MARINE TECHNOLOGY REPORTER

September/October 2023
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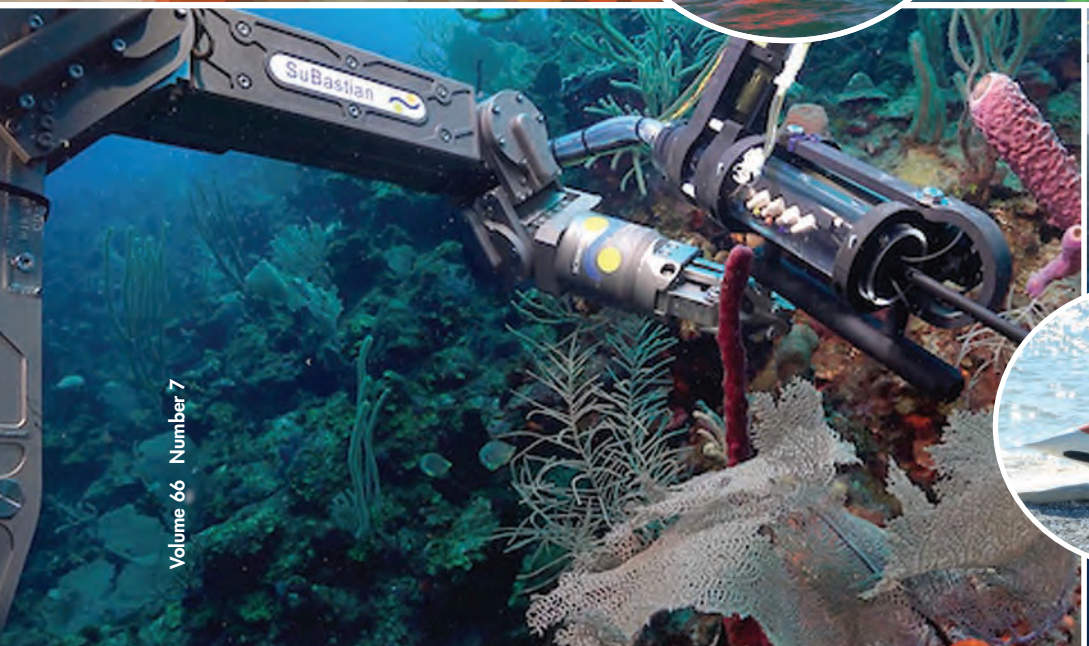
The 18th Annual MTR100



Volume 66 Number 7

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MTR 100
September/October 2023
Volume 66 • Number 7

THE MTR100 2023

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Editorial

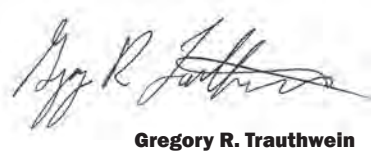
The 18th Annual **MTR100** is brought to you again with the requisite amount of work that never seems to lighten in the least, keeping on top of the people, companies and technologies that serve a fuel for this industry's future.

In fact "fuel" is the perfect bridge to this edition, as in "future" or "alternate" fuels, as the energy transition and all that it entails – from hydrogen-powered UUVs to the fast-growing offshore renewable energy markets and the opportunities it is opening for companies in this sector – appears to be the driver for the coming generation.

Via this edition we welcome contributing editor **Wendy Laursen** to our pages. Based in Australia, Laursen is a long-tenured technical writer in the maritime, offshore and subsea space, and she is an active contributor in sister-publications *Maritime Reporter & Engineering News* and *Offshore Engineer*. This month she takes an inside out look at a tech sector near and dear to nearly everyone reading these pages: battery technology, starting on page 40. The past few years have seen leaps and bounds in battery technology, a boon for all who design, build, own and operate vehicles on and under the oceans.

Overall, this is truly a transcendent time in the maritime and subsea sectors, with a convergence of technical trends, from the energy transition, to automation and true autonomy, to digitalization and the ability to collect, disseminate and create actionable intelligence efficiently, effectively the cornerstone foundation of nearly every tech development and project in the space.

The ensuing 80 pages highlight some of the amazing work that has been accomplished in the past 12 months, with a glimpse of what's to come in the next 12.



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MARINE TECHNOLOGY REPORTER
www.marinetechnologynews.com
Vol. 66 *No. 7*
ISSN 1553-276
118 East 25th Street,
New York, NY 10010
tel: (212) 477-6700
fax: (212) 254-6271

Marine Technology Reporter (ISSN 1559-7415) is published monthly except for February, August, and December by New Wave Media, 118 E. 25th St., New York, NY 10010-1062. Periodicals Postage Paid at New York, NY and additional mailing offices.

POSTMASTER: Send all UAA to CFS. NON-POSTAL AND MILITARY FACILITIES send address corrections to Marine Technology Reporter, 850 Montauk Hwy., #867, Bayport, NY 11705.


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MARINE TECHNOLOGY REPORTER

2024 Editorial Calendar

January/Februay 2024

Ad close Jan.31

Underwater Vehicle Annual

- Offshore Wind: A Floating Future
- Subsea Defense
- Manipulator Arms & Tools
- Autonomous Navigation
- Battery Technology

Event Distribution:

Oceanology International,
London, UK
Subsea Expo
Aberdeen, UK
Floating Wind Solutions
Houston, TX, USA
Europe Offshore Wind
Bilbao, Spain

February 2024

Ad close Feb. 4

Digital Edition

MTR E-Magazine Edition:

Oceanographic

March/April 2024

Ad close March 21

Offshore Energy

- Oceanographic Instrumentation & Sensors
- Subsea Defense: The Hunt for UXO
- Inspection, Repair & Maintenance
- Underwater Communications
- Cables & Connectors

Event Distribution:

Offshore Technology Conference (OTC),
Houston, TX, USA
UDT
London, UK
IPF Wind Conference
New Orleans, LA, USA
AUVSI Xponential
San Diego, CA, USA

May/June 2024

Ad close May 21

Dredging Technology

- Hydrographic Survey
- Scientific Deck Machinery
- Workclass ROVs
- Seismic & Geotechnical Surveys
- Sonar, Telemetry & Data Processing Software

Event Distribution:

WEDA Dredging Summit & Expo
Las Vega, NV ,USA

July/August 2024

Ad close July 21

Autonomous Vehicle Operations

- Underwater Tools & Manipulators
- GPS, Gyro Compasses & MEMS Motion Tracking
- Subsea Defense
- Deck Machinery & Cranes
- Battery Technology

Event Distribution:

Oceans 2024, Halifax
Halifax, NS, Canada

August 2024

Ad close Aug. 4

Digital Edition

MTR E-Magazine Edition:

Hydrographic

September/October 2024

Ad close Sept. 21

MTR100

Focus on 100 Leading Companies, People and Innovations in the Subsea Space

November/December 2024

Ad close Nov. 21

Ocean Observation: Gliders, Buoys & Sub-Surface Networks

- Instrumentation: Profilers, Samplers & Sediment Corer
- ADCPs & DVLs
- Subsea Defense: The U.S. Navy
- Subsea: Electrification
- Underwater Imaging: Lights, Cameras & Multibeam Sonar

December 2024

Ad close Dec. 4

Digital Edition

MTR E-Magazine Edition:

Subsea Vehicles

MTR Editorial Advisors

Gallaudet

The Honorable Tim Gallaudet, PhD, Rear Admiral, U.S. Navy (ret) is the CEO of Ocean STL Consulting and host of The American Blue Economy Podcast. He serves on several boards, is a fellow at The Explorer's Club, and is a strategic advisor for a few dozen startups, research institutions, and nonprofits in the ocean, weather, climate, and space sectors. Gallaudet is a former acting Undersecretary and Assistant Secretary of Commerce, acting and Deputy Administrator of the National Oceanic and Atmospheric Administration (NOAA), and Oceanographer of the Navy. He has a bachelor's degree from the U.S. Naval Academy, and master and doctoral degrees from Scripps Institution of Oceanography.

Hardy

Kevin Hardy is President of Global Ocean Design, creating components and subsystems for unmanned vehicles, following a career at Scripps Institution of Oceanography/UCSD. He holds important patents in the field of ocean landers. He is on the academic advisory board of Instituto Milenio de Oceanografía at the Universidad de Concepción, Chile. Hardy received an honorary Doctor of Science degree from Shanghai Ocean University in 2018. He proposed making thick wall glass spheres to Nautilus Marine Service/Vitrovex (Germany) that opened the hadal depths to routine exploration. Hardy was the Lander Team Leader for James Cameron's DEEPSEA CHALLENGE Expedition. He writes for the Journal of Diving History and the Marine Technology Reporter.


Hydrus Exploring Ningaloo Reef.

Advanced Navigation

Advanced Navigation

President/CEO: Xavier Orr, Chris Shaw
www.advancednavigation.com

Advanced Navigation develops AI navigation systems and robotic technologies for air, land, sea and space applications, leveraging capabilities in AI neural networks and deep learning algorithms. Made possible with extensive research, testing and automated manufacturing, the company develops transformative technologies from inertial and sonar navigation to photonic and quantum sensing. Advanced Navigation's mission is to be the catalyst of the autonomy revolution.

Over the last 12 months, Advanced Navigation has consistently increased customer stickiness and delivered breakthroughs. **In late 2022, Advanced Navigation completed an £55 million Series B funding round.** The funding is being used to expand global sales and marketing, and accelerate R&D programs focused on transformative robotic, navigation, photonic and quantum sensing solutions. Leveraging the raise, Advanced Navigation also opened Australia's largest subsea robotics facility in 2023 to accelerate production of its underwater technologies. This includes its fully autonomous submersible robot, Hydrus.

Advanced Navigation will be among one of the first Australian companies to reach the Moon through the development of space-qualified autonomous navigation systems. The systems will support NASA's endeavor to explore the Moon and beyond to Mars by enabling safe and reliable autonomous landing and navigation on the lunar surface. Most recently, Advanced Navigation was awarded a £2.6 million grant by the Australian Space Agency to expedite the production of these systems, cementing its position as a catalyst for autonomous space exploration and transportation.

There are needs to reduce the cost, risks and complexity associated with subsea exploration. Advanced Navigation was instrumental in providing solutions that enabled the drone revolution to come to fruition. Coupled with 10 years of R&D in sonar technology, we saw the parallels between the underwater robotics market and where the aerial drone market was 15 years ago. The company applied this knowledge to sonar positioning and navigation to develop an underwater robot that miniaturized multiple technologies to enable a

drone-like experience for users, underwater. The result was Hydrus, a fully autonomous submersible vehicle transforming undersea research, inspection, detection and classification by making data capture simple and accessible. The design of Hydrus synthesizes numerous leading edge navigational and data capture technologies with highly developed and sophisticated artificial neural network intelligence. This makes the overall package efficient, portable, fully autonomous, and enables Hydrus to move like no other underwater vehicle, alleviating the need for expensive remote operated vehicles (ROVs), survey vessels, watercraft, highly trained operators and divers. To augment Hydrus's capabilities and unlock its full potential, in May 2023, Advanced Navigation demonstrated its underwater docking capability. This accomplishment transformed Hydrus into a resident autonomous underwater vehicle (AUV), creating a permanent underwater home for it to collect and monitor data with efficiency. Once a mission is completed, Hydrus will return to its resident home to wirelessly recharge. Users can also program the vehicle to complete ad hoc missions from any facility in the world, without having to mobilize boats or personnel. Hydrus will offload data wirelessly to the station, allowing for data to be retrieved in real time, as the station is wired to a communication modem. Researchers will have the ability to conduct cost-effective long-term environmental monitoring with an underwater research lab. When set up in resident mode, Hydrus can perform repetitive surveys on coral species by providing researchers with regular growth rates. The information can then be cross referenced with oceanographic data such as temperature and PH to determine what coral species will perform best in a bleaching event. Hydrus can perform regular inspections of mooring lines, anchor points and tearing of fish pens to guarantee structural integrity, with no risk of contamination to the environment. Hydrus can also monitor fish health by counting marine life, spotting for signs of disease or looking for sea lice. Hydrus' onboard capability to provide AI image processing allows it to capture the best quality images in the most challenging conditions. This can be used to automate tasks such as wind farm inspection by generating consistently high quality, geo-referenced imagery every time. With a persistent presence underwater, Hydrus can monitor critical infrastructure and assets, such as power lines and data cables around harbors.

Spotting Whales – Real Time – with the Alseamar SeaExplorer

PIAQUO Project aims to reduce the acoustic impact of maritime traffic and adapting it in real time to the ecosystems. A main technology partner is the Alseamar SeaExplorer glider, as ***Laurent Beguery****, Alseamar, explains.*

Based in Rousset, France, Alseamar is made of five business units, three of them dedicated to product (buoyancy modules, radio communication antennas and gliders); two dedicated to service and support (life extension services and the SeaExplorer glider 'mission as a service'.) But perhaps it is the SeaExplorer glider for which Alseamar is best known, and to date Alseamar has produced more than 100 gliders, most of which are still in operation, said Beguery.

"SeaExplorer is a glider that can run for months and dive to 1,000 meters, but what's really interesting is the glider's ease of use," said Beguery. While the hardware is well-proven in the field, Beguery said the real value proposition to SeaExplorer is to view it holistically as a system, which includes the physical glider plus the piloting interface called GLIMPSE. "This really helps you to prepare your mission," said Beguery, highlighting an existing mission where there has been a single glider on station for more than two years to monitor a subsea volcano. "Each mission is only two weeks long, because the glider has to stay in the layer of water between 900 meter and 1,000 meters," said Beguery. This operational envelope burns a lot of energy, particularly with a complete sensor suite that includes a CH4 sensor, a CO2 sensor, an ADCP, an oxygen sensor and a CTD. "Every other week we recover the glider, get the data and send it back to sea. It's as easy as that. In fact, the main characteristic of the SeaExplorer glider is that we want to make it easy to use."

The ease-of-use starts with the glider configuration itself, as Alseamar works closely with the end user to deliver a vehicle configured precise for the mission at hand. "Some customers have very specific sensors they want to use, so we do a lot of glider design for those customers," said Beguery. "The fact that we are a company doing product and services make us unique: the data matters to us. What I sell as a service company is analysis of the data. So when we put a sensor on top

of the glider, we try to get the best of the data out of it."

The PIAQUO Project

When talk turns to 'emissions' in the maritime space, first thoughts flock to the air and greenhouse gas emissions. But there is increasing focus on noise pollutions – from ships, from industrial construction activity, from defense – and its impact on the subsea environment. The PIAQUO Project aims at reducing the acoustic impact of maritime traffic and adapting it in real time to the ecosystems.

Of particular interest is the ability to prevent whale collisions, and Alseamar SeaExplorer gliders are proven to be able to detect and localize sperm whales and fin whales in the Pelagos sanctuary in (almost) real time using network of four gliders.

