with the field of view 3D Recon will see. As the simulation is run, the CAD structure will be painted from red to green: The model begins in red, and the structure is slowly painted green to indicate the areas that have been imaged.

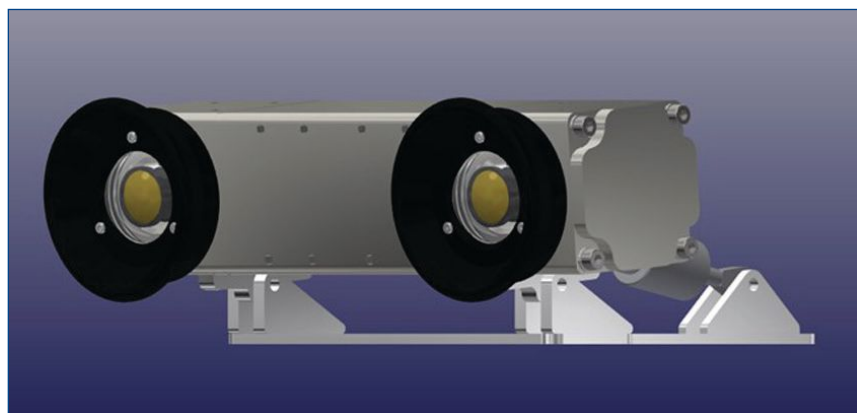
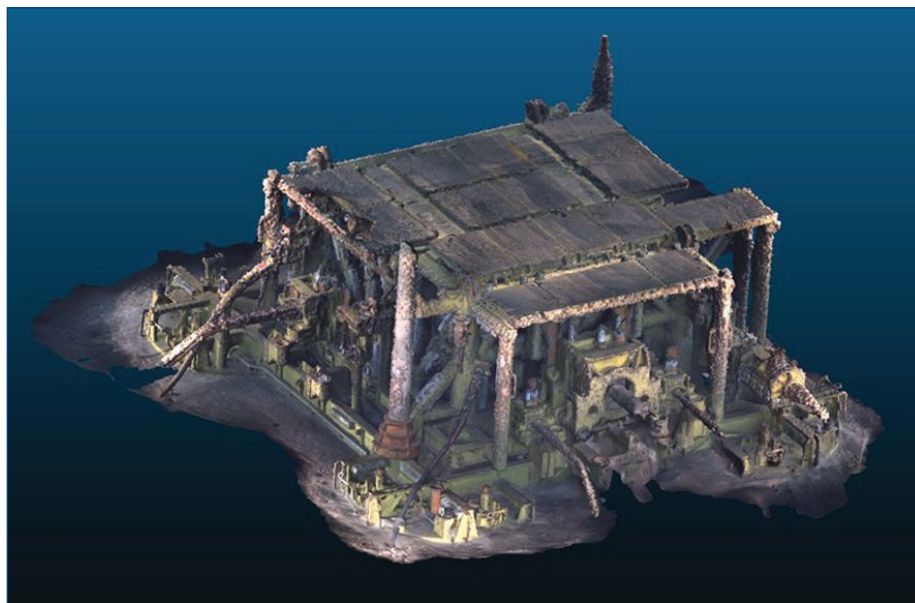
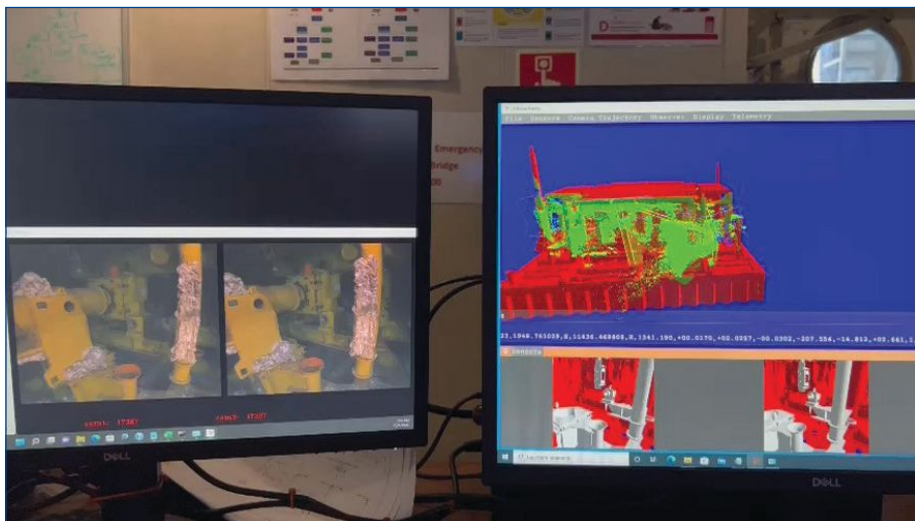
With 3D Recon Painter as a planning tool, after we determine the most efficient path for the ROV to fly around the structure, we can also get an estimate of the overall time it will take to collect the data, along with an estimate of the storage volume of data before we mobilize offshore.

The 3D Recon Painter tool is then used in real time offshore, using the sparse point cloud data for quality control. This way, we can verify that we have collected all the required data to complete a dense model of the structure before leaving the project site. The 3D Painter tool will notify the operator if there is not enough quality imagery to converge the SLAM solution. The long-term goal is to successfully enable the ROV crew to collect 3D modeling data sets using this tool without requiring survey personnel offshore.

Challenges

3D Recon only works if we can see the targeted structure. If we cannot see it, we cannot build a model. Dense particulate matter, reflective surfaces and shadows in the field of view are examples of visual challenges that would prevent 3D Recon from functioning.

For example, if the ROV hits the seabed and kicks up a dense particulate matter “cloud,” we would need the water column to clear in order to continue modeling. If there’s “normal” particulate matter



(From top to bottom) 3D Recon Painter painting the CAD structure from red to green in real time as data are collected. A high-resolution model of a subsea structure generated by 3D Recon. The next generation of 3D Recon will contain two global shutter machine vision cameras, instead of three.

in the water column and we can still see the structure, we can continue working because 3D Recon utilizes the IMU to provide a precise pose estimate. The IMU is critical for 3D Recon to work in degraded visibility by estimating position and attitude and knowing if the ROV is in motion.

If we have a very reflective structure, e.g., a brand new yellow-painted structure, it is challenging for 3D Recon to detect features during feature matching to build an accurate model. However, it only takes a couple of months for a structure to lose its shine once it has been on the seafloor, mitigating this challenge. (If there are no features to match, and it is a very flat, dark, empty seafloor, this could also pose a challenge.)

We developed our unique lights to balance the lumens across the field of view because standard ROV lighting can have intense hot spots in the center of their field of view. If possible, we separate the lights from 3D Recon on the ROV to minimize direct particulate reflection. However, the larger the offset, the more light is needed. We dynamically adjust the lighting as images are collected in order to maintain balance for proper lighting to illuminate a structure. In addition, for a clear field of view, 3D Recon must be mounted in front of any instrument on the ROV to eliminate visual interruptions by other instruments, e.g., shadows.

Deliverables

In real time, 3D Recon generates a sparse point cloud and precise position output. The sparse point cloud is used to show real-time coverage of a structure while data are collected. The post-processed high-resolution models 3D Recon generates are color palletized and geospatially correct. Meaning, once you have a model, you can zoom in and take precise measurements to quantifiably determine such things as anode depletion, coating damage or pipeline free span.

As customers have started to use the products from 3D Recon, a clearer picture has emerged of the various formats required. We deliver in real time a time-tagged accurate position with respect to the structure, along with a sparse point cloud.

It was initially taking us between 16 to 20 hr. to process raw data into a high-resolution model (parallel GPUs). It now takes us between 8 to 12 hr., depending on the quality of the raw data we've collected and the complexity of the structure.

We are working on improving the processing time to the final dense model.

Continuing Development

As 3D Recon continues to develop and the 3D Painter tool matures, we intend to enable an ROV crew to collect and generate the sparse point cloud data independently. Essentially, all the crew would need to do is use the 3D Recon along with the 3D Recon Painter tool to fly around a structure to collect all the data. At that point, a survey team could assist remotely from onshore.

There are many plans for 3D Recon as it continues to develop. For example, the next generation of 3D Recon

will contain two global shutter machine vision cameras, instead of three. We are also developing a lightweight Delrin version for shallow-water, observation-class ROVs for hull and mooring inspections.

3D Recon can also be configured for unique client-specific applications. We are developing a shorter baseline solution containing specific AI object detection/machine learning capabilities for a subsea autonomous vehicle application.

The energy industry will eventually benefit from accurate digital twins for deployed assets above and below the waterline. These accurate 3D digital twins will become the norm for annual inspections, replacing traditional video inspections. Having a high-resolution model is valuable, especially for integrity management and long-term structural monitoring. For example, when using models, we can accurately perform integrity analysis of a structure by laying two point clouds on top of each other, generated at two different times, for automated change detection. This will quickly determine the changes in that structure.

3D Recon and 3D Recon Painter are starting to revolutionize the way operators and inspectors see subsea assets. As this new technology is accepted, efficiency and accuracy for integrity management will continue to increase. **ST**

Christina Land is a digital marketing specialist at Zupt LLC.

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Water Quality Instrumentation

miniDOT Logger Extends Depth Range to 300 M

By Kristin Elliott

Water quality monitoring devices that record accurate and reliable data on dissolved oxygen and temperature are essential in research conducted in both fresh and saltwater. Many loggers are subject to a common limitation wherein readings are not certified or reliable past the depth of 100 m. As a result, finding lasting, durable and affordable loggers that can reach greater depths has been challenging.

Precision Measurement Engineering (PME) has addressed this challenge through advancements in third-party and in-house testing of its miniDOT logger, which is now verified to reach 300-m depth. This triples the device's original logging limit of 100 m.

Design

Constructed from durable plastic, the miniDOT logger records dissolved oxygen and temperature measurements. The sensor uses an optode to measure the lifetime-based luminescence quenching of a thin membrane. Operation of the miniDOT, such as setting the time and sample intervals, can be accomplished via USB cable.

With a form factor that can fit in your hand, the miniDOT is designed for reliable data collection in rugged conditions. The device size and shape allow for many applications, including in underwater caves, boreholes, wells and open water, to name a few.

For longer deployments, the miniDOT is fitted with an optical sensor that can hold its calibration for up to one year without researcher intervention. PME's extensive multi-point calibration preserves logging accuracy over time to provide the best data possible. PME's sensing foil is located inside the logger itself and does not degrade or require multiple replacement pieces within the same year, saving time and money.

Software is provided with every miniDOT and is



The miniDOT logger has an extended depth range to 300 m.

found on the micro-SD card when connected to a computer. The software displays files, creates visual plots to read oxygen measurements, and allows the user to set the internal clock and determine a sample rate.

New Depths

When researchers utilizing the miniDOT logger in numerous projects reported successfully deploying the device at depths in excess of 100 m, PME began reevaluating the miniDOT logger's capacity. Recorded data had already confirmed accuracy beyond the guaranteed limit, so with the mindset of expanding product functions, PME began product testing to reach a greater logging range to benefit researchers worldwide.

Since launching the miniDOT in 2009, testing processes and procedures have also advanced to provide a better understanding of product capabilities. Between researcher feedback and advancements in product test-

“For longer deployments, the miniDOT is fitted with an optical sensor that can hold its calibration for up to one year without researcher intervention.”

ing, the miniDOT logger has increased logging depth to 300 m without altering its structural design or monitoring capabilities.