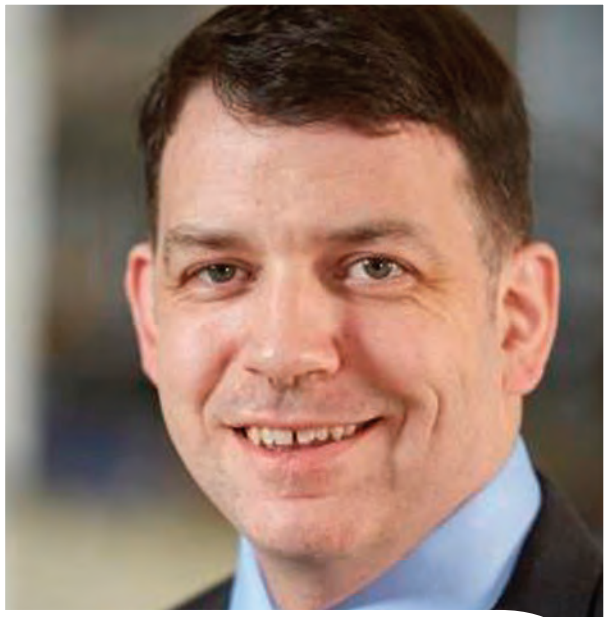
"This project is very important for us, because first of all, it's a Practical Implementation of a project called AQUO, which aims at reducing noise and risk of ship collision," said Beguery. He breaks down the five goals of the project:

1. Reduce propellor noise.
2. Give information to the captain about how much noise the ship is creating, which is variable based on load, speed, sea state, etc.
3. Install a buoy to record noise of ships entering harbor.
4. Measure the impact of noise on ecosystem, both the coastal with leisure boats, as well as offshore in the Pelagos environment for marine mammals.
5. Creating eco-sensitivity maps, crossing the presence of species and expected noise to help inspire action.

Alseamar's role lies mainly in 'number 4' – marine mammal assessment – and includes deployment of four SeaExplorer gliders along ship lanes, creating a network which aims to inform ships of the presence (or absence) of whales, and actually sending them the whale locations.

"We have completed many missions where we automatically detect and position sperm whales and fin whales," said Beguery.

"But the real trick is to give the position of the whales; that's very important for us. It's done through the GLIMPSE software, so on our piloting map interface, we can see now dots when we know there is a whale present. There is a little dot that say, "It's there."



Coveyla Group

Yateley, Hampshire, UK
President/CEO: Stephen Fasham
# of employees: 560
https://covelya.com/

Covelya Group brings together several businesses within the maritime, energy, science, defense and energy markets, all of which have unique technology offerings that are at the forefront of their areas of expertise. As a combination, Covelya Group can deliver a wide range of services and products to its customers and is one of the leading technology developers in its arena. It develops, manufactures, sells and supports instruments, systems and solutions worldwide. Covelya Group's companies have differing origins but complement one another in their technologies and operating arenas. Covelya Group's companies include:

• **Sonardyne** is a family-owned global marine technology business, founded in 1971, that engineers, manufactures, services and supports solutions that transform what is possible in offshore energy, maritime defense, and ocean science. Sonardyne's heritage is underwater acoustics with the addition of inertial navigation and optical technologies in recent years, underpinned by ongoing investment in developing technologies and capabilities to support both existing markets and the exploration of new ones in the wider Blue Economy.

• **Chelsea Technologies**, formed in 1967, provides sensors and systems that deliver sensitive, accurate and reliable solutions for customers across shipping, marine science, water quality and defense sectors. Through the development of Single Turnover Active Fluorescence (STAF) instruments, Chelsea is now at the forefront of practical measurements of phytoplankton photosynthesis, helping scientists understand the part that the oceans play in climate change as we look to achieve Net Zero.

• Formed in 1978, **EIVA** provides software, equipment and integrated system solutions to maritime customers across the world. EIVA's tools support everything from underwater exploration, oceanography and hydrographic surveying to offshore construction, cable laying, dredging and rig operations. With an increase in maritime operations around the world EIVA continues to invest in cutting-edge applied science, including machine learning and AI for practical applications, pushing the boundaries of technology for groups specializing in the opportunities offered by our oceans.

• **Voyis**, founded in 2007, provides underwater optical sensors that expand customers' underwater capability, enabling them to see the depths like we see the surface.

• Founded in 2022, **Forcys** is driving a sea change in naval underwater technology. Forcys is a global maritime defense company backed by 50 years of expertise in the domain and an in-house developed technology portfolio through its technology partners in the Covelya Group.

Coveyla Group has multiple new technologies, developed and introduced to market in the past 12 months, with two featured here.

• **The Origin Acoustic Doppler Current Profiler (ADCP)** launched in April 2023 by Covelya company Sonardyne represents the future of intelligent ADCP. Simple to operate with class-leading data, integrated communications and positioning, they are perfect for almost all marine operations. It is the first ADCP to feature an integrated acoustic modem and advanced onboard edge processing, giving remote access to all core features and providing high-quality data in near real-time. Origin's ability to link to other external sensors and combine them with its own high-fidelity data formats allows the customer to get the most out of a single deployment and the data generated. With a 50m current profiling range, on-board edge data processing and an integrated acoustic modem, Origin 600 provides in-situ, high-res measurements with on-demand data retrieval, reducing survey costs, risk and time. Origin 600 has a 5-beam configuration, with a central vertical beam. This geometry, paired with a maximum sampling frequency of 4Hz on all beams, is suitable for waves and turbulence applications, as well as mean currents. All beams also act as echo sounders, providing high-res backscatter intensity measurements. Origin 600 possesses power-efficient electronics that, combined with its 55Ah internal rechargeable battery, allow for deployments of three months or more, depending on measurement schedule. A dual battery option allows for even longer or energy-demanding deployments. This long battery life reduces the need for risky & costly device retrieval. External power can be supplied by power over ethernet. Origin 600 delivers conventional data as standard, while optionally logging proprietary formats with up to 10 times greater spatial resolution.

These allow users to probe structure in the velocity and backscatter intensity data in finer detail than previously possible. Data is logged to the onboard storage unit with 1TB capacity as standard. A suite of intuitive software tools is available for Origin 600. Schedules can be configured using the Origin Scheduler PC application, enabling operations to be de-risked prior to deployment.

The Origin Portal Web User Interface facilitates device configuration in operational conditions, including modification of the sampling schedule. Two schedules can be run together, allowing dual monitoring tasks to be performed with a single device. File data can be inspected using the Origin Viewer software package. An MF acoustic modem is integrated as standard and facilitates remote actions using a topside modem and the Origin Topside PC software.

This enables data inspection and quick charge battery and storage checks, schedule reconfiguration, and data offload; all core features of the ADCP can be accessed acoustically once deployed. Origin 600 is compatible with the Sonardyne edge computing environment.

- **The Discovery Cameras, by Voyis,** with tightly integrated Nova Mini Lights, capture low latency 4K video for vehicle piloting while simultaneously recording crisp, high-res still images & and Inertial Measurement Unit (IMU) data that can be processed with edge computing into 3D models. The Discovery Stereo camera can be used for smart Remotely Operated Vehicle (ROV) piloting and general inspection apps. The Discovery Stereo with integrated Nova Mini Lights provides a powerful platform for all a vehicle's vision needs, delivering stills images, video, IMU data and 3D data with a data-centric Data Distribution Service architecture. The camera provides a complete solution for accurate 3D modeling & real-time point clouds for general inspection and vehicle autonomy. The system captures both high-dynamic range stills data for 3D modeling while also streaming 4K video for vehicle piloting & quality control. The powerful onboard computer executes image enhancement, 3D point clouds, and video encoding in real-time with low latency and the real-time image enhancement algorithm delivers images ready for 3D modeling. The camera unit incorporates software, developed jointly with EIVA, that delivers Visual Simultaneous Localization and Mapping (VSLAM) capability enabling it to be used as a mapping tool rather than simply a camera; mapping where it has been & creating a local area map.

All American Marine

All American Marine

www.allamericanmarine.com

All American Marine (AAM) remains one of the most prolific builders of research vessels for the subsea exploration and tourism communities. Earlier this year, AAM delivered a new research and hydrographic survey vessel for NV5-Geodynamics, built to service the growing offshore wind market as well as accomplish many other scientific survey missions. Dubbed Shackleford, it is a 73- by 26.7-ft. semi-displacement aluminum catamaran developed by Nic de Waal of Teknicraft Design in Auckland, New Zealand. The newbuild leverages fundamental design elements of the Duke University Marine Lab's Shearwater and Blue Tide Puerto Rico's Blue Manta, both built by AAM. Named after Shackleford Banks, the southernmost barrier island in the Cape Lookout National Seashore chain and a nod to the region's rich maritime history, Shackleford was constructed to USCG Subchapter T standards. The vessel will serve an integral role in NV5-Geodynamics' mission of providing turnkey/"single pass" offshore surveys and has been specifically customized to serve the burgeoning offshore wind sector on the U.S. Eastern Seaboard. To reduce survey mobilization costs, Shackleford is outfitted with fully dedicated and redundant survey systems, including the Kongsberg EM 2040 MKII Multibeam Echosounder that is deployed through the vessel's moonpool via retractable strut. Dimensional Control (DimCon) surveys utilizing applied metrology techniques orient the Shackleford's primary IMU/multibeam reference systems, and a network of discrete benchmarks set within the vessel's reference frame allowing accurate and repeatable lever arm calculations to all survey sensors. Coordinate Uncertainty Analysis of the final DimCon survey establishes an overall RMS of 0.0001 meters between all established points within the network. **Pictured above is the AAM-built, recently delivered research vessel IMUA for the University of Hawai'i at Manoa.**

BIRNS

https://birns.com/

BIRNS, Inc. has been helping shape technology in the subsea industry since the 1960s, when it began developing advanced lighting systems and other unique marine solutions for the U.S. Navy. In the years to follow, BIRNS' lighting and connector systems provided support to a wide range of advanced subsea and defense application projects worldwide. Today, BIRNS designs, develops and tests subsea connectors, penetrators and cable assemblies, with special expertise in high-speed data transfer. The company recently developed a low temperature/high pressure testing capability for deep submergence connectors and cable assemblies, allowing continuous testing to 6000msw in a controlled 2°C (±1°C) environment. BIRNS also received its first SUBSAFE/CSI order this year for custom electro-optical hull penetrators (EHP) for military submarines.

To meet the need for extreme high speed data transfer requirements in extreme depths and conditions, BIRNS has introduced breakthrough connectivity capabilities in several areas: electrical, RF, optical and hybrid. Gigabit Speed **Data Transfer Capabilities:** BIRNS developed exclusive deep submergence cable stock constructed for Cat 8.2 use, and produces 6km-rated cable assemblies with 9.4+/- 0.1 Gb/s data transfer rate. Performance testing shows this data transfer rate is consistent from 0 to 8700 PSI/600 bar. **RF Capabilities:** BIRNS Millennium RF connectors have proprietary coax technology providing low insertion loss, high frequency capability, open face pressure resistance, and 50Ω and 75Ω configurations. BIRNS 1C connectors provide ≤0.7 dB UHF insertion loss and ≤1.7:1 VSWR at 3GHz and withstand open face pressure to 1450msw. BIRNS 1V connectors feature a 75Ω RF contact in a 50Ω footprint for HD/SD video, shortwave antennas, or low-power RF needing minimal signal attenuation. BIRNS 1B ultra-low-loss RF pressure-rated connectors were developed for USN for use to SHF band Ku and have been cold-water and hot-water qualified for NSWCPCD. **Optical Capabilities:** BIRNS Millennium optical connectors and cable assemblies deliver the ultimate in high-performance data transmission, with 0.1dB insertion loss qualified in 48 hours' continuous testing at 600 bar/6000msw in 1°C saltwater.

MIT, General Dynamics

General Dynamics Mission Systems Bluefin Robotics

https://gdmissionsystems.com/underwater-vehicles/bluefin-robotics

It's been 25 years since MIT engineers Dr. James Bellingham and Frank van Mierlo started their entrepreneurial underwater robotics company in a former auto-parts warehouse a few blocks from MIT. Eventually the company moved into a large waterfront facility in Quincy, Massachusetts. Today, Bluefin Robotics, a business segment within General Dynamics Mission Systems, is building upon its legacy of autonomous unmanned underwater vehicles (UUVs) with integrated sensors and processing.

Since the company's beginnings, its vehicles have featured a free-flooded design with open architecture that permits integration with a variety of sensors and payloads to be adapted to any mission. The open architecture allows for data collection devices and batteries, such as the company's Removable Data Storage Module (RDSM) and removable 1.9 kWh Li-ion battery, to be readily swapped out for long missions and short turn-arounds. This modularity also permits the vehicles to be disassembled for rapid shipment around the world. The team also publishes its interface specifications, making it easier for partners to ensure their sensors and systems can work with the Bluefin architecture. While the company has recently introduced updated 12-inch and 9-inch vehicles, the Bluefin-21 has been the flagship system for over two decades, and is the basis for a number of unique vehicles, as well as programs of record, such as the Knifefish surface mine countermeasure (SMCM) UUV.

As Knifefish production ramps up, the company has moved the assembly line from Quincy to its new UUV center of excellence at Taunton, Massachusetts.

Argeo, formed in 2017, and its CEO Trond Crantz are on a mission to transform the ocean surveying and inspection industry via autonomous surface and underwater robotics solutions. The company has created a succession of innovations in the surface and underwater vessel sector, plus its digital platforms and patented electromagnetic sensor systems.

Powered by 50+ employees and four AUVs (a pair of Teledyne SeaRaptor 6000s and a Kongsberg Hugin 6000), Argeo also commercialized its first USV too, to cover the near shore shallow water, typical offshore wind market.

While its management team spent most of its career in the oil and gas business – and today the majority of Argeo's business is found in the traditional energy sector – Crantz said the tide is changing. "We are seeing a significant uptick in offshore wind business as well, especially in Europe, but also in the US," said Crantz in an interview earlier this year with MTR. "And then, we are probably one of very few companies who can maybe contribute both on an environmental side, and the geological assessment side in terms of the deepsea mineral market, which is also coming strong and steady."

Central to its present and future is the seamless application of autonomous systems, surface and subsurface, stitched together with Argeo Scope, which allows us to seamlessly project data from the data acquisition platform into a cloud-based system.

Of particular interest is it's decision to utilize differing AUV platforms, the Kongsberg Hugin and the Teledyne Marine Sea Raptor, as Crantz explained.

"The first AUV we bought was a Hugin system, as we have a good relationship with Kongsberg, and they have a lot of experience: the system is proven. But we also wanted a slightly different system [Teledyne SeaRaptor], one which was more of an open-source setup; one where we can choose the systems, and the integrators, and the sensors, one that we foresaw with the product development that we are ourselves doing on geo-robotics. It's a slightly different concept, in terms of how it's put together and how it can be used. Both are capable of diving down to 6,000 meters water depth. So it's trying to be a bit more agnostic than the ordinary company, allowing us to have a bit of play in terms of what we are developing on our own front, connecting that with our digital platform, Argeo Scope."