Baseline Testing

Both third-party and in-house testing was conducted from August to December 2022 to confirm the miniDOT logger would provide consistent measurements beyond 100 m. A third-party, privately held design and manufacturing company that focuses on advancing technology to be used in the harshest environments was selected to conduct pressure tests.

Initial testing was limited to pressure during three rigorous testing cycles, and structural integrity was monitored by the third-party’s experienced technicians. Three miniDOT loggers were placed in a pressure chamber at varying starting and ending pressures and durations. One miniDOT was tested at a starting PSI of 0, increasing to 500 PSI at a rate of 20 PSI/min. with a logging interval of 25 min. A second was tested at a starting PSI of 500, remaining at 500 PSI with a logging interval of 30 min. The third logger was tested at a starting PSI of 500, decreasing to 0 PSI at a rate of 20 PSI/min. with a logging interval of 25 min. The weight of each device was recorded before

and after each cycle and remained at 0.34 kg, indicating there were no signs of water intake or damage.

Testing to discern the miniDOT logger’s upper limit for depth was completed to establish a baseline limitation. The gauge used during this test was 0 to 1,000 PSI with 1-PSI subdivisions. The device was evaluated at both 650 and 700 PSI, and, in each case, recorded a 3-PSI pressure drop that occurred within a minute.

When elevating tests to 750 PSI (the pressure at more than 500-m depth), the pressure suddenly decreased to 575 PSI, indicating the miniDOT logger had taken on water damage, which increased unit weight from 343.6 to 349.4 grams.

The second round of third-party testing verified the consistent success of 300-m deployments, and PME conducted its own visual inspection afterward to check the integrity of each miniDOT logger’s housing elements, pressure case, window retainer, sensor spot and window core. The loggers were then disassembled, and inner elements were examined to ensure factory-specific requirements were met. The examination included testing for the absence of water, discoloration or deformity, computer connectivity, circuit test and magnitude adjustments.

Further evaluation steps were conducted by PME,



PME MINIDOT® LOGGER

PRESSURE TESTING

CYCLE	STARTING PRESSURE	ENDING PRESSURE	RATE	HOLD	TOTAL TIME
	(PSI)	(PSI)	(PSI/MINUTES)	(MINUTES)	(MINUTES)
					15.0
1	0	500	20		25.0
1	500	500		30	30.0
1	500	0	20		25.0
2	0	500	20		25.0
2	500	500		30	30.0
2	500	0	20		25.0
3	0	500	20		25.0
3	500	500		30	30.0
3	500	0	20		25.0
					15.0

The miniDOT logger underwent three rounds of third-party testing before receiving new 300-m verification.



A researcher checks a miniDOT logger in the field.

which showed that no physical damage or leakage occurred during deployments that reached 300 m. The final assessment indicated the miniDOT logger did not undergo any structural changes up to that depth, therefore confirming that current users can deploy their device at 300 m without having to purchase a new logger.

Application Advancement

Increasing measuring depths will enable current and new miniDOT logger users to reliably measure dissolved oxygen and temperature for more applications, such as dead zone tracking. As described by Altieri (a PME customer) and Gedan, 2010, dead zones are “created by the depletion of dissolved oxygen in coastal waters as one of the most widespread and detrimental anthropogenic threats to marine ecosystems worldwide and have been doubling in occurrence each decade since the mid-1900s.” Dead zones can occur at depths from 4 to more than 800 m and range from small areas within coastal bays to huge expanses in the open sea. Reports further state that dead zones are not geographically exclusive, occurring in the waters of China, Japan, Brazil, Australia, New Zealand and the United States, as well as in lakes.

A second example of how the miniDOT logger's increased capacity benefits researchers can be found in the study of thermocline occurrences and the depths at which these occur in both fresh and seawater. The thermocline is the transition layer between warmer mixed water at the surface and cooler deepwater below. Occurring at varying depths, as noted by Irmasyithah et al, 2017, the thermocline is a section of water marked by

its sharply contrasting temperature range. The study of this layer makes important contributions to a greater understanding of thermohaline flows, upwelling and fish migration. Irmasyithah's team measured the waters of the Andaman Sea at depths between 200 and 1,000 m. Water temperature is a key factor in successful aquatic environments and influences several parameters that can alter their physical and chemical properties. Aquatic life is affected by water temperature, which can disrupt the metabolic rates and biological activity of aquatic organisms.

Research similar to those mentioned here can be assisted by the expanded applications and increased depth rating of the miniDOT logger.

PME continues to develop advanced products that are equipped to succeed in challenging environments. The mission of PME is to manufacture affordable instruments and software to provide researchers with the needed technology to pursue the most challenging studies. Successfully tripling the miniDOT logger depths from 100 to 300 m will enable researchers to expand deployments and increase accurate data.

References

For a list of references, contact: audrey.funchess@trindgroup.com. **ST**

Kristin Elliott is the CEO of Precision Measurement Engineering Inc., a leading manufacturer of oceanographic and freshwater sensor monitoring equipment based in San Diego, California. She also founded Aquasend, a PME Enterprise, in 2017 and is involved with various business organizations. Elliott earned her M.B.A. from Cal State University, San Marcos.

Early Warning for Tsunamis

A Review of Current and Emerging Seismic Technologies

By Geoff Bennett

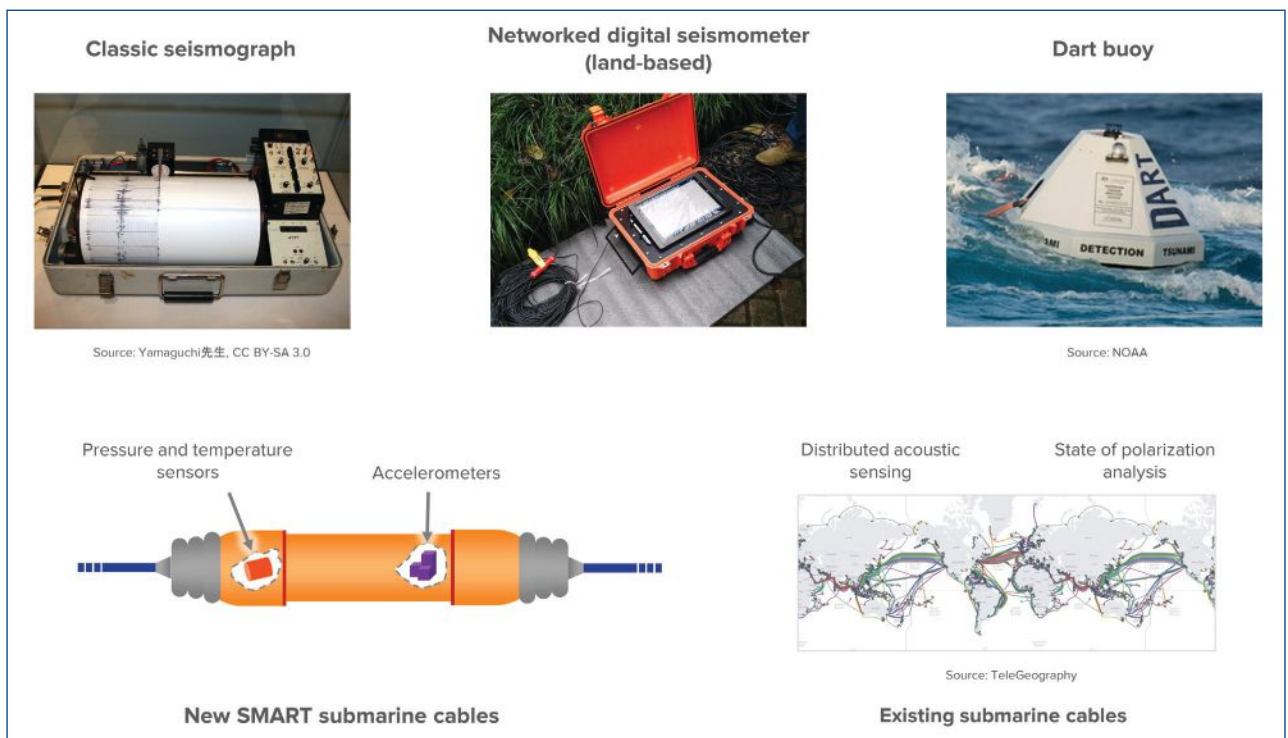
On Boxing Day 2004, I was enjoying the holiday with my family when news of a massive tsunami was reported on TV. The scientific community refers to it as the Sumatra-Andaman undersea megathrust earthquake, and it registered a magnitude of 9.1 to 9.3 on the moment magnitude scale. That makes it the third largest earthquake ever recorded, and it resulted in the deaths of almost a quarter of a million people in 14 different countries.

Thankfully, tsunamis on that scale are rare, but a 2015 United Nations report estimated that every year, an average of 60,000 people and \$4 billion in assets are exposed

to the global tsunami hazard, which can be triggered by certain types of undersea earthquakes or volcanic eruptions.

In response to this hazard, over a number of decades, various countries have deployed dedicated tsunami warning systems, such as floating buoys, to augment land-based seismic detectors. All these work on a basic principle that the seismic waves caused by an earthquake travel through the Earth's crust between 20 and 30 times faster than a tsunami wave travels over the sea.

That means that if the seismic waves can be detected and localized, it should be possible to determine which



Past, current and emerging options for seismic detection.

TECHNOLOGY	PROS	CONS
Land-based Sensors	• Easy to find locations • Easy to maintain power • Easy to maintain • Protected from damage	• Only records seismic data (in this context) • Potentially long distance from source of event
DART Buoys	• Deployed since 1995 and second generation in 2005 • In theory can be placed wherever needed on the ocean surface • Records seabed temperature and pressure	• Limited number may mean shorter warning • Need their own power source • 2- to 3-year maintenance cycle • Exposed to weather and vandalism
Distributed Acoustic Sensing (DAS)	• Use on existing submarine cables • Very high sensitivity – e.g., whale tracking capability • High localization accuracy	• Very short range • Current experiments have used a dedicated fiber
SMART Cables	• Rich array of sensors (seismic, acoustic, pressure, temperature) • Reduced false positive rate • Advances data collection for environmental and seismic research • Relatively low incremental cost to a new subsea telecoms cable • Protected from weather and vandalism	• No SMART cables are deployed today – subsea deployment timescale • May impact subsea cable legal status
SLTE Detection	• Quick and easy to deploy on existing cables • Opportunity to create global monitoring mesh with increasing accuracy, lower false positive rates, and enhanced response times • Higher probability of sensors close to seismic events • Does not impact legal status of cable • May be more acceptable to national security services • Very low incremental cost • Protected from weather and vandalism • Potential to extend technique to include DAS functionality	• Over long distances can only collect seismic data but may be able to offer DAS “for free” • Limited ability to localize seismic events as part of a network of cables • More work needed to optimize collection and analysis algorithms to minimize false positives

Pros and cons of various seismic detection techniques.

coastal areas are at risk and send early warnings to those locations in time to allow people to evacuate. We need seismic detectors in as many locations as possible because, for every 200-km distance between the earthquake’s epicenter and the point of detection, there is an additional 1-min. delay to a potential warning.

Types of Seismic Detectors

I don’t know about you, but when somebody mentions a seismic detector, I think of a device with a highly sensitive arm that moves across a roll of paper—your basic vintage seismograph. Seismic technology has since become more sophisticated.

There is a range of current and emerging options for seismic detection, and I’d like to summarize the pros and cons of each approach, with a particular emphasis on the role of submarine cables as a complementary approach to dedicated seismic detection technologies.