Innovation lies at the heart of Argeo. "Bringing new sensor

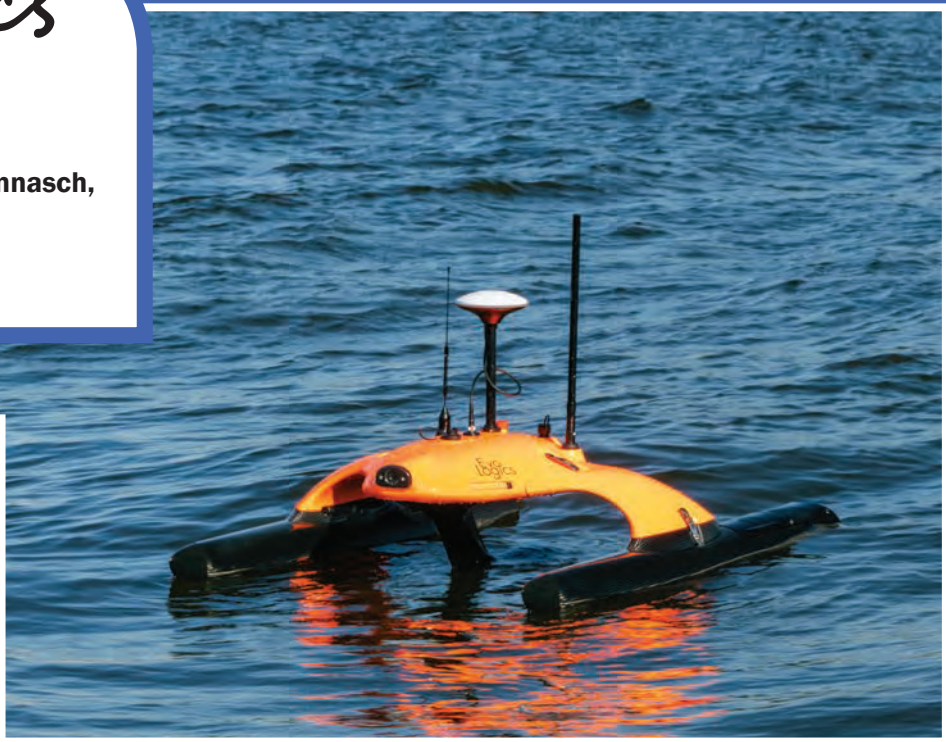
systems to the market is one of our key focal points, and it was part of our uniqueness when we started," said Crantz, who touts his company's "fantastic engineering department developing cutting edge technology on the sensor side. It's a whole family of electromagnetic systems that is being developed, commercialized and patented."

Recent Argeo Highlights Include:

- Argeo entered into a 5-year bareboat contract for the subsea vessel Argeo Searcher. The combination of Searcher, our own AUVs and the possible addition of onboard ROV's makes this a very attractive multi-purpose operational platform for subsea operations.
- Argeo has developed a recently patented portfolio of electromagnetic source and receiver systems for AUVs, Underwater Intervention Drones and ROVs. "Argeo Whisper" is an AUV and ROV system developed for localizing and tracking buried pipelines as well as detecting buried objects in a decommissioning survey. It can also be used for detecting unexploded ordnances. "Argeo Discover" is an application or detecting, delineating, and characterizing deep sea mineral deposits or other conductive objects below the seafloor utilizing an electromagnetic source integrated in an AUV or ROV.
- Argeo SCOPE (previously Digital Ocean Space) software platform reached a milestone when it was released as a commercial product. Argeo SCOPE is a fast and performant 3D visualization of vast amounts of ocean space data in the cloud, supporting a collaborative data sharing and interpretation workflow. The system allows for seamless data fusion from seabed measurements.
- Argeo Robotics AS received a new patent from the Norwegian Industrial Patent office for a subsea electromagnetic remote-sensing system for detecting buried objects below the seafloor. This patent protects Argeo's exclusive services with the "Argeo Whisper" system for detecting metal objects on or buried under the seafloor.
- It was also recently granted a patent from the Norwegian Industrial Patent office for a subsea electromagnetic remote-sensing system for tracking of buried cables and pipelines below the seafloor. This patent protects Argeo's exclusive services with the products "Argeo Whisper" for finding and tracking pipelines and cables below or on the seafloor at depths not possible with conventional technology.

EvoLogics GmbH

Berlin, Germany
President/CEO: Dr. Rudolf Bannasch, Fabian Bannasch
# of employees: 50
https://evologics.de/



EvoLogics is a high-tech enterprise with headquarters in Berlin, Germany, and a US sales office in Yorktown, Virginia. The company launched in 2000 with a group of scientists and R&D experts, aiming to develop innovative technologies for maritime and offshore industries. EvoLogics creates high-end solutions for underwater smart robotics, sensor systems, acoustic communication and positioning networks, combining state-of-the-art engineering with bionic concepts. Research and innovation are the cornerstones of EvoLogics, and the main vector of EvoLogics' development strategy is an underwater "Internet of Things" that enables intelligent cooperation between various vehicles and sensors. Smart underwater networks build on EvoLogics' S2C spread-spectrum communication technology that combines underwater acoustic data networks with integrated real-time positioning. Together with advanced sensor systems, AI-based object recognition and analytics, as well as autonomous underwater and surface vehicles for survey and support operations, they create highly capable underwater solutions for complex mission scenarios.

EvoLogics offers highly reliable, flexible and cost-effective solutions for multiple underwater communication, positioning, navigation and monitoring applications. EvoLogics' developments are based on the patented S2C (Sweep Spread Carrier) technology—reliable acoustic telemetry that provides an independent bidirectional data link along with positioning, broadcasting and networking capabilities. S2C devices can simultaneously facilitate telemetry and navigation of unmanned underwater vehicles. They enable retrieving information from various sensors and allow controlling complex processes by seamlessly combining communication with highly accurate positioning. Moreover, EvoLogics caters to the needs of scientists, developers and commercial customers with a series of underwater acoustic devices and software tools that offer an open development and testing framework, providing endless opportunities for new implementations. S2C systems have been carefully designed for operations in harsh underwater environments and enhanced with special algorithms for signal processing and data management. The company's experience with sensor integration allows it to provide customers with turn-key solutions ranging from initial deployment up to equipment recovery. EvoLogics' core robotic solution is the SONOBOT 5 uncrewed surface vehicle. The USV is a fast, compact and robust platform for planning and executing bathymetric and side-scan sonar surveys that can deliver accurate geo-referenced bathymetry and high-quality imagery with minimum transport, launch and recovery efforts. AI-based object recognition module for the Sonobot enables automatic detection of objects in the side-scan sonar feed live during the mission. In 2023, the company released a new multibeam echosounder option for the Sonobot 5 platform, the EvoLogics Multibeam. The sonar is based on a Norbit OEM solution and is fully embedded in the submersible pod of the vehicle, making it the smallest and easiest-to-handle USV equipped with a professional multibeam sonar. Envisioned as sensor carriers for automated monitoring missions, these include the Quadroin and Poggy robots for various types of surveys performed in self-coordinating swarm formations.

Ben Kinnaman & Greensea IQ

"It's about creating a greater impact."

Ben Kinnaman founded Greensea Systems in 2006, spending more than a decade building the company, its engineering and technical backbone. In 2017 the company kicked into commercialization, mode, and the following five plus years saw significant growth, including the creation of two new companies. Recently, Kinnaman went to his board and laid out a plan that he believes will drive the company for the coming generation, early last month unveiling a new, consolidated company: **Greensea IQ**. When Kinnaman founded Greensea Systems, he did it to "develop an open architecture software environment that would help propel the industry into the coming era of autonomy and perception," as well as intelligence data mining from the ocean using robotics. The result was the ubiquitous OpenSea platform: an open architecture software platform with a modular framework that is designed to enable quick and easy integration of robotic systems, delivering precision and accuracy to ROVs, AUVs and marine robotics. Today, globally, there are thousands of vehicles from 35 manufacturers running on OpenSea, said Kinnaman.

Starting in 2017, the company evolved from its technical innovation period to commercialization, a period which included the launch of Armach Robotics to provide proactive, in-water hull cleaning; and the creation of Bayonet Ocean Vehicles, which uses OpenSea to provide amphibious subsea vehicles for autonomous use in deep sea, surf zone, and land travel. As a result, the company has been "growing consistently over 50% for most of the last five years," said Kinnaman, which made for an interesting conversation with his board when he hatched the plan to essentially scrap the business model and forge ahead as Greensea IQ.

When asked "why" … why merge these separate companies into a single entity Kinnaman said: "The answer is very simple: to create a greater impact. Merging these companies is about focusing these resources to create a greater impact for our employees, our investors, the world."

At the beginning of 2023, Greensea numbered about 60+ employees in three locations, which included the pair of Greensea spin-offs:

- Armach Robotics, which is company using small, autonomous vehicles to proactively clean ships, removing the slime layer of biofouling before macrofouling, a subscription-based product called EverClean for the maritime transportation industry. "We founded Armach in 2021, put it on a two-year build it, prove it growth plan," said Kinnaman.
- Bayonet Ocean Vehicles was launched in early 2022 via acquisition of a product line from a company in the US that had developed a prototype of a sea floor crawling robot. "Bayonet Ocean vehicles commercialized this prototype and the three variants and moved that product line into a defense offering, as well as a robot as a service offering for coastal monitoring and survey."

So with a mature company growing 50% per year by his estimation, a company that was "profitable, in several US government programs of record serving 16 militaries around the world … and two other companies doubling each year, with largely uncontested, patented technology," Kinnaman had a plan as presented to his board: throw that out the window and come out swinging with a new, streamlined corporate entity: Greensea IQ.

In making the change Kinnaman focused less on the successful past and more on what he saw as a boundless future.

"By all measures, as a CEO, I was meeting expectations; I was living and dying by P&L. But I think success, in general and for a company, is a lot more broad than the P&L and the balance sheet," said Kinnaman. "We had amassed an amazing set of resources, some of the world's experts in ocean robotics and ocean data. We have mature technology, we have mature robots. What really struck me was the significant potential."

"This is about opportunity, he said, "it's about creating a higher impact. It's about answering a higher calling. As a CEO, I was meeting my expectations, but I felt as a human I was not because with the resources of Greensea, Armach, and Bayonet my potential was immense. So, merging these companies is about doing just that. Merging these companies is about focusing these resources to create a greater impact for our employees, our investors, the world. And while I still drive a strong P&L, I'll also leave my children and the ocean and world in better shape than what I inherited from my parents. And that is the goal of what we're doing with Greensea IQ."

"Merging these companies is about focusing these resources to create a greater impact for our employees, our investors, the world. While I still drive a strong P&L, I'll also leave my children and the ocean and world in better shape than what I inherited from my parents."

- *Ben Kinnaman on the cover of the March 2017 edition of MTR, about the time his company evolved to its commercialization phase.*

What's in a name?

The world in which we live is increasingly about data, specifically the ability to collect, share, analyze and apply it in meaningful ways more efficiently, effectively.

"IQ represents intelligence, and the rebrand of Greensea to Greensea IQ represents a strategic shift to a higher impact company that's powered by intelligence, particularly data from the ocean analyzed and process to deliver intelligence about how to work in the ocean and interpret what the ocean's given them," said Kinnaman. "For the last 17 years, Greensea has been an industry leader for edge computing software solutions, including technologies for autonomy, perception, data collection, human machine intervention." The shift to Greensea IQ is far more than a name: "As we shift with strategy for higher impact, we're not only focused on collecting that data, but processing the data, analyzing the data, using that

data to inform how we work and understand the ocean," said Kinnaman. "Greensea IQ will use our technology and the intelligence that enables to extend our presence into the ocean, so that our work there can be persistent, safe, efficient, and for the protection of ocean and humankind. So, the tag of IQ behind Greensea represents a higher impact. It represents a company driven and motivated by intelligence, to move not just from edge processing and computing to data collection, but all the way to the human that is making action and making decisions and trying to understand the ocean."

At the time of MTR's interview in August 2023, Greensea IQ had just hired its 90th employee, that's 90 people strong across four strategically located facilities: headquarters remaining in Richmond, Vermont; a facility in San Diego, California; a research facility and the center of our EverClean service in Florida; and a large production and engineering facility in Plymouth, Massachusetts.

"We've invested several million in our Plymouth, Massachusetts facility to build a state-of-the-art production line and production facility for ocean robots," said Kinnaman. This is where our Bayonet product line, its EverClean product line, our product line for inertial navigation systems, and our product line for swimmer and combat swimmer navigation systems will be based, manufactured, tested, delivered and serviced."

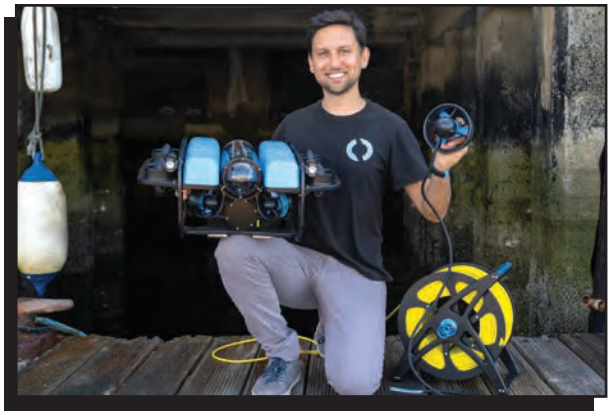
Plymouth will also serve as Greensea IQ's operation center for EverClean. "We have operators in Plymouth that supervise these robots as they clean and maintain ships and collect data and process that data. We'll continue to use our San Diego office to support our US Navy and US Marine Corps defense customers, but San Diego will also be the center of our West Coast expansion for EverClean as we move into ports and harbors on the West Coast. We'll continue to use our Florida facility for research and we'll also expand the Florida facility to service the South Florida Gulf Coast and Texas markets for cruise ships."

In evaluating the physical manifestations of Greensea IQ, the product line, Kinnaman said: "From a product and technology line perspective, we will move into a strategy that is focused on higher impact endeavors. We will be focused on using data and intelligence software, autonomous robotics to make big change in the world. It's difficult to be a high impact organization and continue low impact business sales. So, there are some business segments we will begin divesting. [To be clear] we'll continue all of our products, we are not divesting any products. We continue to invest in our Bayonet Ocean Vehicle product line, as well as our EverClean service and our EverClean robots for maintaining ships."

Even as the company re-tools, Kinnaman project the growth path that he has driven will continue, forecasting a 35% growth for the combined entity this year with a 50% growth beginning again in 2024.

Blue Robotics

https://bluerobotics.com/



Blue Robotics designs, manufactures, and sells components for marine robotics. It started in 2014 with the release of our T100 and T200 Thrusters and have since grown a product line of over 350 products ranging from watertight enclosures to cable penetrators to control electronics to batteries. Our products range from propulsion to vehicles to sonar, and we are official sponsors of the MATE ROV Competition, the RoboNation RoboSub/RoboBoat/RobotX competitions, the Singapore AUV Challenge, to name a few. Our 25,000 sqft manufacturing facility has state of the art tools, a high degree of quality control, and a manufacturing team with constant attention on improvement.

Blue Robotics has a broad product line now with many different types of technology, the newest being the BlueBoat USV and the recent release of our BlueOS software.

The BlueBoat is a 1.2 meter long surface vessel with a unique weedless design and a favorable price point. Like our BlueROV2, the BlueBoat is fully capable and useful on its own, but is designed for users to make their own modifications and additions. It has open-source electronics and software and a hull that has many mounting points for user-added sensors and hardware.

The second key development this year is BlueOS 1.1.0, the most recent release of our operating system software for the BlueROV2, BlueBoat, and other marine vehicles. BlueOS is built on top of Linux and, like other operating systems, it manages hardware connections, processes, networking, software updates, and the user interface for a subsea vehicle. BlueOS is open source and freely available for use on any vehicle. This new release of BlueOS has tens of new features and tools, including the official release of BlueOS Extensions. BlueOS Extensions are available through an "app store" section of BlueOS and allow users to add new functionality quickly.

Del Mar Oceanographic

www.delmarocean.com

Del Mar Oceanographic (DMO) was established in 2015, but its roots are deeper with the initial development of the Wirewalker, a wave-powered vertical profiling system developed by the Ocean Physics Group at Scripps Institution of Oceanography. Today Wirewalker is now produced commercially by DMO under exclusive license from the University of California. Systems are in the field globally, supporting coastal pollution monitoring, aquaculture, coastal ecology, basic science and climate research.

In 2022, DMO secured funding from NASA's Jet Propulsion Laboratory (JPL) to provide Wirewalker profilers to ground truth a new Surface Water and Ocean Topography (SWOT) satellite. Wirewalkers were installed on four deep-ocean moorings off the coast of California for the calibration and validation (Cal/Val) of the new satellite. Onboard the satellite, a next-generation altimeter using a wide-swath Ka-band interferometer (KaRIn) will collect detailed global measurements of Earth's surface water and sea surface height. The satellite launch was planned for November 2022 and moorings have been in the water since March 2023. Calibration and validation are critical to any satellite mission. For the SWOT, a portion of the Cal/Val activities include the assessment of the satellite estimates of sea surface topography relative to direct ocean measurements. In the open ocean, sea surface height (SSH) is connected to the distribution of temperature, salinity, and density, as well as ocean currents. These properties must be measured with high vertical and temporal resolution to provide a ground truth for the satellite. The four Wirewalker moorings are part of an overall 11 mooring array, situated directly under the satellite flight path to gather snapshots of steric height for comparison with the measurements gathered from space. The Cal/Val moorings are designed to withstand all weather and provide high data density in the upper part of the ocean, where the density field changes rapidly. Per experiment requirements, the Wirewalkers will profile the upper 500 m of each mooring, using single CTDs to provide the data that would otherwise be required from numerous instruments closely spaced in depth. A key innovation for Ca/Val is the development of a robust mooring that enables real time communications from both the Wirewalker and from numerous fixed sensors. The design combines a conventional taut mooring from the sea floor to a subsurface float at 600 m depth. The Wirewalker is operational in the top 500m, producing vertical profiles of density roughly every hour. Using inductive technology, sensor data from throughout the entire water column are transmitted in real-time. For Ca/Val, the Wirewalkers will be equipped with CTDs. An initial test of the Cal/Val mooring concept was conducted during winter 2019-2020. This site was 300 km west of Monterey, California, in the heart of the North Pacific storm track, and at a water depth of approximately 5 km. During this pre-launch field campaign phase, the Wirewalker yielded about 3500 roundtrip profiles to 500m (~3500 km traveled), during its 86 days of deployment. The mooring allowed a full-ocean depth estimate of SSH with an uncertainty of less than 1 cm, according to results published this year in the *Journal of Atmospheric and Oceanic Research* by a team of institutions led by JPL.

DWTEK

https://www.dwtekmarine.com/

DWTEK was established in 2008 in Taiwan, the first and only Taiwanese subsea technology company.

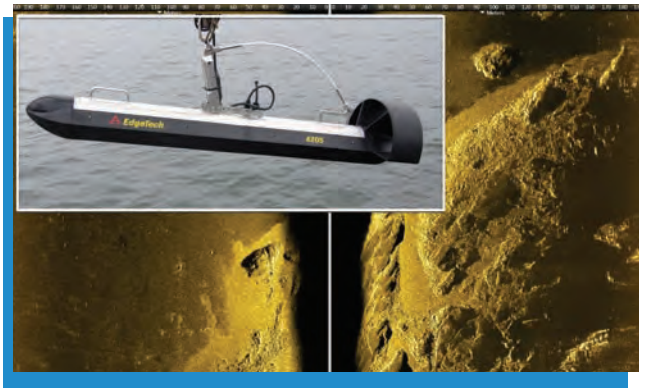
Thanks to a manufacturing center equipped with multimeters, megger, pressure chambers, and high-precision machines DMG MORI CTX beta 800 and 2000 TC, alongside the in-house and global support engineering team, the company can customize and design for underwater technology and equipment. They can also IMR (inspect, maintenance, and repair) to meet every need and achieve every unique goal. The first configurable platform designed ROV Investigator 90 (I90) was born in 2012, and other ROV series, from the working class and observation class to the particular use of ROV, arrived in the following years. Independent research and development ROV components include: HD camera, 150W 6,957 Lumens Sea Bright LED, sensor PCG 1000X, servo, and 550 VDC direct-drive and magnetically coupling thrusters. In 2022, DWTEK, with its affiliated enterprise Sunny Bright Co. Ltd., jointly owned a Taiwan flag ROV offshore service and survey vessel—Sunny Bright. The ship serves offshore farm construction projects in the Taiwan Strait, with the capacity to load customizable DNV, GL-certified control container sizes from 10ft, 16ft to 20ft. With self-developed ROVs and IMCA-certified pilots, the company serves all types of missions such as deep sea cable inspection, buoy deployment, operation and maintenance (O&M), general (GVI), and close (CVI) inspection. In 2023, Sunny Bright acquired the oil loading and bunkering license and became the first and the only Taiwan flag OSV to support the offshore working vessel's bunkering. Within the last two years, DWTEK's progress soon led the company to become the first partner for the Taiwan offshore wind farm developers. The company is now active in oil and gas, offshore energy, defense, and aquatic farming sectors. oceanology, aquaculture and hydrography research and survey, underwater infrastructure projects, dam O&M, wreck and cable inspection, and more.

EdgeTech

www.edgetech.com

EdgeTech is a manufacturer of underwater technology solutions, best known for its products including side scan sonars, sub-bottom profilers, bathymetry systems, deep sea acoustic releases, shallow water and long-life acoustic releases and on demand (ropeless) fishing systems. EdgeTech continues to innovate and advance all aspects of their sonar systems and acoustic release based ropeless fishing systems. The company has seen a strong demand for near shore, shallow water survey systems including the 6205s2 combined bathymetry and side scan sonar system and 3400 sub-bottom profiler. The compact, lightweight systems are a perfect fit for small to medium size boats and unmanned surface vessels (USV). The EdgeTech 6205s2 produces real time, high resolution, 3D maps of the seafloor while providing an enhanced and fully integrated swath bathymetry and dual frequency side scan sonar system with gap-fill.

In the AUV, ROV and ROTV market, EdgeTech offers the 2205 OEM-based solution to provide tightly integrated side scan, sub-bottom, bathymetry and combined systems for manufacturers. EdgeTech's innovative Buried Object Sonar System (eBOSS) is an advanced sub-bottom sonar system capable of penetrating the seabed to accurately detect, locate, classify, and identify buried and partially proud objects. This low-frequency acoustic imaging system can be operated in real-time for general survey purposes such as cable and pipe tracking and route surveys or have the data post processed utilizing synthetic aperture sonar (SAS) processing to render three-dimensional images of buried objects. Advancements also continue in the company's on demand ("ropeless") fishing systems. New features include integrated transducers, available hull mount transducers and an upgraded cloud-based Trap Tracker app that allows operators the ability to command, control, track and categorize the underwater systems.



Exail

www.exail.com

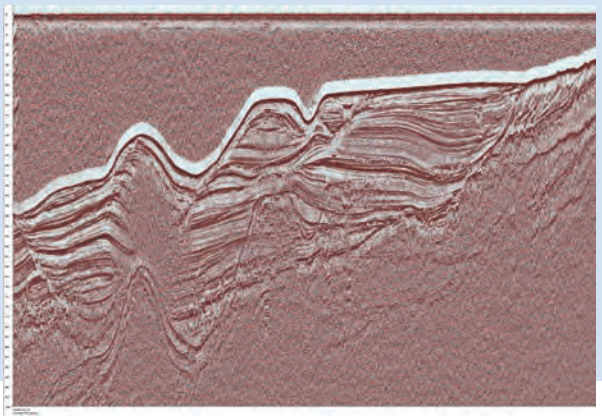
Exail launched Gaps M3, a subsea ultra-short baseline (USBL) acoustic positioning system for permanent vessel installation. Gaps M3 is a USBL positioning system with no embedded Inertial Navigation System (INS), making it a cost- effective choice for operators who can rely on existing onboard navigation systems. Intended for permanent USBL installations, Gaps M3 can indeed be coupled with navigation systems already on board to provide users with continuous access to high-level precision meeting any operational requirement for survey and Dynamic Positioning (DP) operations. Deployments from opportunity vessels are still possible thanks to Gaps M3 integrated MEMS Attitude and Heading Reference System (AHRS). Benefitting from the existing Gaps Series renowned features, the Gaps M3 is equipped with a 3D, 4-hydrophone acoustic antenna which provides maximum 200° aperture, along with new telemetry features, enabling advanced acoustic communication capabilities. It offers true horizontal tracking and communication capabilities in shallow and deep water, especially when multiple vehicles need to be located simultaneously at 360°. The Gaps M3 is available in an export-free version with a 995m maximum operating range and in an extended range version for operations to depths over 4000m. Exail also launched the Rovins 9 DVL, a new all-in-one system for subsea vehicles that combines the best of inertial navigation and Doppler Velocity Log (DVL) technologies in one tightly integrated system. Described as highly compact for easy vehicle integration, the Rovins 9 DVL all-in-one design combines, in a single housing, Exail advanced Fiber-Optic based INS with a Nortek DVL. This tight integration of raw sensor data from both INS and DVL provides operators with highly accurate position, velocity, and attitude information, even in challenging subsea environments, Exail said. This system is suited for subsea companies looking to maximize efficiency, and allows for higher levels of reliability, with a position accuracy of up to 0.02%TD and a heading accuracy of up to 0.01°RMS, according to the manufacturer.

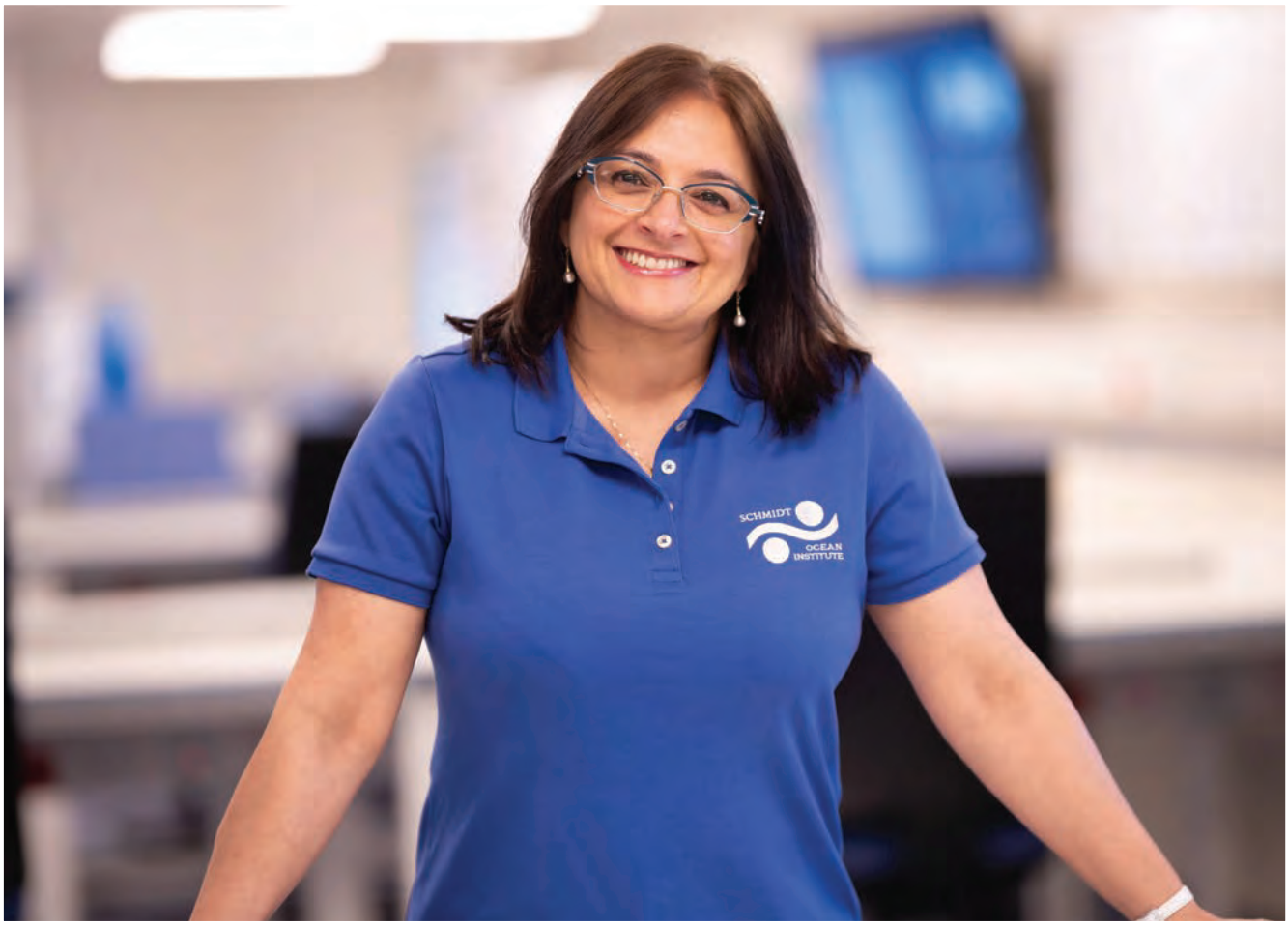
Falmouth Scientific Inc.

www.falmouth.com

Falmouth Scientific, located in the heart of the New England marine technology cluster, has a 10,000 sq. ft purpose built facility allows for innovative and reliable sensor, system and transducer solutions for a variety of global applications in salt and freshwater environments.

The 2023 areas of development focus are standard and custom transducers and the HMS-620 series of Bubble Gun Bubbleless Seismic Sources and Systems. Two transducer developments in the past year include a new design to replace an obsolete underwater telephone transducer for a full ocean depth rated manned submersible. The design is a pressure compensated high power tonpilz design with integrated impedance matching to allow both backward compatibility with the existing Underwater Telephone system and to allow for higher power capability for the next generation system. Second was the development of an integrated low frequency broadband transducer and power amplifier sub-system for an AUV application. The integrated transducer and amplifier meet the requirements of low frequency, high power while minimizing overall mass. The HMS-620 series of bubbleless seismic sources have two new sources that have been developed with a lower frequency spectrum and higher energy within the same footprint as thecurrent sources. The HMS-620HP is the same footprint as the standard 18” / 46cm source. The HMS-620LFHP is the same footprint as the HMS-620LF 36” / 92cm source. The Bubble Gun Bubbleless Sources are electro-mechanical devices with an air volume inside and gasket seals to prevent water ingress. When electrical energy is put into the system, the system compresses. Once electrical energy input is removed, the system expands generating a positive pressure pulse. This is similar to the secondary bubble pulse of an airgun without requiring a compressor. The resulting output is a single wavelet with a very repeatable amplitude signature and narrow pulse length.