Land-Based Detectors. Modern land-based seismic detectors, known as seismometers, have evolved to become extremely sensitive, operate over a wide range of frequencies, and, of course, have a network output that

can be sent directly into a computer monitoring system.

There are thousands of such detectors installed all around the world. They are easy to maintain and keep calibrated, they operate in a benign environment, they form the backbone of long-term global seismic research, and they help to warn us about earthquakes that directly affect land areas.

But even detectors that show up on a map as being in the middle of the ocean are actually based on an island, and this means they are more likely to be further away from an undersea earthquake epicenter.

DART Buoys. In 1995, the first prototype Deep-ocean Assessment and Reporting of Tsunamis (DART) buoy was deployed off the coast of Oregon in the Pacific. Since then, NOAA has expanded the network to 39 U.S.-owned DART buoys spread across the Pacific and Atlantic Oceans. Following the 2004 earthquake, NOAA has collaborated with several international partners to deploy buoys in the Indian Ocean. Japan, Australia and New Zealand have also deployed networks of buoys.

DART buoys are currently the most effective deployed source of tsunami data, but there are relatively few of them, and they require frequent maintenance because they are exposed to extreme weather conditions and potential vandalism (apparently this is a thing—even in the

middle of the ocean). So they may not always offer the longest warning times.

SMART Cables. An obvious solution to the idea of getting sensors closer to potential undersea earthquake epicenters would be to take advantage of the hundreds of submarine communications cables deployed today. However, these cables do not include seismic sensors—or any other kind of sensors, for that matter.

The SMART (Science Monitoring and Reliable Telecommunications) Cables initiative includes seismic, pressure, temperature and acoustic sensors that can be installed in adapted subsea repeater modules, or even in separate, dedicated modules along the cable.

There is no doubt that SMART cables represent the pinnacle of data collection, in addition to being protected from extreme weather (and vandalism) and having a relatively low incremental cost for new cable deployment. However, there are no SMART cables deployed today.

The first such cable will probably be the CAM2 ring of cables connecting Lisbon, Madeira and the Azores in Portugal. This system is important to the region because it lies near the boundary of the Eurasian and African tectonic plates, and scientists have observed activity that may point to the creation of a new subduction zone there, an area in which one tectonic plate slides under another and creates stresses in the Earth's crust that may one day trigger a seismic event. In 1755, Lisbon was destroyed by a magnitude 7.7 quake that caused a tsunami and extensive fires across the city. CAM2 won't enter service until 2025, and other SMART cable deployments may only follow quite slowly.

One of the details that has to be ironed out beforehand will be the legal status of these hybrid cables under the United Nations Convention on the Law of the Sea (UNCLOS). Ideally, they should be treated as communications cables, but this needs to be confirmed. There is currently no treaty that clearly safeguards submarine cables, and there are political and military concerns about how cables should be classified in international law.

When they arrive, SMART cables will offer outstanding data collection capabilities that will include the most extensive data collection on environmental factors of the oceans that we will have been able to achieve so far. There is no doubt about the importance of these data in the context of climate change.

Adapting Existing Submarine Cables

According to TeleGeography, there are almost 500 submarine cables deployed or in planning around the world today. Imagine if we could do something to transform them into a global seismic sensor network.

When we talk about “transforming” a submarine communications cable, we need to understand that the only part of the system we can change is the submarine line-terminating equipment: the equipment installed at the ends of the cable. The rest of the system lies deep under the sea and will likely stay that way for decades.

So, what can we change at the ends of the cable? We need to think about three factors: What can we measure at the ends of the cable that might be a reliable indicator of seismic activity; can this measurement be made along the entire length of the cable, or is it range limited; and, given that submarine cables can be many thousands of kilometers long, is there a way to localize the signal along the length of the cable?

Distributed Acoustic Sensing (DAS) is an established technique based on coherent optical time-domain reflectometry (OTDR), which was originally developed to help detect potential interference, either accidental or deliberate, occurring relatively close to the landing points of submarine cables. The technique is not limited to communication cables; it is also useful for the thousands of electrical cables that run under our seas and oceans, as long as they have been equipped with monitoring fibers.

DAS generally requires a dedicated optical fiber, and it works by sending optical pulses at “acoustic frequencies” (in the range of several thousand hertz) into the end of the fiber. Rayleigh backscattering at various points along the cable will cause some fraction of the pulse energy to be reflected back to the transmitter. By monitoring the signals, it's possible to detect extremely small disturbances—including the passage of marine animals such as whales—in the vicinity of the cable. Seismic activity is very much within the capabilities of DAS, and it can offer very high levels of accuracy within 120 km or so of the shore.

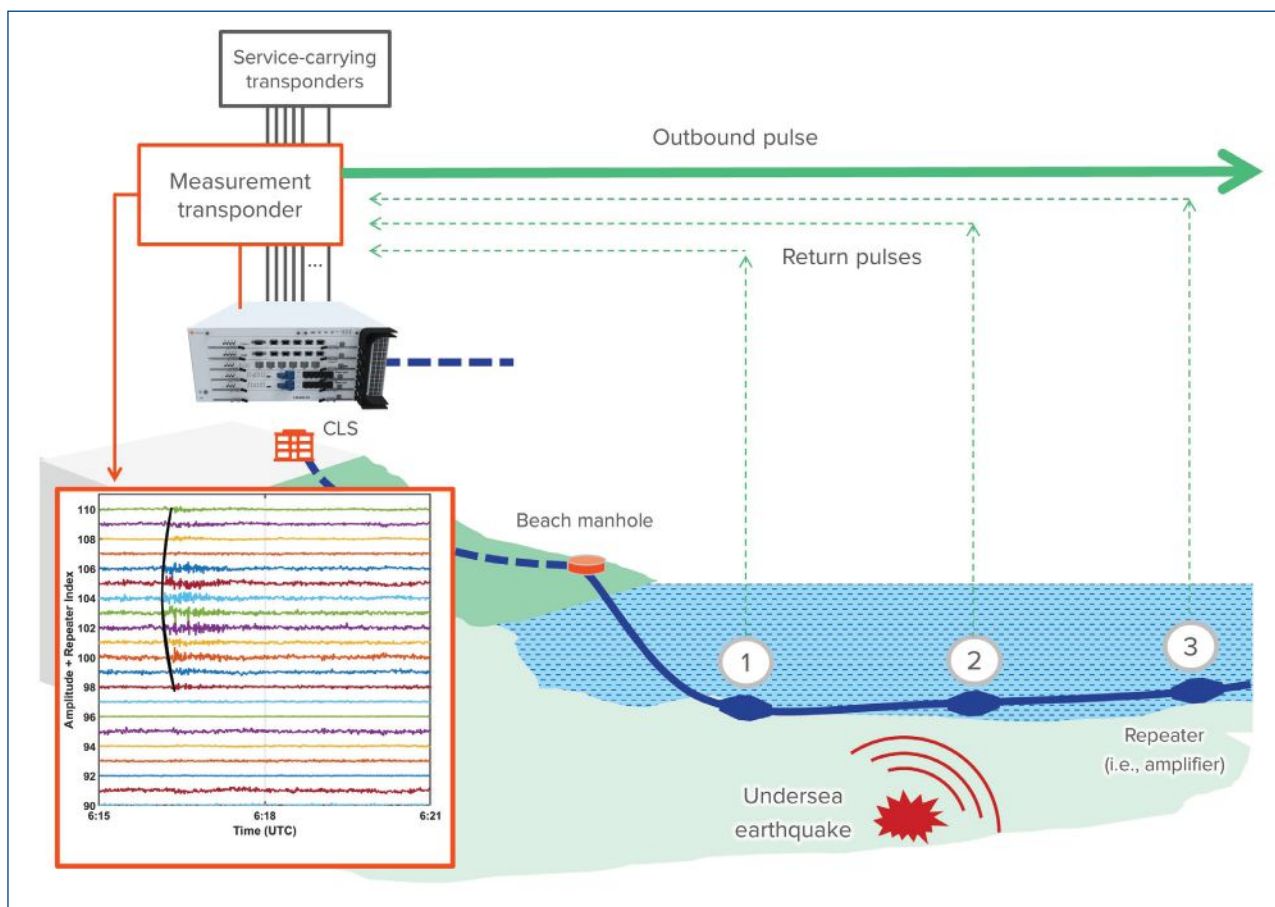
In 2021, the EllaLink cable system came into service, an optical submarine cable linking Europe to South America. It includes an extra fiber pair on the Madeira section of the cable that became the first permanent infrastructure dedicated to DAS in a commercial subsea telecom system. EllaLink operates this facility, known as GeoLab, in conjunction with the Madeira-based operator, EMACOM; Portugal's National Regulatory Authority, ANACOM; and research and education organizations GÉANT, FCT and BELLA.

Despite the range drawbacks, there are plans to deploy DAS on some new cables, for instance, in the Mediterranean Sea, where a 120-km range would allow for a useful amount of area to be covered.

State of Polarization Analysis

Modern coherent transponders use a technique known as polarization multiplexing to double the number of bits carried by each modulation symbol. In this approach, separate data signals can be carried on the X and Y polarizations of the light, and, during the journey along the cable, birefringence changes in the fiber will cause the state of the polarization to change. For this reason, state of polarization (SOP) tracking and active correction is essential for these transponders to operate reliably.

Transient physical events that occur along the cable, including tidal effects and, of course, seismic disturbances, will change the SOP in the receiver. While the SOP disturbance will be automatically corrected, by collecting the processing information, it's possible to get an idea of the magnitude of the physical disturbance causing the



SOP (state of polarization) analysis using high-loss loop-back in existing repeaters on Google's Curie cable off the coast of Chile. With data from three repeaters, the chart shows the wave of responses from different amplifiers.

SOP changes. Thus, in terms of our three factors at the ends of the cable, we have “something to measure” that is caused by seismic disturbances.

However, this information is essentially an integration of SOP disturbances along the entire length of the cable, which could be over 10,000 km long. There could also be a significant “noise floor” as a result of other physical events affecting the cable. In ongoing trials with multiple cables, Google is one company that is trying to use the combination of signals from multiple cables to triangulate a location. But this is extremely challenging without some way to localize the measured effect.

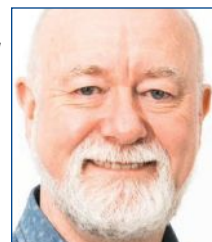
Recent trials, including those by the U.K.'s National Physical Laboratory (NPL) and by Infinera in collaboration with Google, take advantage of the fact that most existing subsea cable amplifiers include a high-loss loop-back (HLL) component that will bounce back a small fraction (less than 1 percent) of the light at a specific diagnostic wavelength: typically 1,561 nm. This is in the middle of the amplified band of the cable, so the echoes from the entire cable length can be detected from either end—overcoming the distance limitation of DAS. If the timing of these return signals is correlated with their SOP data, it is possible to isolate the location of the effect on

the cable to within the spacing of the repeaters.

Pulses are sent out from the measurement transponder, and part of the pulse is reflected back at different times from various repeaters. For example, using data from three repeaters, a chart was made from a real earthquake detected on Google's Curie cable off the coast of Chile that shows the wave of responses from different amplifiers. In this case, the center appears to be located on Repeater 104. This allows isolation to a maximum of the repeater spacing, and there may be some tricks whereby this range of isolation could be reduced. Epicenter location could be achieved by combining synchronized data from multiple cables, as Google has already proposed.