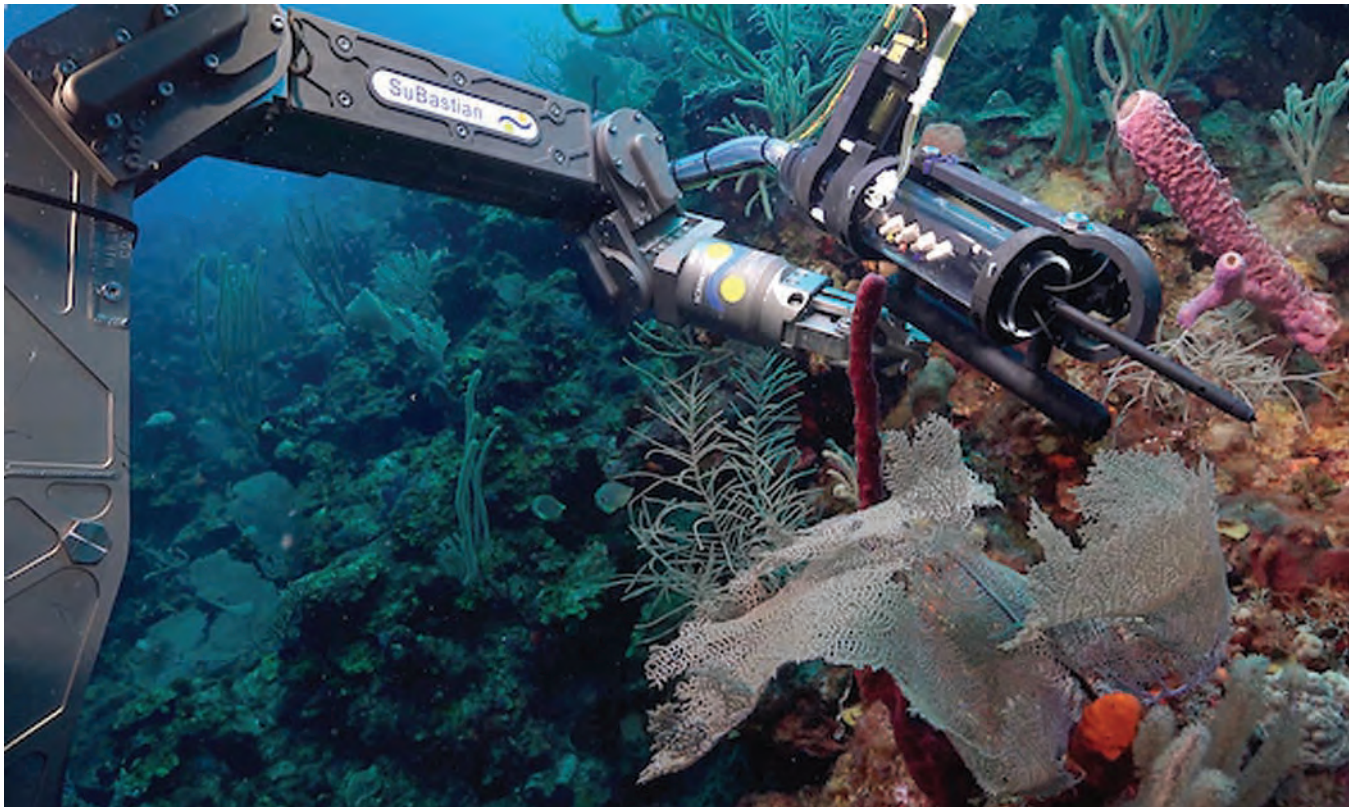
Dr. Jyotika Virmani

President & CEO Schmidt Ocean Institute

Schmidt Ocean Institute was established in 2009 by Eric and Wendy Schmidt to catalyze the discoveries needed to understand our ocean, sustain life, and ensure the health of our planet through the pursuit of impactful scientific research and intelligent observation, technological advancement, open sharing of information, and public engagement at the highest levels of international excellence.

Schmidt Ocean Institute launched its newly refitted 110-meter global-class research vessel in March for use by scientists worldwide to dramatically advance marine science and push the frontiers of deep sea expedition. Funded by Schmidt Ocean Institute founders Eric and Wendy Schmidt, the research ship, Falkor (too), is available to scientists and technologists globally at no cost in exchange for making their research and discoveries publicly available. The ship replaces the previous research vessel, which was in service for a decade and hosted more than 1,100 scientists, discovered over 50 new marine species and underwater formations and mapped over half a million square miles of the seafloor.

Since launching its new research vessel, Falkor (too), in March of this year, Schmidt Ocean Institute has conducted



SOI

six expeditions with remarkable discoveries on each one. This includes the discovery of a new way species populate hydrothermal vents, finding a new octopus nursery in Costa Rica, revealing three new hydrothermal vent fields on inaugural expedition, and testing new technology to examine the health of deep-sea corals. In addition, Schmidt Ocean Institute has created new partnerships and collaborations including the UN Decade of Ocean Sciences, National Geographic Society, and the Ocean Rising Alliance, which aims to deepen people's relationship to the ocean by galvanizing connections and tangible initiatives within all major sectors of global culture. Schmidt Ocean Institute has also expanded its Artist-at-Sea program, which has welcomed more than 44 artists to the ship and hosted more than 16 exhibits.

Harvest Technology Group Limited

https://harvest.technology/

Since 2020, Harvest Technology has been developing and perfecting innovative technologies to enable organizations to have 24/7 eyes on their remote operations and assets, utilizing existing infrastructure and network capacity, along with the ability to communicate and control subsea assets.

Harvest's proprietary Nodestream technology is pivotal to businesses looking to digitalization as a way to increase productivity and decrease cost. Nodestream is the ultimate remote operations system for organizations. A fully secure integrated communications platform for real-time collaboration, communication and data sharing - all in one place, accessible to everyone: anytime, anywhere. Proprietary transfer protocol technology that enables live streaming of video, audio and data, using ultra-low latency and ultra-low bandwidth, and capable of being integrated with a customer's existing systems and network infrastructure. The technology offers significant operational flexibility and cost savings, reducing carbon footprint by up to 90% and HSE exposure hours by up to 100%.

The ability to reliably communicate in real-time at a fraction of the bandwidth provides customers with a cost-effective way of monitoring and controlling their operations remotely. It is also the key in removing people from hazardous environments, increasing efficiency, reducing operational costs, and facilitating a move toward managed autonomy. With the need to transfer large packets of data growing exponentially, the demand on SATCOM services is also increasing, making it imperative for organizations to have the ability to maximize bandwidth efficiency.

HYDROMEA

https://hydromea.com

Hydromea is focusing on miniaturization and automation of underwater robotics solutions for the operators of submerged assets. Having its roots in developing swarm-capable mini-AUVs (autonomous underwater vehicles), the company has deep expertise and significant IP in smart miniature construction of robust inspection robots EXRAY, high-bandwidth underwater wireless communication technology LUMA, hubless ultra-thin thrusters DISKDRIVE, distributed networking, autonomy features and many other cutting-edge features that differentiates its inspection robotic solution from other alternatives in the market.

Breaking new ground in the realm of mini-ROVs, the EXRAY ROV system offers an extension option with a flyout robot. This detachable companion can be fully controlled remotely, complete with live HD video streaming, eliminating the risk of entanglement. The topside control station enables the pilot to place the tethered ROV in station-keeping mode, where it acts as a communication relay for the flyout as well as a third eye providing an additional perspective. With a quick manual switch, the pilot can alternate between the tethered and untethered robot. The flyout can be equipped with a metal thickness probe featuring A-scan functionality and is capable of hosting a variety of other payloads, just like its tethered twin. To operate the flyout wirelessly, Hydromea has developed a proprietary wireless communication system that utilizes blue light for data transmission. Blue light enables the wireless range of up to 30 meters (100ft) in confined flooded spaces in addition to the tether length of the relay ROV. EXRAY received its visual class certification from DNV in May 2023.

Additionally, Hydromea's high-speed underwater wireless communication technology, LUMA, enables wireless control of and HD video streaming from AUVs around complex subsea infrastructure. Moreover, Hydromea also leads the development of the wireless communication standard in free-space optical communication as part of Subsea Wireless Group.

JW Fishers Mfg

www.jwfishers.com

JW Fishers Mfg. was founded by the late Jack Fisher in the 1960's. Handheld underwater metal detectors were the basis of foundation for the brand, but quickly advanced into a full array of underwater search equipment. Today the extensive line of product includes hand-held and boat-towed metal detectors, magnetometers, underwater HD video systems, ROVs, sonar systems, acoustic pingers & receivers, pipe & cable trackers, a sub bottom profiler system and the Pulse 8X underwater metal detector recognized #1 by US Homeland Security.

JW Fishers once again has raised the bar in 2023 by introducing the SeaLion-3 ROV with 2x as many thrusters for horizontal movement, and is twice as powerful as its predecessor. The four vectored thrusters allow horizontal motion in any direction, and the ability to rotate-in-place. Vertical power is also increased, with three thrusters for diving and lifting. The unique vertical thruster placement also provides the ability to adjust pitch and trim of the ROV. The SeaLion-3 is depth rated to 1000 ft. with the option of up to 1500 ft. of tether. The SeaLion-3 has two full HD video cameras and recording capability. The new topside console has two monitors for viewing and controlling the ROV. The top monitor is a large 15-in. screen for viewing the 1080p videos from either camera, or both using the picture-in-picture. Sensor readings and navigation information can also be displayed on either screen. The solid-state internal storage can record over 200 hours of HD video. The SeaLion-3 has a full complement of sensors and attachments: an inertial measurement unit (IMU), a depth and water temperature sensor, front and rear high-intensity LED lighting, altitude sensor, an optional gripper attachment, and optional sonar. The advanced IMU and depth sensor on the SeaLion-3 allow for automated 'hold' modes of operation, during which the ROV can maintain its own depth or altitude, and magnetic compass heading, without operator control. The operator can concentrate on driving and searching with the ROV, without having to worry about maintaining depth, heading or other navigational concerns.

Kongsberg Discovery

www.kongsberg.com/discovery

Kongsberg Discovery is a new entity within KONGSBERG GRUPPEN. Formerly part of Kongsberg Maritime, Kongsberg Discovery has been established as a separate business unit to allow the company to focus on its core business. The company's essence is discovery—developing innovative technologies, implementing new methods, and finding new applications for our customers.

Proven technologies include the HUGIN family of Autonomous Underwater Vehicles; the accuracy of the EM series of multibeam echosounders capable of mapping even the Mariana Trench; the reliable and robust HiPAP range of high precision, long range acoustic communications and positioning systems charged with safe positioning of the largest offshore installations; and, HISAS, our advanced synthetic aperture sonar for unrivaled seabed imagery and bathymetry, used to detect small objects right down to 6000 meters.

One of the most important developments of recent years has been to make data access easier, faster and more secure than ever before. Blue Insight is the one system that binds all that we do together. A cloud-based data distribution system, it comprises the ability to upload, store, process, and display data from a myriad of sensors right around the globe. Blue Insight allows operators and supervisors to stream live data, control sensors many thousands of miles away, conduct rapid replays of surveys and interrogate data to generate actionable information. It is a secure service that offers hot and cold storage options, allows users to implement third-party processing tools, and even uses data from sensors manufactured by third parties. By ensuring Blue Insight is an open platform from the outset, it enables scientists, surveyors, and more an easy and secure way to distribute their results faster than ever before. Recently launched with ocean science customers in Norway and Europe, Blue Insight is now available globally across all market segments.

McLane Research Laboratories, Inc.

https://mclanelabs.com/

McLane Research Laboratories, Inc. is celebrating 40 years in the marine technology industry. Founded in 1983, McLane manufactures and develops advanced time-series instrumentation for the international oceanographic community. Through long-term research, development programs and time-tested association with diverse research projects, McLane has established a significant base of knowledge and proven technology in support of our objective. A leader in technology transfers in the field of oceanographic instrumentation, the company maintains significant development, innovation, and commercialization capabilities.

The company produces three main product lines: Profilers, Samplers, and Flotation. Samplers include Sediment Traps, the Remote Access Sampler (RAS), Particle and Phytoplankton Sampler (PPS), and Large Volume Pumps. In fall 2023, McLane premiers the Robotic Cartridge Sampling Instrument (RoCSI), a field-proven in situ autonomous oceanographic sampler that collects and preserves water samples into industry standard 0.22 and 0.45 micron Sterivex filter cartridges for later eDNA analysis. A 2023 technology transfer from the National Oceanography Centre (NOC), RoCSI provides high sample count capability in a compact instrument. Water samples are collected and then biologically preserved with a user-specified fixative. In addition, McLane's in-situ laboratory platforms, Environmental Sample Processor (ESP) and Imaging FlowCytobot (IFCB), support emerging genomic and optical research methods for automated time-series oceanography and limnology. The McLane Profiler line collects high density data in the vertical water column from the near surface to the deep ocean. Products include the Prawler, the Ice Tethered Profiler (ITP) and the McLane Moored Profiler (MMP). McLane also manufactures glass and steel flotation, as well as custom instrument housings. McLane instruments are all designed to withstand the rigors of long-term time series open ocean and freshwater deployments. McLane instruments are central to many long-term global projects and cruises including such initiatives as OOI, GEOTRACES, and the RAPID array.

Metron Inc.

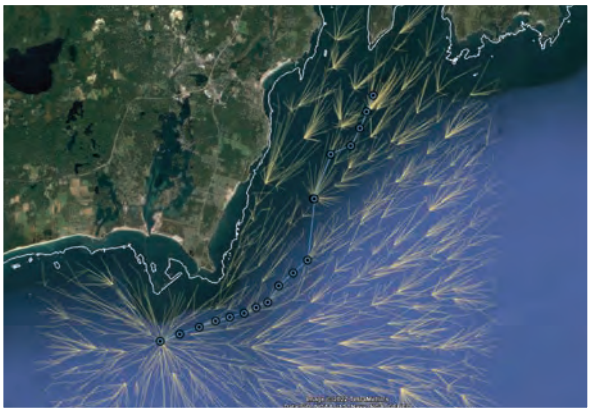
www.metsci.com

Metron is a provider of advanced research, scientific, and software solutions for government and commercial markets. Its multi-domain experience spans Bayesian inference, probabilistic modeling, signal processing, artificial intelligence, machine learning, and data fusion. Grounded in a first principles approach, Metron solutions transform information into intelligent action for our customers' most critical mission objectives.

For 40 years, Metron has worked with a wide range of federal agencies, including DARPA, ONR, NAVSEA, NAVAIR, NASA, FAA, etc., to provide solutions that solve challenges at the edge of innovation. More than 13 years ago, a small autonomous systems group within Metron set out to prototype the largest fully autonomous mission, payload, and sensor-capable underwater vessel for the U.S. Navy's LDUUV Innovative Naval Prototype program. The result was a complete hardware and software solution that paved the way for today's large format UUV's called ANCC (Autonomy, Navigation, Command, and Control). ANCC provides a Resilient Mission Autonomy software suite for fully autonomous, AUV robotic systems without any human in the loop that could easily integrate across independent component capabilities, including mobility, perception, intelligence, awareness, communications, and state space characterization.

Metron continues to expand into the commercial sector. With the success of ANCC's long-duration DoD applications, Metron launched the commercial version of ANCC in the winter of 2023 to focus on the offshore energy survey sector, leveraging a holistic approach incorporating both extrospective and introspective autonomy.

ANCC has now been deployed across a range of different manufactured AUV platforms and systems: UxV autonomy integration: 5x DARPA program vehicles; Commercial – Anduril DIVE-LD, New partnerships in October 2023; ONR programs – REMUS 100, 600, and 1000 UUVs; and Manipulator(s) for AUV payload suites or stand-alone platforms.



Kraken Robotics

Mount Pearl, Newfoundland and Labrador
President/CEO: Greg Reid
# of employees: 245
www.krakenrobotics.com

Kraken Robotics is a marine technology company providing complex subsea sensors, batteries, and robotic systems. Its high-resolution 3D acoustic imaging and battery solutions and services enable clients to overcome the challenges in our oceans – safely, efficiently, and sustainably.