While much more work still needs to be done on this approach, SOP detection can be applied to most of the 450+ subsea cables in service around the world today that include HLL components in their repeaters, and it could provide a vital detection boost until the deployment of SMART cables. **ST**

Geoff Bennett is the director of solutions and technology at Infinera Corp.



AIS Trends

Emerging Applications for Space-Based Tech

By Kevin Nakao • Richard Proud

Automatic Identification System (AIS) vessel tracking was first deployed in the 1990s to avoid ship collisions. Satellite-based AIS tracking evolved in the 2000s to track regions of the world that terrestrial-based receivers cannot cover. AIS satellites, such as Spire's LEMUR (Low Earth Multi-Use Receiver) spacecraft, have been designed to constantly improve their capabilities through software-defined radio (SDR) and hardware updates.

As a result, AIS technologies and services have developed to provide an extensive range of solutions for supply chain optimization, insurance underwriting, offshore asset protection and reducing carbon emissions, among other applications. This article discusses predictions for trends in AIS.

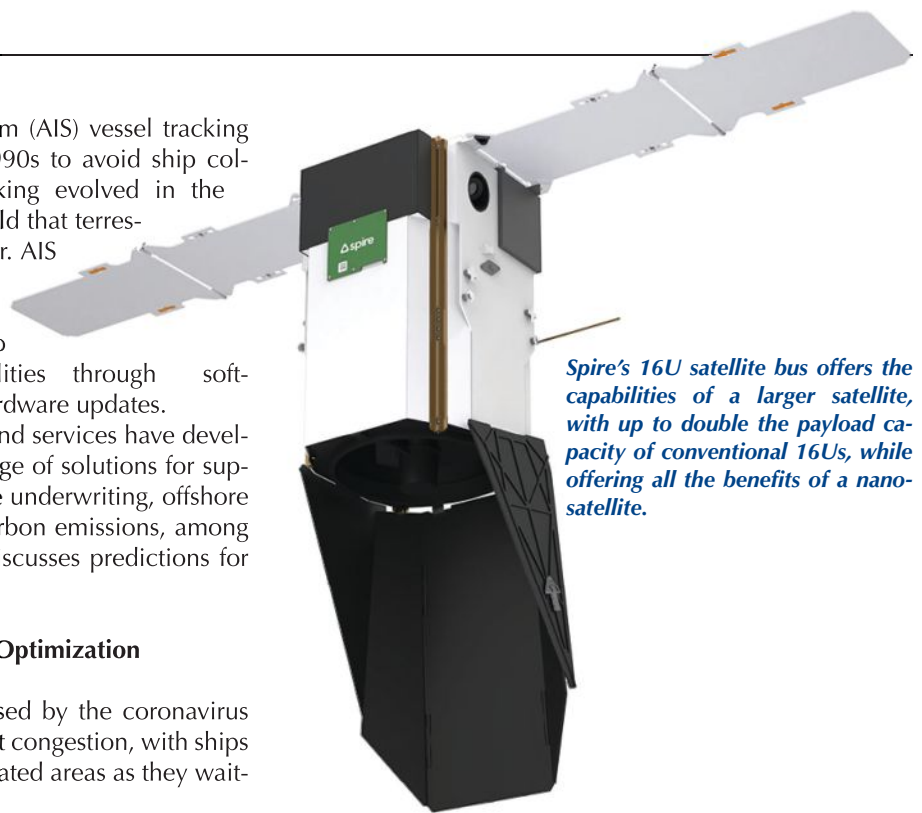
The Link Between Supply Chain Optimization And Decarbonization

Supply chain disruptions caused by the coronavirus pandemic resulted in massive port congestion, with ships emitting carbon in densely populated areas as they waited for their berth.

One of the challenges is that a ship's estimated time of arrival is typically 40 hr. off from the actual time of arrival. Can you imagine the planning challenges of hosting a dinner party where you don't know if your guests will show up on time or 40 hr. later? That's what's happening in the shipping industry.

Data-driven solutions such as vessel-to-port ETA (<https://spire.com/maritime/solutions/vessel-to-port-eta>), which leverages machine learning applied to over 10 years of historical AIS data, along with real-time AIS (<https://spire.com/maritime/solutions/real-time-ais>) recalculations provide more reliable estimates. If a vessel knows that there will be congestion ahead, it can slow its speed, save on fuel and reduce its carbon emissions.

Third-party logistics data can also be inaccurate and

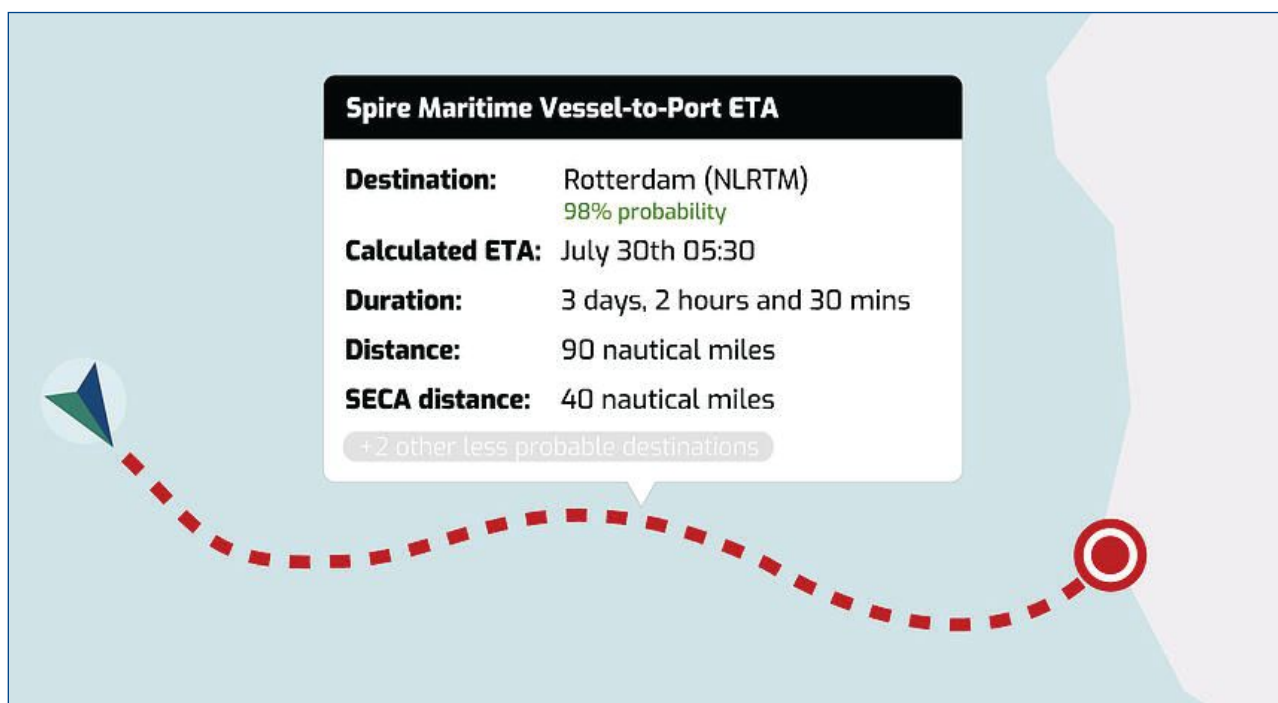


Spire's 16U satellite bus offers the capabilities of a larger satellite, with up to double the payload capacity of conventional 16Us, while offering all the benefits of a nano-satellite.

outdated so the company Gravity Supply Chain Solutions (<https://gravitysupplychain.com>) uses AIS data to help logistics providers unlock operational efficiencies. As its CEO Graham Parker says, "Accurate, timely data is the foundation for capturing precise projections of vessel movements that enable shippers and logistics providers to optimize operations, mitigate risks and control costs."

The Supply Chain Goes Beyond Big Ships

While we typically think about how supply disruptions may impact the availability of iPhones and purchases from Amazon that travel via large vessels, we don't often think of the effects on fishing, an important component of local ecosystems and economies.



An example of vessel-to-port estimated arrival time.

While standard AIS concentrates on larger ships equipped with onboard power and two-way communications, a low-cost traceability and safety-of-life solution has been developed by Spire for small fishing and work-boats. exactTrax is a unique technology that enables transmissions from battery- or solar-powered AMRD/ AIS-SART transponders to be reliably received by Spire's global satellite network. This improves the safety of small boats while at sea and helps local communities and national agencies manage their local fish supplies via catch traceability, catch reporting and understanding changing fishing patterns that are a consequence of climate change.

AIS data are also used to study and protect the breeding grounds of endangered species. Collisions with ships is reported to be one of the biggest threats to whale sharks, which frequent shallow waters and shipping lanes. Global Fishing Watch, along with a team of scientists from more than 50 universities and research institutes, used satellite tracking technology to reveal the global overlap of whale sharks and shipping activity as a step toward shark protection.

The End of the Carbon Free-Ride

The business case for sustainability in shipping is getting real. The International Maritime Organization (IMO), EU and U.K. have started the process of reporting, monitoring and verification of vessel emissions. The IMO adopted new measures, which will take effect January 2023, requiring all ships to calculate and improve their current energy efficiencies via the Energy Efficiency Existing Ship Index (EEXI) and to establish their annual operational Carbon Intensity Indicator (CII) and CII rating.

The CII measurements correlate greenhouse gas emis-

sions to the distance the cargo has traveled. Ships will get a rating of their energy efficiency (A through E, with A being the best). Governments, port authorities and other stakeholders can incentivize ships to achieve A or B ratings. This also signals to markets and financial sectors that top energy ratings are good business. If a ship has a D rating after three consecutive years, or E for one, the shipowner must submit a plan to remedy and demonstrate how it will improve to reach a preferred rating of C or higher. The first annual report will be completed in 2023, with the first rating given in 2024.

Companies that successfully reduce their emissions may, in fact, be better underwriting risks. Significantly, some insurance experts are advising the industry to utilize their expertise in risk and climate change to temper the effects for their clients and their own businesses. Additionally, insurers are using exclusion—that is, removing clients with high carbon emissions from the underwriting portfolio—or engagement: helping clients move to a greener business model.

Earlier this year, the U.S. Securities and Exchange Commission (SEC) proposed guidelines for public companies to disclose their environmental impact. AIS historical ship tracking data, along with vessel characteristics (<https://spire.com/maritime/solutions/vessel-characteristics>), can be used as part of these compliance efforts to track travel time, ship features, routes and nautical miles.

Shining a Light on Dark Shipping

"Dark shipping" is a term used to describe a vessel operating with its AIS turned off or manipulating its reported vessel position, often to hide illicit activities such as sanctions violations, illegal fishing and human trafficking. Fortunately, technology continues to be one step ahead of the bad actors. For instance, this year, Chris Cook at the Financial Times was able to use a combination of satellite technologies and investigative journalism



Spire's Richard Proud installing an exactTrax-enabled transponder for an exactTrax trial in the Comoros as part of the World Bank-funded SWIOFish1 fisheries management project.

techniques to identify stolen Ukrainian grains (<https://maritimemeans.spire.com/episodes/episode-6-chris-cook>).

The nonprofit SkyTruth has used AIS data in a similar way, conducting a process of elimination of ships in the area of the 2021 Huntington Beach oil spill to identify two ships that were then put under investigation.

Unless a ship can wrap itself in tinfoil, it is likely to be detected, even when it turns AIS off.

Protection of Offshore Assets

While AIS was created to protect ships from colliding with each other, its applications include the protection of offshore assets. More companies are focusing on renewable energy, reducing emissions, and developing methods for carbon transport and storage. Location data for shipping vessels, routes and trade lanes are vital for the safe installation of clean energy alternatives such as wind farms and tidal turbines. AIS data can help determine the optimal location of offshore assets by enabling the recognition of shipping patterns so that those areas can be avoided by developers.

Undersea cables are another vital offshore asset. They form the backbone of the world's communication system and account for 95 percent of global international voice and data traffic. AIS data and vessel tracking are also used to protect these important offshore assets.

Crowdsourcing Maritime Technology

One of the most effective ways to leverage new technologies and data is to develop a commercial ecosystem

that enables participation and rewards innovation. Spire's Port Events (<https://spire.com/maritime/solutions/port-events>) provides the essential building blocks for others to build their own internal or commercial applications, in addition to providing data and application programming interfaces (APIs) for predicted estimated time of arrivals for vessel tracking.

Conclusion

The layout and location of every port is different, and tracking the movement of ships from anchorage to the terminal area or a canal are critical for optimizing logistics. Increasing the granularity and visibility of a vessel's status in the port helps the logistical chain to understand the past and present and estimate the next steps in the journey. More detailed information increases the accuracy for shore-side actors (transportation, loading and unloading, etc.) to plan their work as well.

As the Danish Philosopher Søren Kierkegaard once said, "Life can only be understood backwards, but it must be lived forward." In the case of AIS, we can look back at historical data with machine learning and look forward with real-time AIS to yield actionable insights from space that improve life on Earth. **ST**

Kevin Nakao leads the maritime (<https://spire.com/maritime>) marketing and customer success teams for Spire Global. He is a contributor to the Spire blog and adviser to the "Maritime Means" podcast (<https://maritimemeans.spire.com>). He has over a decade of experience in software and data as a service. Nakao has an M.B.A. from Harvard Business School and a B.A. in philosophy from Whitman College.

Richard Proud is the director of advanced maritime products for Spire Global. As part of Spire's maritime government team, he is responsible for Spire's small vessel tracking and satellite IoT services. Originally a software engineer working on ESA's ERS-1 mission, Proud has over 35 years of experience in company/business development and project management in the AIS, Earth observation, satcom, GNSS and GIS domains.

international

Engine Control Cybersecurity

Swiss marine power company WinGD has become the first marine engine designer to gain cybersecurity type approval for its engine control system, ahead of mandatory regulations due to enter force in 2024. DNV has granted WinGD Control Electronics (WiCE) an SP1 type approval, aligning with International Association of Classification Societies (IACS) Unified Requirement (UR) E27 technical system requirements, a cybersecurity standard that will apply to all newbuilds.

Mine ID, Detonation via USV

Seatronics, a brand in Acteon's Data and Robotics Division, has begun the final installation and commissioning phase in the first sale of two mine identification and detonation solutions (MIDS) to Elbit Systems Ltd., one of the world's largest defense contractors. MIDS is a multi-shot, configurable mine disposal solution that can detonate multiple charges acoustically without having to sacrifice itself. Elbit's Seagull USV is an ideal host platform for remote deployment of the Seatronics MIDS ROV using a custom launch and recovery system.

Polish Navy Orders More Gavia AUVs

The Ministry of Defence of Poland has procured, through Remontowa Shipbuilding, three additional Tele-dyne Gavia AUVs for its next batch of *Kormoran II*-class new mine countermeasure (MCM) vessels. The AUVs will join the current Gavia AUV fleet, which has been successfully operated by the Polish Navy for MCM since 2015. To complement the Gavia AUVs previously procured, the acquisition will include all required topside equipment, as well as AUV operation and maintenance trainings.

INTERCARGO Says: Make Green Fuels Accessible

INTERCARGO continues to fully support the ambition to achieve net-zero emission shipping by 2050 and argues that this goal can only be achieved by providing the shipping industry with alternative zero-carbon fuels. The responsibility for decarbonization cannot be placed solely on the shoulders of the ship operator at the end of the line. It is a challenge that must be dealt with holistically by the entire industry.

Appropriate policies must be included in the Revision of the International Maritime Organization (IMO) GHG (greenhouse gas) Strategy to ensure that green fuels are secured, as well as the necessary infrastructure to ensure availability and bunkering in ports around the world. INTERCARGO believes these aspects are not sufficiently discussed and addressed, despite their critical role.

IMarEST Opens Tech Hub in China

The Institute for Marine Engineering, Science and Technology (IMarEST) has opened the IMarEST China Technology Centre in Ningbo, China, to support professionalism in the area with access to IMarEST services

and events. The center was opened with a ceremony at China-UK Maritime Service and Talents Development Cooperation Forum and coincided with the launch of a partnership between IMarEST and new company Ningbo Lanzhi. They will work closely together to enhance professional standards and globalization of people working in the maritime industry in China.

New Maritime Service Hub in Manila

The Columbia Group has opened CSM Manila to offer a variety of ship management and maritime-related services, including the development of new logistics and ship performance solutions.

Columbia also has an exclusive partnership with the Nautilus Pacific Training Centre in Manila, which enables CSM to train up to 5,000 seafarers in the Philippines per year with the most advanced training programs in the industry. Nautilus is equipped with state-of-the-art simulators with the latest Wärtsilä technology.

Molten Salt Nuclear Power Barge

Bureau Veritas and nuclear power technology developer ThorCon have entered an agreement for the technology qualification and the subsequent development of a 500-MW molten salt nuclear power barge for operations in Indonesia.

The concept developed by ThorCon is a molten salt fission reactor. Unlike current nuclear reactors, the ThorCon reactor operates at low pressure and uses liquid fuel. The liquid fuel enables much higher operating temperatures, leading to greater efficiency while also enabling completely passive safety (requiring no action from the operator nor intervention on the power source to stop the reaction).

The 500-MW fission power plant will be integrated within a floating barge hull and then towed to a shallow water site before being ballasted to rest on the seabed. The technology will then deliver energy to the power grid to meet land-based energy needs. ThorCon plants will be designed to be mass produced, which will support the transition to carbon free and reliable energy.

Seed Funding for Expense Analysis Software

Tech startup Harbor Lab has secured €6.1 million to further develop its shipping disbursement analysis software program. Disbursements are all expenses that the agent makes on behalf of the operator while the vessel is in port. Port expenses are the second largest cost behind bunkers for a shipping company and amount annually to more than \$120 billion.

The Athens-based company is the first to offer SaaS (software-as-a-service) disbursement account analysis software that automatically calculates and evaluates port expenses against real-time port tariffs.

Rivertrace Acquires Solar Solve

Rivertrace, a specialist in developing environmental monitoring solutions for the marine market, has completed its acquisition of Solar Solve Ltd., a manufacturer and supplier of anti-glare window roller sunscreens in the

marine, offshore, aviation, agriculture and commercial sectors. Solar Solve will continue to operate as an independent entity with all its current staff retained. The four Rivertrace directors have been appointed to the board of Solar Solve. The two family-owned companies, both founded in the 1980s, are export oriented with distributors, OEMs and end-user customers, selling to over 65 countries around the world.

MidAtlantic Engineering Adds NJ Offices

MidAtlantic Engineering Partners, a civil, environmental and marine engineering and surveying firm, has opened two additional New Jersey office locations, in Morristown and Mt. Laurel. MidAtlantic Engineering Partners also maintains offices in Wall Township, New Jersey; Newark, New Jersey; and Media, Pennsylvania.

Pulse 8X Assists Crime Investigation

JW Fishers' Pulse 8X is a handheld underwater metal detector that continues to be a popular commercial-grade detector that is useful in finding evidence for criminal investigations. For instance, it was used in summer 2022 by the Department of Underwater Operations of the Investigations Police of Chile to locate a weapon related to an attempted homicide. The Pulse 8X detected the firearm in the Río Elqui River Wetlands.

Marina Company Acquisition

Marine Development Inc. (MDI), a decades-long specialist in new marina construction, expansions, restoration and repair, wave attenuators, fuel docks and more, has been purchased by Mick Webber, an industry professional in the boat lifts and marina equipment markets.

MDI was founded in 1991 by Steve and Roger Otis. Webber is a former president and CEO of HydroHoist Marine Group (HMG) and has sat on various industry boards. Webber will lead MDI, and third- and fourth-generation members of the Otis family, Jeff and Jeremy Otis, will remain highly involved in day-to-day operations.

AR, VR Development Partnership

Greensea Systems Inc. and Blue Ring Imaging have announced a new collaboration on rapid augmented reality (AR) and virtual reality (VR) development to enhance Greensea pilot/operator performance in the sub-sea sector. The two companies were brought together through mutual involvement in the U.S. Navy's PMS 408 program of record and a shared desire to improve the man-machine teaming experience.

Computer Vision Tech for USCG

Sea Machines Robotics Inc. has installed its new AI-ris computer vision product on board a U.S. Coast Guard (USCG) 270-ft. *Famous*-class, medium-endurance cutter. AI-ris uses artificial intelligence to identify and track visual targets of interest for maritime domain awareness.

This installation will enable Sea Machines to refine its computer vision technology with performance feedback from USCG in various environmental conditions and operational scenarios. **ST**

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Rock Bag Installation For Galloper Wind Farm

Rovco has been awarded a contract for the provision of offshore rock bag deployment and installation at the Galloper offshore wind farm in the Outer Thames Estuary, located 27 km off the Suffolk coast.

The project scope covers the application of a solution for the installation of rock bags, which need to be placed at precise locations on and around the cable protection systems (CPS) in the wind farm.

Following previous subsea surveys, rock bag placement was selected from a number of options considered by the operator as the most suitable solution to eliminate or vastly reduce excess cable movement of the CPS, stabilizing and prolonging the life of the array cables that carry the generated electricity from the wind turbines.

Rovco will deploy the DPII sub-

sea support vessel VOS *Star*, on charter from Vroon Offshore Services, during the project. The vessel will be pre-installed with cutting-edge survey equipment and Rovco's Saab Seaeye Leopard WROV, which will be fully calibrated and system tested for swift commencement. The project is led by personnel from Rovco's offshore team and a dedicated onshore project manager.

The 353-MW Galloper offshore wind farm has a site area of 180 km² and wind turbine generators located at depths of 26.5 to 39.5 m. Galloper's 56 turbines will generate enough green electricity every year to power the equivalent of more than 380,000 homes in the U.K.

BMT Demonstrates Smart Microgrid Tech

BMT's prototype for an independent microgrid management and distribution system has undergone

testing at the Sustainable Marine Energy (SME) Grand Passage site in Nova Scotia, Canada, using SME's PLAT-I tidal energy device as the primary renewable energy source. This recent deployment in Canada of the microgrid controller demonstrates BMT's expertise in this emerging energy technology field that could potentially position Canada's off-grid communities as leaders in the growth of the sector.

This project is supported by Canada's Ocean Supercluster and its flagship industry-led Ocean Energy Smart Grid Integration Project. The collaboration on microgrid technology is an example of new options available for the energy transition in various geographies across the country, as well as for commercial and military applications globally.

RivGen Hydrokinetic System Launches in Canada

ORPC Canada has launched its first hydrokinetic power system in the country. RivGen generates proven, emission-free electricity from

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free-flowing rivers and tidal currents. Installed in partnership with the Canadian Hydrokinetic Turbine Test Centre (CHTTC) located at Seven Sisters Falls, Manitoba, RivGen can provide baseload renewable energy to remote communities and will play a key role in supporting Canada's goal for net-zero emissions by 2050.