Today, Kraken Robotics employs 245 globally, involved in the development of new and enhanced underwater technologies (complex subsea sensors, batteries, and robotic systems) and undertakes subsea survey services. Headquartered in Canada, Kraken has offices in North and South America and Europe. Key technology offerings include:

- **KATFISH Towed SAS Vehicle:** KATFISH is Kraken's intelligent, high-speed, high-resolution and actively stabilized Synthetic Aperture Sonar towed subsea survey system that operates at speeds up to 10 knots. The high-speed capability of KATFISH greatly increases Area Coverage Rates (ACR, reducing operating time and cost. KATFISH provides unprecedented high-resolution ACR of 4 km^/hr with 3.3 cm x 3.0 cm* constant resolution across ranges up to 200 m per side with simultaneous 3D bathymetry. *1.9 cm x 2.1 cm constant resolution possible with post-processing. KATFISH incorporates Kraken's latest generation Real-Time SAS processor. RTSAS enables real-time processing of SAS imagery and bathymetry. On-board Automatic Target Detection survey data and contacts can be viewed directly on the ship as it is collected, or remotely from a mothership or shore-based command station.

- **AquaPix MINSAS:** AquaPix MINSAS is Kraken's off-the-shelf Miniature Interferometric Synthetic Aperture Sonar (SAS), replacing high-end sidescan systems with improved resolution, range, 3D bathymetry, and deliver the industry's best Area Coverage Rates (ACR). It offers 3.3 cm x 3.0 cm or 2.1 cm x 1.9 cm Ultra High Definition (UHD) constant resolution up to 200 meters per side, with simultaneous 6 cm x 6 cm bathymetry. Its unique features make it suitable for various underwater platforms and UUVs, based on a modular array system adjustable from 60 cm to 180 cm lengths, fitting different vehicle sizes. Another feature of Kraken's AquaPix sonars is its RealTime SAS (RTSAS) processing module, an

industry-first that converts live sonar data into SAS tiles in real-time during missions, supporting Automatic Target Recognition (ATR) and data exfiltration of processed SAS data. This technology streamlines post-mission analysis. Once limited to expensive military systems, AquaPix now extends SAS capabilities to commercial and research-based entities, enhancing capabilities while cutting survey expenses and time.

- **Man-Portable SAS:** Kraken's Man-Portable SAS payload utilizes our new MINSAS 60 Light Weight arrays and is designed to retrofit existing Man-Portable UUVs with diameters from 7.5 to 9 inches. This modular payload section can be added and removed quickly in the field without recalibration; retaining the ability to use the vehicle's existing OEM shipping containers. The MINSAS 60 LW delivers picture-perfect seabed images with unprecedented image resolution and detail in a compact, man-portable package. It provides detailed images with a resolution of 3.3 cm x 3.0 cm out to a range of 100 m from each side of a UUV (200 m swath). The MINSAS 60 LW also produces real-time bathymetric data with a resolution of 25 cm out to full range while delivering high depth accuracy. At the heart of the MINSAS 60 LW is Kraken's new Gen III, Real-Time SAS (RTSAS), industry-first, true full swath SAS processing which greatly reduces power consumption. Onboard SAS processing reduces post-mission analysis and enables embedded Automatic Target Recognition, providing a foundation for contact ExFil and other advanced autonomous behaviors.

- **SeaPower Subsea Batteries:** Kraken's SeaPower range are pressure tolerant, deep-sea batteries, enabling commercially offered AUVs to more than double their previous survey endurance, while using the same battery payload volume. Each SeaPower battery block is equipped with an advanced Battery Management System (BMS) which continually monitors the status and health of the battery. SeaPower batteries can be used singularly or connected in modular banks, depending on your requirement for capacity and voltage.

- **Subsea 3D Acoustic Survey Services:** With the acquisition of PanGeo Subsea, Kraken moves beyond seabed imaging into sub-seabed 3D imaging with the Sub-Bottom Imager (SBI) and Acoustic Corer (AC) technologies. The Sub-Bottom Imager uses state-of-the-art beamforming SAS arrays, providing a real-time 3D view of the sub-seabed. The SBI identifies buried objects, anomalies, geohazards, and stratigraphy, acquiring data in a continuous 3D acoustic swath, a minimum of 5m wide (at the seabed) and penetrating to 5m below the seabed. Applications include depth of burial, out of straightness, debris locations, unexploded ordnance, and decommissioning surveys. SeaKite is Kraken Robotics' next generation SBI deployment method, utilizing a Remotely Operated Towed Vehicle (ROTV) incorporated into the SBI. The high-speed depth of burial platform operates in water depths from 7-250m and is 6x faster than ROV surveys by traveling at speeds up to 4kts. Having the same benefits as the ROV mounted SBI, the SeaKite images both ferrous and nonferrous anomalies. The Acoustic Corer is a subsea surveying technology that interrogates the subseabed to optimize offshore installation programs. Its capabilities include buried boulder identification and support for foundation location selections and foundation engineering design. The Acoustic Corer fills the gap between current geophysical and geotechnical site investigation methods by providing a 3D acoustic core 14 meters in diameter penetrating up to 60 meters into the sub-seabed.


HARBOR BRANCH
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James M. Sullivan, Ph.D.

Executive Director, FAU Harbor Branch

James M. Sullivan, Ph.D., was named the Executive Director, FAU Harbor Branch, three years after joining the organization. In his heart, Sullivan is an engineer and a scientist, an internationally renowned researcher and oceanographer, with a long history engaged in deep study of the world's waterways, his specialty was in phytoplankton physiology and ecology.

Even up until the time that he joined FAU Harbor Branch, Sullivan admitted he never possessed the ambition to enter the administrative part of academia, let alone take the top spot.

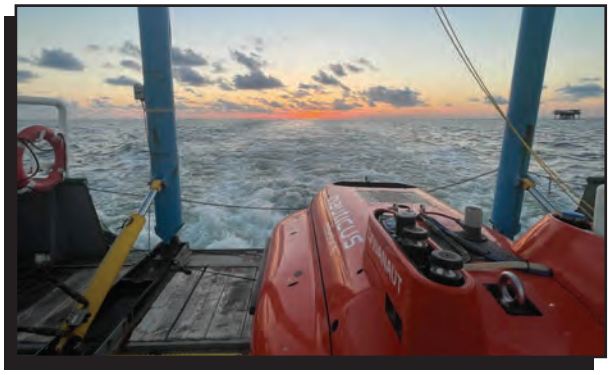
But his natural ability plus circumstance met, and he was deemed the most viable candidate, and acquiesced when asked to take on the executive director role as an interim position. "I had no interest whatsoever in the position, but was asked 'will you be interim executive director while we do a national search to find somebody.'" Sullivan agreed, in part because he realized that there were a number of issues at the Institute that he could help rectify in the new role. "There were substantial changes I [could effect] while I'm interim, because I'm going to go back to the faculty, and I want this stuff fixed." With an eye on making substantial, constructive changes, Sullivan set about the job with a vigor. Then a funny thing happened. "I guess I did too good of a job because three months after I was interim, they asked me to become the permanent director … and here I am."

While Sullivan misses some aspects of his former research position – physically engineering new products and systems; and the "eureka moments" … making that rare, first find – he is well-suited for success in his leadership role, and understands that in the Executive Director seat he can effectively enable a much broader swath of change than he could as a scientist/engineer alone. "I can drive science a lot more in this position than I could just working in my lab on my own projects."

In addition, Sullivan is the figurehead of the institute and interfaces with politicians, outside organizations and community groups to help influence how funding is made to ocean sciences. "It's a different level, but really it's all the same thing; we're trying to improve science and facilitate research," guided by the university's four core pillars, including: Biomedical Research, Aquaculture, Marine Conservation Research, and Ocean Engineering.

Looking ahead, he sees these technologies that will have the greatest impact on the study of world's waterways for the coming generation: Autonomous Measurement Systems; Sensors; and Big Data Analytics.

FAU Harbor Branch is the second largest (144 acres) campus in the FAU system, with 250 people on campus, including 70 graduate students and 40 research faculty members. In 2021 FAU Harbor Branch had almost $18-20 million in external research funding (1/3 of all the external research dollars that come into FAU run through Harbor Branch).



Nauticus Robotics

https://nauticusrobotics.com/

Nauticus Robotics develops autonomous robots using AI for data collection and intervention services for the ocean industries. Founded by a group of former NASA engineers, Nauticus' robotic systems are delivered to commercial and government-facing customers primarily through a Robotics as a Service (RaaS) business model for many offshore industries and activities. By adapting technologies derived from spaceflight robotics, Nauticus is challenging legacy offshore methods that have largely remained unchanged for 50 years. The company's technology is visible across its entire product suite but is perhaps most evident in its all-electric AI-powered tandem robot pairs: Hydronaut and Aquanaut. In April of 2023, Nauticus announced the second-generation Aquanaut Mark 2 (MK2). Aquanaut is a fully electric, free-swimming subsea robot controlled through acoustic communication networking that performs a wide range of data collection, inspection, and manipulation tasks. Aquanaut – along with its surface-level counterpart, Hydronaut – comprises the Nauticus Fleet, an industry-changing robotic navy of electric robots representing the most promising operational and technological step changes in this industry. The fleet's tandem robotic pairs will be deployed in multiple offshore industries serving applications ranging from subsea maintenance and intervention to data collection activities. Aquanaut MK2's defining capability is operating in two separate modes, actively transforming itself between the excursion and intervention configurations. Excursion mode involves the usage of data collection and perception sensors, while intervention mode utilizes two of Nauticus' Olympic Arms – electric work-class manipulators – to perform precise yet powerful interactions with subsea infrastructure and objects to complete complex, underwater tasks. The delivery of the initial second-generation Aquanauts was announced in April 2023.

Neil Brown Ocean Sensors, Inc. (NBOSI)

https://www.nbosi.com/

NBOSI specializes in designing and manufacturing a range of semi-custom conductivity/ temperature/ depth (CTD) sensors. Operators in the defense, offshore, and ocean research sectors, who deploy autonomous vehicles for reconnaissance, survey, and inspection, require knowledge of ocean temperature, salinity, density, and sound velocity to achieve optimal vehicle, navigational, and acoustic payload performance. NBOSI's sensors are specifically tailored to meet the requirements of autonomous subsea and surface ocean platforms, and deliver scientific-quality data, from one of the most compact, rugged and hydrodynamically efficient systems available in the market. NBOSI sensors are deployed on underwater vehicles globally, and offered as standard equipment on leading platforms, including the Hydroid (now Huntington Ingalls Industries) REMUS family and the OceanServer (now L3Harris) IVER vehicles.

NBOSI's CTDs are designed to easily be integrated either as an externally-attached modular cabled sensor, or directly attached using a variety of custom hull penetrators. Both approaches enable a robust, low-profile installation that minimizes drag and potential snagging.

NBOSI's sensors bring advancement and innovation to the maritime robotics industry. The sensors deliver accurate and precise data, whilst being compact and hydrodynamically efficient. Furthermore, NBOSI's sensors and their corresponding electronics allow for convenient off-vehicle calibration throughout the lifetime of the sensor.

NBOSI has been delivering sensors to researchers and vehicle manufacturers worldwide since 2005, establishing a strong presence in the industry. A version of the NBOSI CT sensor has been engineered for the unique requirements of the new HII REMUS 300 UUV and is now delivered as standard equipment on one of the most advanced vehicles on the market.

VideoRay

CEO: Chris Gibson
www.videoray.com

With more than 4,000 vehicles delivered worldwide, VideoRay is a leading inspection-class underwater robot manufacturer. VideoRay's Mission Specialist systems are designed to easily integrate accessories and tooling, which enables capabilities optimized toward customers' missions. Through close partnerships with third-party organizations, we maintain an understanding of emerging technologies and their potential benefits to our customers, ensuring they retain an advantage in their field.

The Mission Specialist Pro 5 is designed for performance when size, speed, and efficiency matter most. Weighing in at just 10 kg (22 lbs.), the three-thruster system has a forward speed of over 4.4 knots and a 305-meter depth limit. This system is easy to transport and is ideally suited for missions with space, weight, and deployment constraints.

The Mission Specialist Defender is VideoRay's largest and most powerful system, weighing in at 17.2 kg (38 lbs.) It has been optimized for precise control and heavier payloads, making it ideal for lifting or conducting specialized operations. The system is highly adaptable, allowing for innovative payloads that vastly expand its capabilities despite its compact size. The Defender's seven thrusters can handle currents up to four knots at depths of up to 1,000 meters.

The Defender was recently selected for the US Navy's Maritime Expeditionary Standoff Response (MESR) program, making it the U.S. Navy's Expeditionary ROV system of choice. To date, the U.S. Navy's total procurement of Mission Specialist Defender vehicles and accessories is nearing $50M since it entered into a Production-Other Transaction Agreement (P-OTA) with VideoRay. One of the many determining factors in the Navy's selection is VideoRay's use of universal modules. This configuration ensures a required part can be dispatched and repaired or replaced promptly in the field, while also providing the ability to upgrade components as new products and features become commercially available, without the need to replace the entire system.

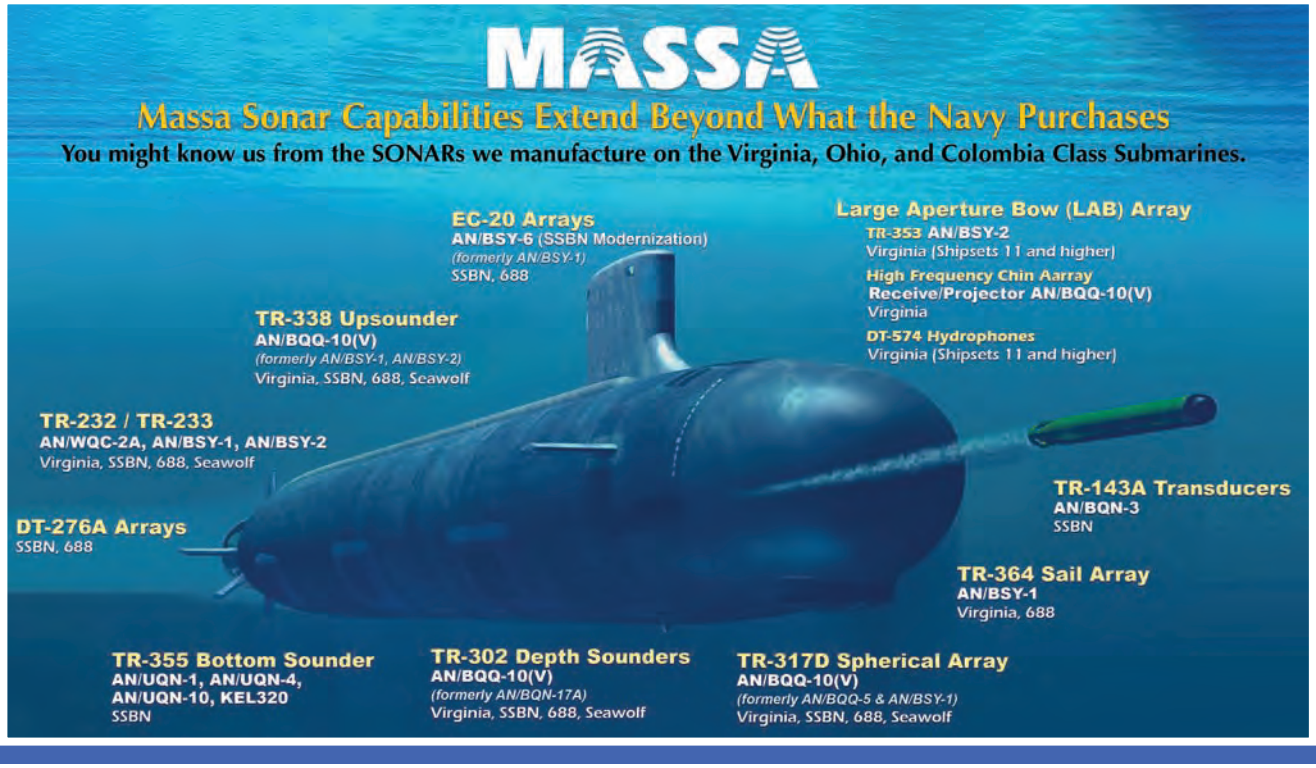
The combination of a modular design and open architecture allows for the integration of a wide array of highly advanced accessories to expand the capacity of the vehicle far beyond its size. Recently, VideoRay, Sarcos Technology and Robotics Corporation partnered to offer Mission Specialist ROVs equipped with the Sarcos Guardian Sea Class robotic system, including its power-efficient dexterous arms. The Sea Class system has a modular design that easily integrates with VideoRay's line of one-person portable ROVs.