The RivGen device was fabricated by Stace in Quebec, then shipped to Manitoba, where the device was reassembled near the CHTTC with the help of Canadian partners and local contractors: NRCan-CanmetEnergy, Hatch, University of Manitoba, Manitoba Hydro, Turtle Island Innovations, Able Crane, Dominion Divers and Griff's Mechanical. ORPC Canada is helping Canadian suppliers that have historically worked in offshore oil and gas to develop expertise in the marine energy sector.

Preventive Maintenance Assigned for Hornsea

Sembcorp Marine Ltd., through its wholly owned subsidiary, Sembmarine SLP Ltd., has been awarded the planned preventive maintenance (PPM) contract by Ørsted A/S for the Hornsea 2 offshore wind farm, one of the world's largest wind farms, located 89 km off the Yorkshire coast in the U.K. North Sea. The contract involves the maintenance and servicing of the low-voltage and ancillary systems on both the offshore substation and reactive compensation station, with provisions for service extension.

This exclusive contract marks the first sole supplier maintenance award for Sembmarine SLP and aligns with the company's strategic transition from fabricator to service provider in the offshore renewable space.

Supercomputer to Advance Renewable Energy, Biofuels

Predicting the potential of renewable wave energy and producing greener biofuels is faster and more accurate than ever before, thanks to a £5 million state-of-the-art national supercomputer launched at Queen's University Belfast.

The Kelvin-2 Tier-2 High Performance Computing Facility (HPC), based at the McClay Library at Queen's, is the first national facility of its kind in Northern Ireland. It is a collaboration between Queen's University and Ulster University.

The supercomputer can analyze huge amounts of data, deal with multiple requests simultaneously, and run very complex simulations to help design biocatalysts for man-

ufacture of biofuels and pharmaceuticals using renewable resources.

Marine Mammal Protection

During the construction of the 800-MW Vineyard Wind 1 project, Vineyard Wind will use Awarion technology, provided by Charles River Analytics, for marine mammal, ship and fishing gear detection. Awarion is an AI and computer vision system. **ST**

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Certified Surface Drone



Lloyd's Register has awarded its first certification for a USV to the DriX maritime drone. This new certification attests that the surface drone meets critical safety requirements to be operated at sea. DriX is used by major hydrographic institutes and energy companies worldwide and has already received Bureau Veritas approval in principle. Exail.

Offshore Crew Transfer Vessel

At 32 m (105 ft.), the vessel's size has been increased for a larger cargo deck area and load capacity. This will enable the vessel to play an increased role during the wind farm construction phases, with the ability to carry more equipment in support of the larger ships. BMT Group Ltd.

Optical Oxygen Sensor

SBS 83 is the latest iteration set to become the standard for Navis float applications. Improvements include the ability to take in-air oxygen measurements and the integration of the CTD flow path through the plenum. This optical oxygen sensor gives scientists and researchers a means to field calibrate the sensor through post-processing. Sea-Bird Scientific.

Autonomous ROV

Boxfish is now autonomous-capable, enabling customers to increase efficiency and minimize human er-

rors in subsea asset inspection. The capability to upgrade the Boxfish ROV platform to perform autonomous and semi-autonomous tasks will deliver better data and enhanced survey repetition in underwater operations. Boxfish Research.

Fishing Electronics

HDS PRO chartplotter/fishfinder, high-resolution ActiveTarget 2 Live Sonar and ultrahigh-definition Active Imaging HD provide anglers the complete package of the latest fish-finding technology. HDS PRO offers complete bow-to-stern control on a SolarMAX HD touchscreen, which provides sonar images of fish and structure from the Active Imaging HD and ActiveTarget 2 Live Sonar technologies, along with incredibly detailed chart information. Lowrance.

Workboat Solutions



With a 13-liter engine, the IPS30 can power a wide range of commercial marine vessels, such as offshore wind farm and passenger transport vessels of up to 100 tons. The upgraded D16 engine suits heavy-duty operations and is available as a propulsion engine, complete marine genset and auxiliary. The IMO Tier III is a compact aftertreatment system for vessels 79 ft. and above that allows for more freedom of vessel design and simple retrofitting. Volvo Penta.

Technical Publishing from 3D Files

Document3D Suite has been updated for 2023 with new features, including Pages3D for technical documentation and Publisher3D for technical illustrations. By repurposing existing 3D CAD files and associated data, customers can rap-

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Oyster Aquaculture Could Improve Potomac River Estuary

Oyster aquaculture in the Potomac River estuary could result in significant improvements to water quality, according to a new NOAA and U.S. Geological Survey study published in *Aquatic Geochemistry*. All of the nitrogen currently polluting the Potomac River estuary could be removed if 40 percent of its riverbed were used for shellfish cultivation, according to the joint study. [2-23-SEA00108](#)

Navy's Laser Weapon Ready For Summer Deployment

Navy engineers are making final adjustments to a laser weapon prototype that will be the first of its kind to destroy a ship late this summer. The prototype, an improved version of the laser weapon system, will be installed on the USS Ponce for a testing in the Persian Gulf. Navy leaders have made direct-energy weapons a top priority to counter what they call asymmetric threats, including unmanned and light aircraft and small attack boats that could be used to deny U.S. forces access to certain areas. [2-23-SEA00109](#)

Ferry Sinks Off Coast of South Korea

With 482 passengers onboard, a ferry sailing from Incheon, South Korea, to the island Jindo sank near the southern tip of South Korea Wednesday, according to Associated Press. Most of the more than 400 people on the ship were high school students headed for a school trip to the tourist island. At the rescue effort, more than 90 vessels and at least 18 aircraft sought to pull passengers from the water to safety. [2-23-SEA00110](#)

Pay Increase for Sailors Soon to Come

Sailors waiting for the U.S. Navy could see a father paycheck in the coming weeks, reported the Virginia Pilot. On May 1, sailors serving aboard ships will receive a pay raise. The increase in pay comes as an effort by the Navy to incentivize thousands of unified seafaring jobs. The bonus is a part of sea pay, a perk to those who work in jobs involving long deployments. Currently, the stipend is between \$50 and \$700 dollars. [2-23-SEA00111](#)

US Senate Reviews DOE Budget Request

For fiscal year 2015, the Department of Energy requested \$23.8 billion. The U.S. Senate Appropriations Committee, Subcommittee on Energy and Water Development, held a hearing last week to review the funding request and discuss financial priorities. According to Lamar Alexander (R-Tenn.), research should be a focus of spending. [2-23-SEA00112](#)

US Technology Helps in Search for Flight 370

More than a month after Malaysia Airlines flight 370 went missing, crews are hard at work trying to uncover what happened to the plane's black acoustic signals emitted from the flight, providing a lead to the location of the plane, and eight countries are participating in the effort to scan the waters off the coast of Northwest Australia. Crews aboard from Naval Sea Systems Command told Sea Technology how the U.S. Navy is helping in the search. [2-23-SEA00113](#)

2014 Sea Technology Buyers Guide Now Available

Published annually by Compas Publications, the 2014 edition of the *Sea Technology Buyers Guide* is now available. The Buyers Guide/Directory features a market analysis and scores sub-directories, including industrial firms, services, federal government organizations, educational institutions, oceanographic research vessels and specialty survey vessels.

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idly create technical documentation and illustrations. When 3D CAD designs change, they can seamlessly update their printed, PDF or HTML deliverables. QuadriSpace Corp.

Marine Audio



Intended for boat builders, the range of products includes custom speaker grilles, OEM-branded user interfaces, and even complete product designs for specific space or performance requirements. These audio solutions are ideal for the small and mid-size boat market. Banshee.

Sonar Software Update

SonarWiz 7.10.1 features new vertical exaggeration controls in SBP digitizer to maintain scale from file to file; faster bathy-processing merge with new Octree algorithm; a new unified record button for easier start/stop of logging; and fixed drawing of map view of side scan data in draft mode. Chesapeake Technology Inc.

Sunlight-Readable Touch Screen

SRMHXTRWP-12R-36 is a 12-in. monitor that comes with a waterproof stainless steel panel-mount enclosure. It is five times brighter than a standard desktop monitor and highly resistant to dirt, dust and moisture, which makes it ideal for use in direct sunlight. The screen has over 1,500 nits of brightness, with a five-wire resistive touch screen that can be activated by a bare or gloved finger, pen, stylus or other object. TRU-Vu Monitors Inc.

Panama Canal Navigation

SafePilot P3 was developed in response to the recent advisory issued by the Panama Canal Authority

(ACP) requiring a new positioning system for Neopanamax vessels beginning in October 2023. It provides real-time certified data to and from the pilot's display, enabling more efficient operations in constrained waterways. The unit features an advanced motion sensor and an exceptionally precise GNSS that measures the vessel's movement in three dimensions. A built-in backup battery ensures function even during power outages. Trelleborg Marine and Infrastructure.

Claims-Reporting App

The MRCE Handbook app will help senior officers, surveyors and shore-based technical and marine personnel gather evidence quickly and efficiently, using standardized formats on mobile phones and tablets. Compatible with iPhones, Androids and tablets, the app is free to access for all North members and correspondents. It covers incidents involving people, cargo, vessels and commercial disputes. North P&I Club.

Clear Deck Plates

High-Torque Access Plates are made in the U.S., formed from durable marine plastic for total corrosion resistance, and are watertight in even the most challenging environments. Each incorporates a combination of extra-deep finger-holes and a full pry, raised channel integrated into the surface design. This enables easy removal of the cover by hand, or, when extra leverage is needed, using any 1-in. round handle. Beckson Marine.

Fuel Monitor

Permaflow is a 24/7 visibility solution that constantly monitors/logs more than 90,000 measurements of volumetric, mass and energy (heat quantity) flow rates, with units displayed in kWh and BTU. It comes with a variety of communication and I/O options, including PT100 thermometer integration, RS232, USB and 4 to 20 mA. There is no requirement to drill into pipes, and setup and operation can be done by one person. Coltraco Ltd. **ST**



AI-Based Marine Mammal Identification Tool

Whale Seeker has been awarded a contract from Innovative Solutions Canada as part of a testing stream for technologies to detect marine species and biodiversity. This project involves analyzing 100,000 aerial images of Arctic marine mammals from Fisheries and Oceans Canada (DFO) using Whale Seeker's proprietary AI tool, Möbius. The project runs from November 2022 through March 2023.

DFO uses aerial surveys to estimate the size of different marine mammal populations. In recent years, aerial surveys have relied on manually analyzed aerial photographs to identify animals of interest. This method is time consuming and requires multiple readers to verify counts. By standardizing data analysis and reducing time and costs related to wildlife survey campaigns, DFO hopes to scale up the size and scope of its projects, expand monitoring capabilities to new contexts, and ultimately make decisions based on easier access to high-quality data.

Möbius is an AI tool that has been trained over the past four years with high-quality data sets specifically to identify marine mammals. It uses a human-in-the-loop approach, which combines the bulk processing power of computer models and feedback from expert marine scientists. Möbius processes aerial survey images substantially faster and more accurate than manual annotation, then returns detailed, transparent and auditable data in standardized form, allowing for meaningful comparisons across survey years and regions.

Augmented Reality to Manage Vessel Provisions

Safetytech Accelerator is collaborating with research and innovation center CYENS and marine services provider Oceanic to explore augmented reality and computer vision to assist crews in the safe handling and storage of vessel provisions.

CYENS is the research and innovation center of excellence in Cyprus focusing on interactive media, smart systems and emerging technologies aiming to empower knowledge and technology transfer in the region. The collaboration will explore augmented reality and computer vision for better management and utilization of stock, reduction of food waste, and improved hygiene and safety practices.

BC Ferries Goes Paperless

BC Ferries, one of the largest ferry operators in the world, has moved to paperless navigation systems. This transition follows a year-long process of testing and onboarding ChartWorld's digital navigation services across the BC Ferries fleet.

BC Ferries moves more than 60,000 customers and 23,000 vehicles daily throughout coastal British Columbia.

Safety, environmental, and performance regulations and standards are increasingly intertwined as digitization spreads through the shipping and transportation industry. Operators now require integrated systems that promote vessel safety, are easy to operate, and produce reliable and quantifiable results.

ThayerMahan Chooses SEA-KIT X-Class USV

SEA-KIT International has announced its first USV export sale to ThayerMahan, a specialist in autonomous maritime solutions based in Connecticut. The X-Class USV combines extended range, high sea state endurance and payload capacity.

ThayerMahan will use the SEA-KIT USV to support introduction of the technology into government service, as well as for its own commercial activities in U.S. and international waters. ThayerMahan will take delivery of the latest 12-m SEA-KIT X-Class design in spring 2023 for operation in the summer.

Joint Cybersecurity Research

Singapore Shipping Association (SSA) and ClassNK have signed a

memorandum of understanding to establish a framework for cooperation in cybersecurity research activities.

Cybersecurity has been acknowledged by the maritime industry as a key element to keep ships safe during operations and to ensure its solid and steady digital transformation in coming years. Singapore, being a global maritime hub that connects regional and global markets, is ideally positioned for such research activities that will eventually contribute to reinforcing cyber resilience of the global supply chain.

The two parties will conduct joint basic research to establish vessel cybersecurity operation centers that provide crew members with support from onshore to monitor and respond to cyber events on board.

Based on expertise and experience gained from this research, SSA and ClassNK will work on drafting a joint white paper on the findings of the research and developing education and training plans for personnel for vessel cybersecurity operation centers.

DNV Verifies SHI Blockchain

In the first of its kind for a shipyard, DNV has awarded a statement of fact to Samsung Heavy Industries (SHI) for applying blockchain technology to its own SAS (Samsung Autonomous Ship) and SVESSEL eLogbook data streams on an operating vessel.

The project was accomplished by interfacing SHI's data stream and eLogbook with the VeChainThor blockchain to demonstrate the technology's potential for secure data stream applications on ships.

As the shipping and offshore industries become more digitized, yards, shipping companies, manufacturers and class societies worldwide are actively developing and verifying smart and autonomous ships amid rising need to strengthen cybersecurity. This is increasingly important for real-time data transmissions from ship to shore, remote monitoring and equipment maintenance. Blockchain technology is groundbreaking in data security for autonomous ships. **ST**

Rig-to-Reef in Angola

The transformation of an oil platform into an artificial reef is underway in Angola. It is the first platform in Africa to be decommissioned in a project led by environmental quality services company EQS, with a Saab Seaeye Falcon underwater robot deployed for the task. The Falcon is assisting in the survey and mapping of all underwater components, including checking the wellhead, pipelines and the surrounding maritime environment.

Baseline environmental conditions are determined by taking water and sediment samples at several stations and at different depths, focusing on biological matter, namely zooplankton, phytoplankton and benthos.

Significant marine growth exists throughout the structure, with abundant marine life already present for populating the rig when toppled on its side to become an artificial reef.

Once decommissioning is complete, a series of surveys will be scheduled to monitor the evolution of marine growth on the newly created reef.

EQS selected the Seaeye Falcon for its ability to handle an array of cameras, sensors, tooling and complex data gathering systems that include a digital multifrequency profiling sonar.

Upcoming work involves clearing an area of fish nets, restoring platform signaling and marking, positioning of signal buoys and confirmation of pipeline locations, along with the surveys to monitor marine growth.

Natural Product Extracts Can Treat Black Band Disease

Mote Marine Laboratory & Aquarium teamed up with the U.S. National Park Service and pharmaceutical scientists at Ocean Alchemists LLC to develop treatments for black band disease (BBD), a lethal coral disease, which will contribute to the management of infectious coral diseases and aid in restoration efforts. In the new peer-reviewed

research, scientists tested and treated BBD, one of the first and most prevalent coral diseases reported on reefs worldwide, with a multitude of potential therapeutic agents.

BBD is visually described as a dark band that progresses across healthy coral, leaving behind bare skeleton. The research reports that although BBD is seen globally, it is consistently documented on shallow-water reefs in the Caribbean. This disease infects more than 42 species of Caribbean corals, and although the prevalence and virulence peaks during the summer months, it can be observed affecting corals year-round.

A total of 13 different possible treatments were tested on *Pseudodiploria*, a genus of stony brain coral, with active BBD lesions at Buck Island Reef National Monument in St. Croix, U.S. Virgin Islands. Two antiviral/antimicrobial-based ointments, referred to as "CoralCure," slowed the progression of lesions and completely eliminated the disease in affected corals. These corals also remained healthy at least six months after treatment.

This is the first study to use natural product extracts as the primary active ingredient and shows the potential for full treatment efficacy of a worldwide coral disease, ultimately preserving coral biodiversity.

NI Offers Free Membership For Maritime Students

The Nautical Institute (NI) has introduced free membership to students and cadets undergoing initial maritime training or education.

NI, which has just celebrated its 50th anniversary, has branches around the world with members from all ranks. It provides training and technical resources, as well as professional leadership through its representation of members at the International Maritime Organization.

NI encourages young mariners to join the institute and offers continuing professional development through training and education, as well as networking opportunities

and the chance to learn from more experienced mariners.

Student membership is free for the full length of study, followed by a further grace period of up to 12 months while they establish their maritime careers. During this time, students will have the option to upgrade to full membership at half price.

Recognition for SeaBot MASS Remote Operator Training

The U.K. Maritime and Coastguard Agency (MCA) has bestowed voluntary recognition of SeaBot Maritime for its pioneering Maritime Autonomous Surface Ships (MASS) Remote Operator Training.

This training is designed for personnel conducting USV operations and is the first training module in SeaBot Maritime's wider MASS Certified Professional Training Scheme (MCP). The MCP Scheme is a career pathway for users of uncrewed vessels. Developed by SeaBot Maritime in association with its long-term customer Fugro Middle East, Module A in MASS Operations was launched to help overcome the challenges of the adoption and operation of next-generation maritime technology.

Maritime Data Best Practices

The Smart Maritime Council, a cross-industry membership group focused on technology harmonization, standardization and interoperability, has released new best practice guidelines for data ownership and access in the maritime sector, providing a recommended list of data control issues for shipping companies and technology providers to consider when discussing contracts for the supply of ship-board systems.

The guidelines (<https://smartmaritimenetwork.com/data-owner-ship-and-access-guidelines>) include recommendations on establishing ownership of the data created by vessel equipment and systems; translation of digital signals into usable data formats for analysis; consent-based sharing with third-party analytics providers; and other key digitalization issues. **ST**

Electrical Installation on New German Research Vessel

Wärtsilä will provide and integrate the electrical system package for a new German research vessel. The *Meteor IV* project has been contracted by Germany's Ministry of Education and Research, and the ship will be constructed by the Meyer-Fassmer-Special Shipbuilding Division consortium.

Wärtsilä will be involved throughout the entire duration of the project. Work will include detailed design during the engineering phase and will continue with all the appropriate installation and connection requirements at the manufacturing shipyards in northern Germany. Wärtsilä will also take responsibility for commissioning of its scope of supply, as well as the entire cabling system.

When delivered, the *Meteor IV* will carry out international and interdisciplinary missions focusing on climate and environmental research in Atlantic waters.

MBARI Chooses USBL

The Monterey Bay Aquarium Research Institute (MBARI) has chosen deepwater positioning technology from Sonardyne for its new, state-of-the-art scientific flagship, the RV *David Packard*.

The 50-m-long research vessel, named in honor of MBARI's founder, will undertake a diverse range of missions in Monterey Bay and beyond, supporting the institute's mission to advance marine science and technology to understand a changing ocean. The ship will accommodate up to 18 researchers and enable MBARI's continued exploration of the deep sea, from the midnight zone to the abyssal seafloor.

The RV *David Packard* will be the command center for MBARI's deep-diving ROV Doc Ricketts and will also be capable of deploying a variety of AUVs. Underpinning this deepwater capability will be Sonardyne's Ranger 2 ultrashort baseline (USBL) system, with an HPT 7000 transceiver.

Biggest Seagrass Ecosystem

The largest seagrass ecosystem in the world has been discovered and mapped: an area in the Bahamas estimated to be up to 92,000 km².

The study "Tiger sharks support the characterization of the world's largest seagrass ecosystem," published in *Nature Communications*, details the researchers' innovative approach of using camera tags to track the movements of tiger sharks over seagrass meadows, which helped the scientists map and ultimately validate spatial estimates of these vast blue carbon ecosystems in the Bahamas for the first time.

Tiger sharks (*Galeocerdo cuvier*), the largest marine predator found in tropical seas, have been protected in the Bahamas for more than a decade. Beneath The Waves (BTW), an ocean NGO research institute, has been monitoring the behavior of the species to determine how current and future marine protected areas could be optimized to conserve sharks.

In 2019, BTW's lead scientist and CEO, Dr. Austin Gallagher, began attaching customized camera tags to tiger sharks throughout the Bahamas, and the recorded videos provided evidence of the sharks traversing over dense seagrass meadows over expansive areas.

In order to map the total area covered by seagrass in the Bahamas, the team performed their own remote sensing analysis, while integrating previous satellite imagery estimates, to generate a composite estimate of the Bahamas seagrass ecosystem. These records were paired with extensive ground-truthing validation, involving more than 2,400 diver seagrass surveys throughout the area. Working with tiger sharks allowed the researchers to map even more seafloor.

This first-time arrangement using camera tags on tiger sharks provides a model for collaborating with large marine animals to explore the ocean. The research team also collected sediment cores from the extensive seagrass ecosystem to

evaluate how much carbon is stored in the sediment, ultimately revealing that the Bahamas likely holds up to 25 percent of the global stock of seagrass-based blue carbon.

Academic-Industry Tech Partnership

Hydroacoustic technology specialist GeoAcoustics Ltd. and the University of Plymouth have signed a new technology partnership agreement based on the use of a GeoPulse Compact sub-bottom profiler for education and research purposes. The university took delivery of the system, which includes an over-the-side transducer mount for deployment flexibility, in December. The partnership also includes the potential to switch to a next-generation GeoPulse system in 2023, as well as a one-day guest lecture and processing workshop for the university's M.S. hydrography and B.S. ocean exploration and surveying students.

The GeoPulse Compact enables the university to expand and enhance teaching of the fundamentals, workflows and best practices of sub-bottom profiling with the opportunity to apply the theory in a live setting using an industry-standard shallow-water acoustic system. The system will be integrated into undergraduate and postgraduate research projects, as well as broader academic research. Upcoming research projects within the Coastal Processes Research Group will use GeoPulse Compact for dependable, accurate sub-bottom data acquisition.