The Guardian Sea Class system can be operated with one or two six-degree-of-freedom arms and performs in depths of up to one kilometer (1,000 meters). It can be teleoperated or operated via supervised autonomy.

Additionally, VOYIS has integrated its Discovery Vision System, which is an ROV camera designed for both low-latency vehicle piloting and 3D inspections. It uses integrated Nova Mini Lights to deliver crisp still images and 4K video from a single powerful platform. The system's real-time enhancement algorithm delivers images for direct use in photogrammetry.

Massa Products Corporation

Hingham, Massachusetts
President/CEO: Dawn Stancavish
# of employees: 75
www.massa.com/

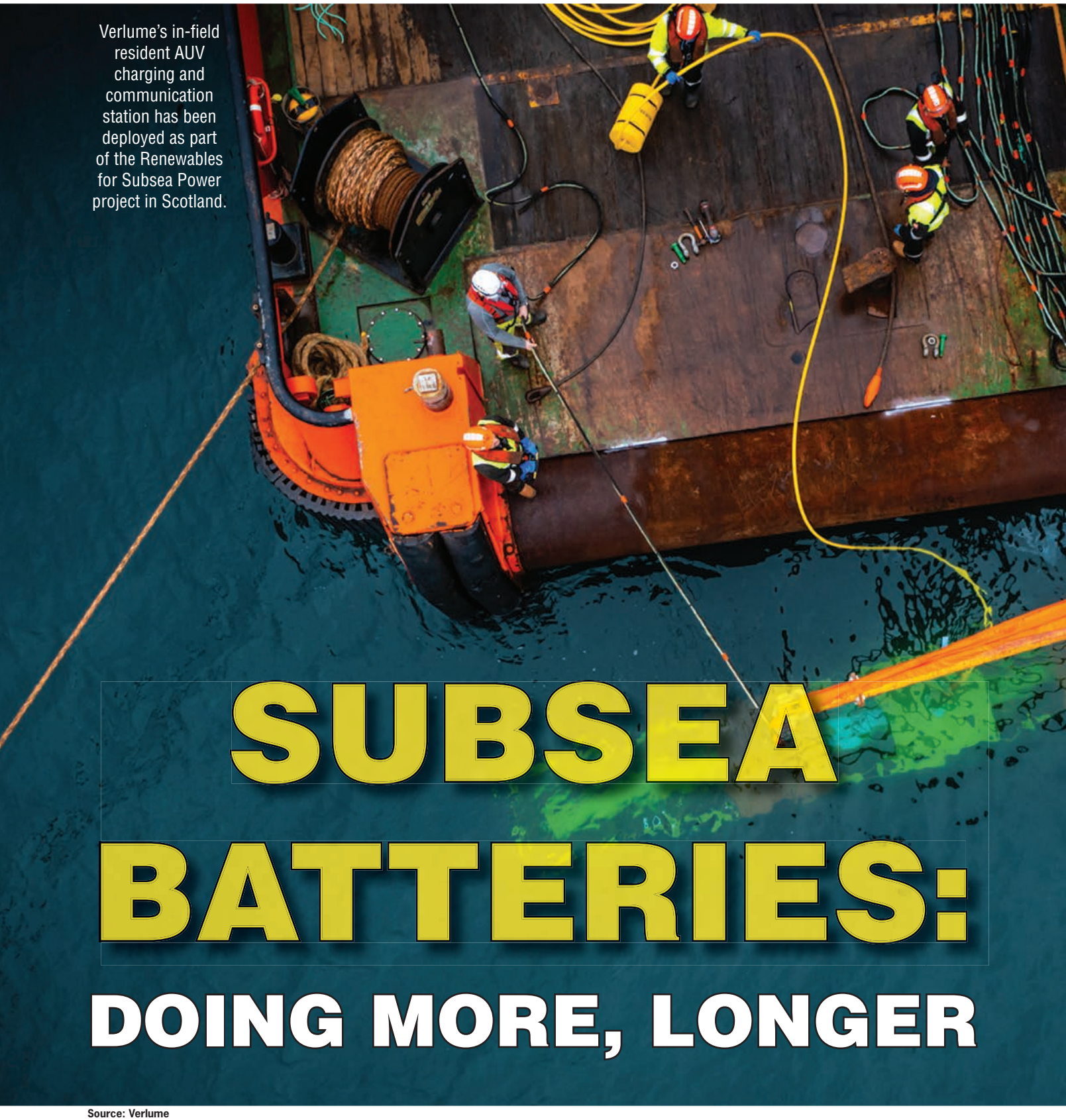


Massa Products Corporation is a sonar and ultrasonic product manufacturer with expertise and experience in the advancement of electroacoustic technology. Massa's history and experience as an innovator in the field of electroacoustics is as extensive as it is unique. They are the only company in their field that has direct continuity in the design/development and mass-production of sonar since WWII. Massa's founder, Frank Massa was the Point of Contact for Industry to the Navy with regards to the advancement and production of sonar for the war effort. He designed over 150 transducers, thousands of which were produced, in the three and a half year period of WWII. He achieved this by being the industry's leading expert in the field of acoustics and as one of the founding fathers to apply engineering principles to the theoretical science of sound.

Massa remains an industry leader and under family ownership, currently run by third generation Dawn Stancavish. With a significant presence in both government and commercial markets, Massa offers a full line of solutions for both underwater and in-air applications such as sub-bottom profiling, underwater communication, UUV/AUV sensors, connectors, level measurement, and proximity detection. Massa also develops custom solutions for uniquely challenging applications, environments, and use cases where sound has not previously been considered.

Massa also works closely to nurture strong internship programs with local high schools, trade schools, and colleges. They are a long-time partner with Northeastern University and a large supporter of their CO-OP Program. They are constantly adding new graduates to their pool of experienced workers in an environment that thrives on collaboration. This unique culture results in a robust combination of practical experience and new-age thinking, enabling Massa to create innovative, practical, and reliable products efficiently. They are also an integral part of the Submarine Industrial Base Workforce Development Program, continuing to build America's "New Collar" Workforce by providing meaningful careers to the next generation of technically inclined men and women. Currently, Massa builds over 60% of the sonar transducers used on the Virgina, Ohio, and upcoming Columbia Class submarines, in addition to its other government production, innovation, research contracts. Furthermore, it holds more than 170 US patents and provide a diverse assortment of commercial products for use in air, chemicals, and oceanographic applications.

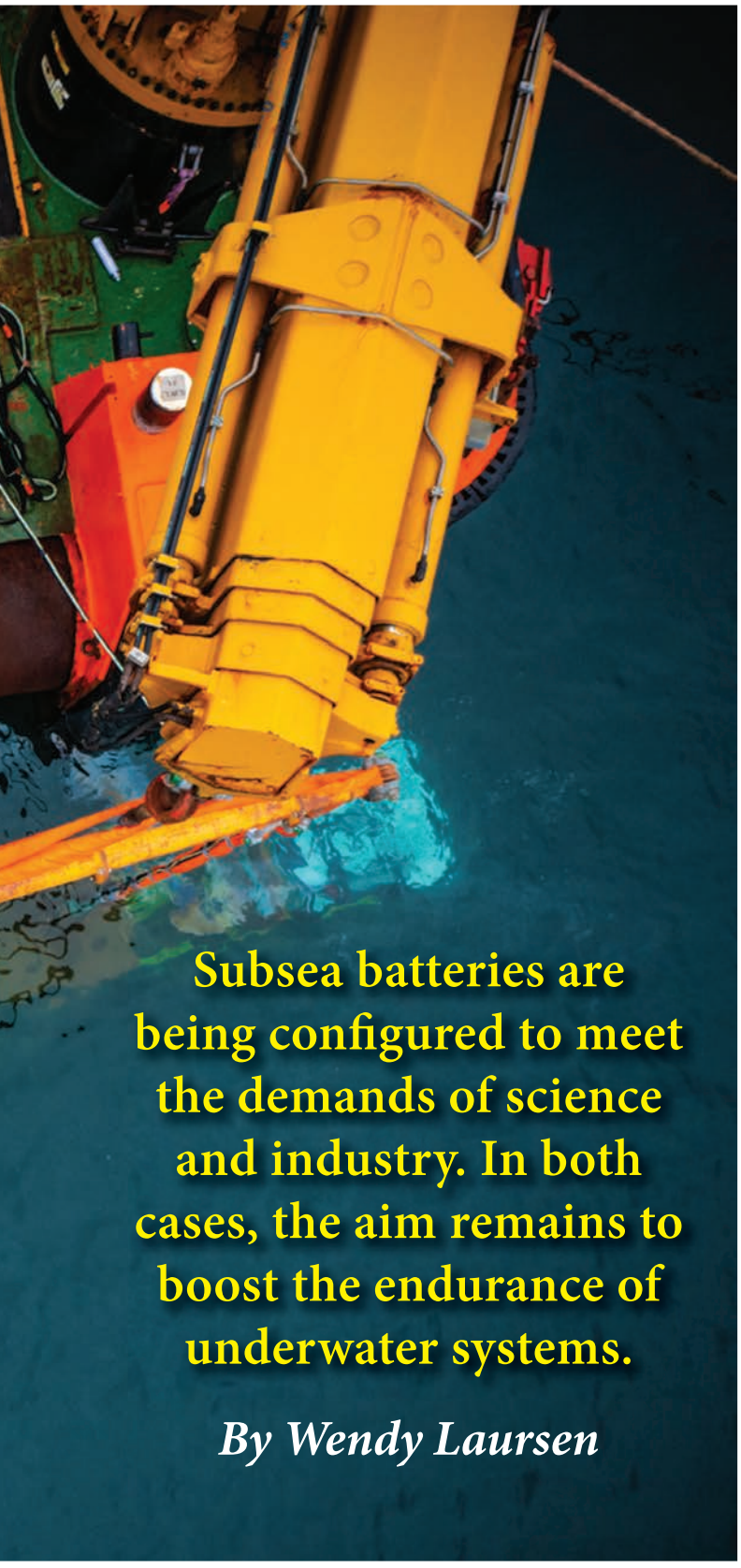
Massa is working on several new products, soon to be released. It is presently collaborating with different partners in the oceanographic arena and in government programs. It is involved with creating solutions that can help clean-up and protect shorelines, oceans and marine life.



Verlume's in-field resident AUV charging and communication station has been deployed as part of the Renewables for Subsea Power project in Scotland.

SUBSEA BATTERIES: DOING MORE, LONGER

Source: Verlume



Subsea batteries are being configured to meet the demands of science and industry. In both cases, the aim remains to boost the endurance of underwater systems.

By Wendy Laursen

Not that long ago, **SubCtech** claimed to be building the world's largest and only Li-ion battery for subsea oil and gas applications - a 1MWh, 22-ton battery storage skid. The stakes are increasing in this upsizing market, with **Kraken Robotics** recently announcing an order for subsea batteries worth $16 million, adding to its already $120 million order book.

The desire for underwater power infrastructure is growing as concepts such as mothership-deployed and subsea resident vehicles are introduced. There are a lot of advantages to electrifying subsea operations, and this will be a future market for more batteries, says **Corvus Energy** CTO Dr. Lars Ole Valoen. Corvus collaborated with Oceaneering on the E-ROV concept pioneered by Equinor a few years ago to reduce emissions and costs and boost operational flexibility. The self-contained, battery-powered ROV can operate for extended periods of time without being recovered to surface.

Earlier this year, **Verlume**'s seabed battery intelligent energy storage system, Halo, was deployed as part of the Renewables for Subsea Power project in Scotland. The system enables AUVs to dock, recharge batteries, upload data and receive new mission data multiple times without needing offshore intervention, and it can be recharged in-situ using renewable wave, wind, tidal or solar power. There are also potential applications for residential ROVs and AUVs.

"The success of residential AUV charging in this project is a really exciting development, and having that long term residency has opened up some big opportunities for offshore inspection, including within the offshore wind market," says Slorach. "We're just starting to build a resident underwater vehicle docking station with integrated battery for offshore wind applications."

The long metal cylinders are A.G.O. Environmental Electronics battery packs on a rig for the SWIFT project.

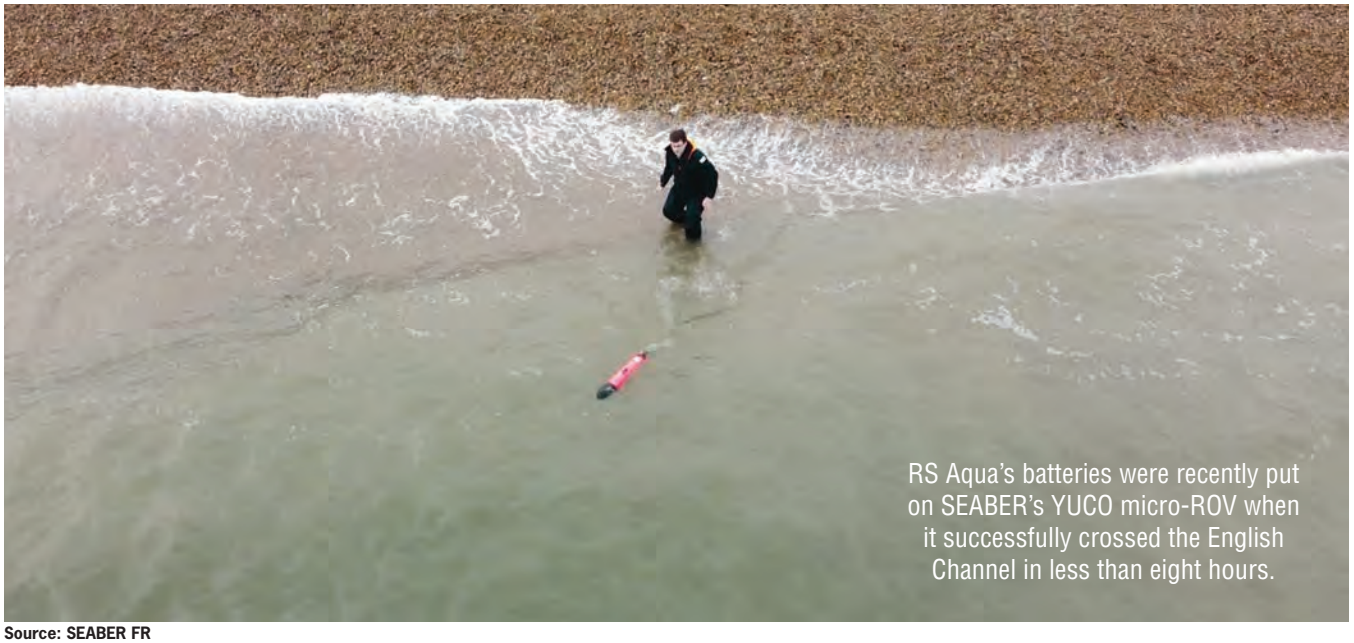
Source: A.G.O. Environmental Electronics

Source: Electrochem

Electrochem Solutions produces lithium-oxyhalide batteries, a type of lithium primary battery that use a lithium metal anode and a liquid cathode that doubles as the electrolyte.