TDI-Brooks Relies on Starlink

TDI-Brooks has successfully installed the Starlink Maritime platform on two of its four research vessels, RV *Brooks McCall* and RV *Miss Emma McCall*. Both vessels are currently working on the U.S. East Coast performing geological and geophysical surveys for offshore wind programs. Starlink Maritime is a division of SpaceX. This satellite connectivity service for maritime vessels has no data cap on capacity and offers typical download speed rates of 60 to 150 Mbps. **ST**

contracts

Merco Vial S.A., Buenos Aires, has ordered a CSD650 cutter suction dredger to expand its current fleet. The delivery includes the supply of a matching booster station. The CSD650 is a dismountable dredger with a cutter power of 700 kW and a maximum dredging depth of 18 m. The in-board dredge pump has a mixture capacity of 7,000 m³/h. Damen Shipyards Group.

WinGD, Winterthur, Switzerland, has received orders from two LNG carrier operators for its WinGD Integrated Digital Expert (WiDE) engine monitoring, diagnostics and remote support service. The orders will deliver diagnostics to a total of 17 WinGD X-DF dual-fuel engines. Knutsen OAS Shipping and CoolCo.

Hundested Propeller, Hundested, Denmark, will supply a complete propulsion system, regeneration solution and thrusters to two additional sail cargo boats in build. Currently in production are the hybrid marine gearboxes, CP propellers and propeller shafts, stern tubes and thrusters for two 81-m, sailing cargo boats. TOWT.

Dualog, Tromsø, Norway, has been contracted for the Dualog Drive data transfer service to improve the management of a fleet of 25 vessels. The customer will be able to spend less time on the IT system while improving the workflow when distributing documents and data across the fleet. Spring Marine Management S.A.

Ardmore Shipping Corp., Hamilton, Bermuda, has ordered the emissions-reducing Filtree system, including the Clean Loop system, for an initial six MR tankers. The tankers will be made carbon capture ready for collecting CO₂ emissions on board in the future. Value Maritime.

Marlink, Oslo, Norway, will deploy its hybrid connectivity solutions on selected vessels, integrating Star-

link LEO with its Sealink GEO VSAT service and its digital platform. The Marlink network will come with an L-band backup solution. Mitsui O.S.K. Lines.

Boat Fix, Southport, Connecticut, has been selected as an approved tracking provider for Markel policyholders. All new boat rental customers insured by Markel may subscribe for the Boat Fix service and will receive its monitoring and tracking device at no additional cost. Markel. **ST**

meetings

Note: The coronavirus (COVID-19) pandemic could affect event dates. Check event websites for the latest updates.

MARCH

March 12-16—US Hydro, Mobile, Alabama. www.thsoa.org/us-hydro.

March 26-28—Canadian Underwater Conference & Exhibition (CUCE), Halifax, Canada. www.cuce.ca.

March 28-30—International Offshore Wind Partnering Forum, Baltimore, Maryland. www.offshorewindus.org/2023ipf.

March 28-30—MCE Deepwater Development, London, U.K. 713-447-8559, Sara.Wilkins@GulfEnergyInfo.com or <https://tinyurl.com/456e9yjb>.

APRIL

April 18-20—Ocean Business, Southampton, U.K. www.oceanbusiness.com.

April 26-28—NOIA Annual Meeting, Washington, D.C. www.noia.org/event/noia-2023-annual-meeting.

MAY

May 1-4—Offshore Technology Conference, Houston, Texas. <https://2023.otcnet.org>.

May 8-10—World Utilities Con-

gress, Abu Dhabi, United Arab Emirates. www.worldutilitiescongress.com.

May 8-11—XPONENTIAL, Denver, Colorado. meetings@auvsi.org or www.auvsi.org/events/xponential/xponential-2023.

May 9-11—UDT, Rostock, Germany. team@udt-global.com or www.udt-global.com.

May 17-19—OceanTech Expo, Zhoushan, China. www.oceantech-ap.com.

May 17-19—Subsea Technology Eastern Mediterranean, Limassol, Cyprus. www.subseatechnologyconference.com.

May 23-24—Blue Food Innovation Summit, London, U.K. www.bluefoodinnovation.com.

JUNE

June 5-8—OCEANS 2023, Limerick, Ireland. <https://limerick23.oceansconference.org>.

June 6-8—Capitol Hill Ocean Week, Washington, D.C. <https://marinesanctuary.org/chow-2023>.

June 20-22—INMARTECH, Barcelona, Spain. <https://sites.google.com/view/inmartech-2023>.

AUGUST

August 20-24—World Water Week, Stockholm, Sweden. www.worldwaterweek.org.

August 27-September 1—IMAGE 2023, Houston, Texas. <https://tinyurl.com/uc2db9k3>.

SEPTEMBER

September 11-15—London International Shipping Week, London, U.K. <https://londoninternationalshippingweek.com>.

September 25-28—OCEANS 2023 Gulf Coast, Biloxi, Mississippi. <https://gulfcoast23.oceansconference.org>.

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people

Kristen J. Sarri has stepped down as the National Marine Sanctuary Foundation's president and CEO. Sarri joined the foundation in 2016 with a vision to bring America's marine sanctuaries to the forefront of ocean and Great Lakes conservation in the U.S., centered around the many diverse communities and organizations critical to improving the well-being of these places. Under her leadership, the foundation developed programs for wildlife conservation and underwater marine debris cleanup and habitat restoration, and advocated for new and expanded sanctuaries.



Rafael Velezmoro has joined BIRNS Inc. as quality assurance manager for all the company's design, manufacturing and supply operations, including oversight and management of its ISO 9001-2015-certified and 10CFR50 App. B-compliant quality management system. Velezmoro joined the team at BIRNS with 25 years of manufacturing and quality experience, having served in a range of leadership roles. He has more than two decades of experience as a lead auditor.

The Marine Technology Society has elected the following new members to its board of directors: **Susan Hunt**, president; **Katharine Weathers**, vice president of early-career ocean professionals; **Josh Kohut**, vice president of education; and **Jerry Miller**, vice president of government and public affairs.

Pioneer Consulting, a full-service submarine fiber-optic telecommunications consulting and project management company, has promoted **Bertrand Clesca** to a partner. Clesca, who is based in France, was previously director of client solutions and a senior consultant.

Echandia, a developer of advanced battery and fuel cell systems for maritime and industrial applications, has appointed long-time maritime executive and business developer **Göran Fransson** as chief commercial officer. Echandia has entered new segments, e.g., naval applications, and is seeing renewed interest from the offshore wind vessel market.

Joonatan Haukilehto has joined Foreship as lead consultant for newbuilds and decarbonization, and **Pekka Pohjanen** has been appointed senior technology specialist for sustainability. Haukilehto came from the Finnish Environment Institute, where he was senior specialist in ship technology. Pohjanen came to Foreship from Yara Marine Technologies conducting project management and specializing in decarbonization tech. **ST**

Deep-Sea Mining Needs a New Approach for Plume Monitoring—Dr. Carlos Muñoz-Royo

Dr. Carlos Muñoz-Royo is an MIT ocean engineer, co-founder of at-depth LLC and co-author of many papers on the physics of sediment plumes published in top-tier, peer-reviewed journals. He was the project manager for two recent, large-scale deep-sea mining plume studies. With the atdepth team, he is turning state-of-the-art scientific knowledge and tools into actionable solutions for ocean-based industries.



Deep-sea mining is a nascent industry that proposes to obtain valuable minerals from vast deposits lying on the abyssal seabed. It is coming under great scrutiny, however, because of its potential environmental impact. A key facet of the impact question is the scale and fate of the sediment plumes that would be created by the activity and transported away from the mining area by ocean currents.

Critical questions that need to be answered to develop robust environmental impact statements that will be subject to scrutiny include: How far will sediment plumes travel, at what concentrations, and where will they deposit? Traditional approaches to answering such questions that come from other offshore industries, such as dredging or oil and gas, face fundamental challenges that make them ill-suited to deep-sea mining. A custom, new approach built on fundamental science, advanced modeling of fluid and transport dynamics, and novel monitoring methods is needed.

The evolution of sediment plumes, from the immediate vicinity of the mining activity to potentially far away, is made complex by a sequence of distinct dynamic plume phases governed by very different physical processes, including advection by ocean currents, buoyancy-driven flows, sedimentation, flocculation and turbulent

mixing. As a result, the form of the plumes varies greatly in both space and time. This evolution of plumes occurs over a wide range of spatial and temporal scales, making both modeling and monitoring very challenging, with some key processes happening on a scale of meters and seconds and others on a scale of tens of kilometers and weeks.

In the face of such complexity, traditional approaches to monitoring sediment plumes have major challenges. Shortly after the plume is created, suspended sediment concentrations vary by orders of magnitude over a few meters going upward from the seabed. A standard approach of using Niskin bottles to take water samples of the plume cannot accurately pinpoint the vertical position of where a sample is taken, nor ensure that the platform on which the Niskin bottles are mounted has not substantially disrupted the plume conditions.

Another standard approach that is challenged is the use of ADCP acoustic backscatter intensity to determine suspended sediment concentration. This method might work in homogeneous marine environments, but the high heterogeneity of deep-sea mining sediment plumes over short distances makes reliable calibration practically impossible. One would need to have a calibrated optical sensor or obtain an in-situ sample at the point an ADCP acoustic beam is measuring, which itself would corrupt the acoustic backscatter signal. Novel technologies are emerging, such as the LISST-RTSSV sensor co-developed by MIT, Scripps Institution of Oceanography and Sequoia Scientific, which measures suspended sediment concentration, size, shape properties and settling velocity directly within a plume, which are critical data to plume modeling. Innovative solutions for measuring very low turbulence levels in the deep ocean, again of critical im-

portance to the modeling of plumes and not accessible to traditional technologies such as ADCPs, are also being developed.

The physics of deep-sea mining sediment plumes should not only drive the technology to monitor them but also the deployment strategy. Consider a test nodule mining operation during which ocean currents are predominantly to the west. A conventional approach that is agnostic to the physics of a deep-sea mining plume would likely deploy most of the sensors and monitoring platforms a few hundreds of meters to the west of the mining site. Now, add a gentle bathymetric slope of a few degrees to the north, and the plume will initially spread downslope because of gravity, forming an underwater avalanche called “turbidity current.” The monitoring array is now out of the path of the plume, missing the bulk of the sediment budget and the physics creating it.

Going forward, a key consideration is that monitoring of deep-sea mining sediment plumes needs to be much more than just a collection of instruments deployed around a mining area. It must provide a clear, nonambiguous and generalizable picture of all that took place. This is achieved through physics-informed planning, using the right analytical and modeling tools to select the appropriate instrumentation and place it in the right locations.

Rather than applying approaches that were conceived for established industries such as dredging and offshore oil and gas, new approaches are needed to deal with challenges specific to deep-sea mining. This is the only way to obtain data to properly evaluate the dynamics and extent of deep-sea mining sediment plumes and to validate the models at the core of the heavily scrutinized environmental impact statements required to ultimately obtain approval for a mining operation. **ST**

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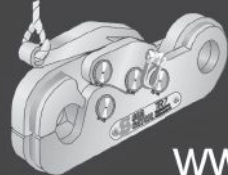
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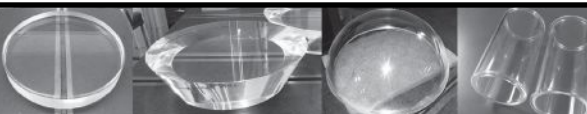
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