Source: RBR Global

RBR has deployed its RBRfermata battery canister and its RBRcervata deployment extender into deep-sea earthquake and tsunami monitoring systems.



RS Aqua's batteries were recently put on SEABER's YUCO micro-ROV when it successfully crossed the English Channel in less than eight hours.

Source: SEABER FR

Verlume's intelligent energy management system, Axonn, can deliver a constant output of power from renewable sources to support offshore decarbonization projects and minimize energy loss from electricity generated from offshore wind.

Power management system advancements are key, but Verlume's CTO, Paul Slorach, says the company is also continually improving the energy density of its systems. Most recently, that has involved a new module design, but he is also keeping an eye on the developments in the electric vehicle market and exploring new battery chemistries.

One of **A.G.O. Environmental Electronics**'s latest projects involved designing a set of large battery packs to supply 172V with 21Ah capacity at up to 3,000m depth for subsea technology company Envirex's SWIFT project. The system was designed for Aker Solutions as a completely wireless and self-powered tool for tubing hanger installation on subsea oil wells.

The deep sea can experience near-zero temperatures that can significantly reduce batteries' rated performance. Available space is limited such that overall battery pack capacity may be dictated by the pressure vessel size required to withstand the design depth. A.G.O. balanced these challenges by designing titanium pressure cases with nickel-metal hydride (NiMH) batteries. These batteries are rechargeable with a long life and offer the highest energy density by volume of all standard non-lithium-based battery chemistries. They are also rated for operation at near-zero temperatures with minimal performance reductions.

Source: DeepSea

DeepSea's SeaBattery Power Module has a pressure-compensated design that works from surface depths down to 11,000m.

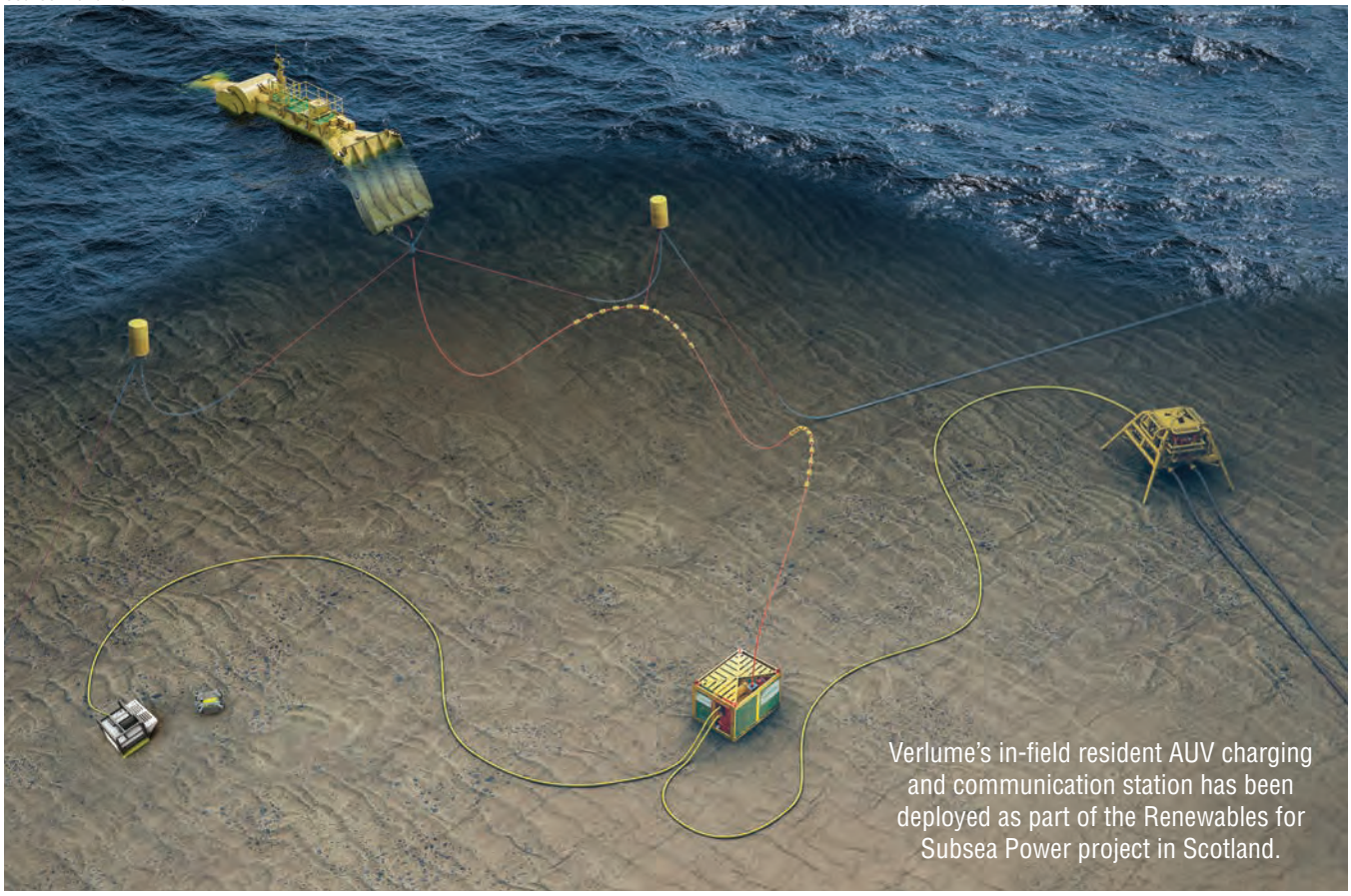
Source: Caladan Oceanic, LLC.

DeepSea's SeaBattery in use on one of the Five Deeps Expedition landers.

DeepSea says its SeaBattery Power Module has a pressure-compensated design that works in the most demanding applications from surface depths down to 11,000m. While the SeaBattery is used in a variety of contexts, it continues to be favored when reliability is critical to mission success, says DeepSea. This includes use as emergency power for diving bells and autonomous research landers deployed to 11km below the surface, such as those deployed by the Five Deeps Expedition.

The SeaBattery Power Module uses Absorbent Glass Mat lead-acid cells which feature vibration and shock resistance. It is capable of continuing to work at any orientation, and because of their chemistry, the cells do not have the same shipping restrictions as Li-ion batteries.

Source: Verlume



Verlume's in-field resident AUV charging and communication station has been deployed as part of the Renewables for Subsea Power project in Scotland.

Sensor and instrument supplier **RBR** aims for low power consumption but some applications still require additional power. "We regularly deploy RBR instruments and underwater battery canisters on DMO Wirewalker systems - wave-powered profilers that are used in long-term deployments," says Rob Lee, Director of Marketing. RBR has also deployed its RBRfermata battery canister and its RBRcervata deployment extender (with added battery capacity and data storage) into deep-sea earthquake and tsunami monitoring systems through Ocean Networks Canada.

"We can see the need for more power in shorter-term moored applications as well. A package of active optical sensors can require supplemental power even if the deployment is relatively short. And, if it's in an area that is subject to biofouling, then the mechanical wipers that are required to keep the sensor windows clean will also be a factor," says Lee.

Electrochem Solutions produces lithium-oxyhalide batteries, a type of lithium primary battery that use a lithium metal anode and a liquid cathode that doubles as the electrolyte. The cells have high energy density and specific energy, in some cases more than 1120 Wh/L and more than 520 Wh/kg, and they have very low rates of self-discharge. They are well suited to devices that are remotely deployed to the sea floor where there is no energy source available for charging, applications where the device is mobile but cannot remain at the surface long enough for adequate charging, and situations where the device will be idle for long periods.

The company's BCX solution is designed specifically for low temperature performance. Arden Johnson, Fellow Scientist and R&D Manager, says: "Our BCX cells deliver excellent performance at very low temperatures, 0°C to -55°C. The cells contain an additive that increases the cell voltage and leads to improved start-up and discharge performance under low temperature conditions. A BCX D cell can deliver up to three times the capacity of competitive cells when discharged at -40°C, making the performance of these cells extremely well suited for subsea, oceanographic, and Arctic applications."

RS Aqua's batteries were recently put on SEABER's YUCO micro-ROV, weighing just 10kg and measuring under one meter in length, when it successfully crossed the English Channel in less than eight hours. RS Aqua's Ocean Scientist, Nathan Hunt, says that prior to the introduction of micro-AUVs, collecting scientific data in coastal environments faced challenges such as spatial coverage and weather. At the end of this 39km test, the micro-ROV still had 35% of its battery power remaining.

Ohmsett - The National Oil Spill Response and Renewable Energy Test Facility

https://ohmsett.bsee.gov

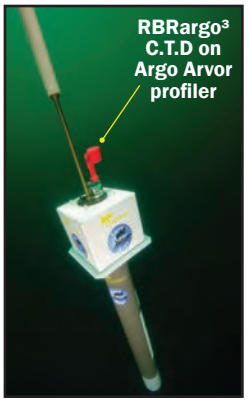
Ohmsett – The National Oil Spill Response Research & Renewable Energy Test facility is the test bed for some of the most innovative technologies used in the spill response industry for oil spill detection, containment, and removal, as well as marine renewable energy and technology for the blue economy. Managed by the Department of Interior's (DOI) Bureau of Safety and Environmental Enforcement (BSEE) under a contract with Applied Research Associates, Inc. (ARA), it is one of the largest outdoor saltwater testing facilities in the world.

Ohmsett is internationally recognized by the oil spill response technical community as one of the premier facilities to develop or assess response equipment. As the largest outdoor saltwater wave/tow tank facility in North America, it offers an ideal setting for testing, research, and training in a marine environment under near-real-world conditions. Activities within the 203 meter-long, 10-million liter, above-ground wave and tow tank simulate realistic environments for evaluating technologies to determine autonomous operation, maneuverability, sensor integration, performance when exposed to different wave conditions, and general durability in waves up to 1 meter in amplitude. By providing objective performance testing of oil spill response equipment and marine renewable energy systems, customers can conduct tests on skimming vessels, sorbents, dispersants, sunken oil detection, oil emulsions, oil-in-ice recovery, remote sensing, marine energy converters, marine debris removal systems, technologies for the blue economy, and much more.

The DOI recently expanded the role of BSEE as the federal offshore energy regulator to oversee workplace safety and environmental compliance functions related to offshore renewable energy development. One of the most effective ways BSEE carries out this new mission is through its management of Ohmsett. The knowledgeable staff assists developers and researchers with a variety of tests for blue technology, marine energy devices, and the challenges associated with cleaning up lubricating and dielectric fluid spills.

RBR

https://rbr-global.com/



This year, RBR celebrates its 50th anniversary of providing oceanographic sensors, instruments, and measurement systems. RBR designs, manufactures, and calibrates high-precision oceanographic instruments and related systems. Designed with the user experience and flexibility in mind, RBR's instruments can be configured to measure up to 10 physical or biogeochemical water parameters. Communication is available with USB-C as the standardized connector on every instrument, and Wi-Fi connectivity is available on every standard logger. All instruments run on standard off-the-shelf batteries. By having one cable that fits all, with widely available batteries, and a single software tool to interface with all RBR instruments, preparing for deployments has never been easier.

RBR has been actively advancing its product line to meet global research requirements. Since 2018, RBR has worked with the international Argo program to diversify the floats' CTD sensor technology. Following rigorous testing and validation in collaboration with the Argo community, the data collected by the RBRargo3 C.T.D received a QC-1 flag, signifying its trustworthiness as a CTD for the Core Argo program. Today, all major Argo float manufacturers offer RBR sensors on their platforms.

This year, RBR continued the expansion of its optical sensor line with the introduction of the RBRtridente three-channel fluorescence and backscatter sensor and our RBRquadrante four-channel radiometer. In addition to providing outstanding performance specifications, the sensors are designed with low power consumption, rugged packaging, and ease of use that users have come to expect from RBR.

Furthermore, RBR has made significant design updates to its suite of system components, including the RBRfermata underwater battery canister, the RBRcervello data controller, and the RBRcervata deployment extender. These updates cater to the increasing demand for long-term, autonomous deployments in challenging environments. RBR also proudly introduced the new RBRglissando underway profiling winch, enabling automated free-fall profiling with instrument payloads of up to 20kg, pay-out line speeds of up to 10m/s, and a line length of 1000m.

Remote Ocean Systems

www.rosys.com

For more than 40 years, Remote Ocean Systems has been an industry leader in the development and manufacture of reliable, latest technology camera, lighting and positioning systems for extreme oceanographic, industrial, commercial and military applications and environments. ROS has a 10,000 square foot research and manufacturing facility dedicated to producing products that are reliable in extreme environments and applications. Our staff includes experts in video engineering, mechanical design, reliability engineering, EMI resistivity and radiation resistance design. Our product line includes underwater video cameras, lights, rugged pan and tilt positioning systems, video inspection systems and control systems manufactured primarily for the oceanographic, nuclear and defense industries. ROS manufacturing is a cell-based operation, incorporating one-piece flow and a SS lean manufacturing environment. Our Quality Commitment is based on operational best practices including: Control Plans, HALT/HASS Testing, 100% Functional and Pressure Testing, ANSI/ESD S20.20 Compliance.

ROS has developed two new technology products designed for deep sea ocean applications. The SeaStar is a high-powered compact LED light that delivers 10,000 lumens output with full-range dimming capability. The SeaStar is completely field serviceable and available with flood or spot reflector options. It is depth rated to 6,000 meters. The Accu-positioner is a new ROS Technology Pan & Tilt Positioner that features a reliable and rugged deep ocean design and computer-controlled accuracy to +/- 0.1 degree (6 arc minutes). The Accu-positioner is controlled with COTS controllers, devices and ROS GUI. It operates with zero backlash and is depth rated to 6,000 meters. ROS Testing Capabilities include: continuity checks (voltage, current, resistance, capacitance and inductance), power cycles, light output, torque calibration, continuous operation, vacuum seal check, low pressure pot, and hydrostatic pressure chamber testing (100-10,000 psi).

Saildrone

https://www.saildrone.com/

Saildrone provides comprehensive turnkey data solutions for maritime security, ocean mapping, and ocean data. Saildrone's fleet of uncrewed surface vehicles (USVs), powered by renewable wind and solar power, are designed to make ocean intelligence cost-effective at scale. Saildrone's are capable of collecting data above and below the water, and the Saildrone comes in three sizes of USV to balance mission payload flexibility and endurance. The 7m Saildrone Explorer, powered by wind for propulsion and solar energy for onboard sensors, navigation, and communication, is equipped with sensors for collecting metocean data in support of climate research and sustainable fisheries management. The 10m Saildrone Voyager carries a payload for survey operations, including high-resolution MBES and Innomar SBP systems, and can deliver long-duration IHO-compliant multibeam mapping surveys and ocean data collection at depths up to 900 feet (300 m). The 20 m Saildrone Surveyor is able to carry the same cutting-edge sonar equipment as survey ships to deliver high-resolution data. Across Saildrone's range of USV solutions, real-time data is delivered via the Saildrone Mission Portal, a secure web portal with advanced

collaboration features and mission planning tools. Communications are encrypted via VPN over Iridium, and an API for data integration into other systems is also available. Saildrone USVs have already sailed nearly 1,000,000 nautical miles from the Arctic to the Antarctic, spending some 25,000 days at sea. Saildrone's masthead 360° optical camera system combined with the ML model running onboard GPU compute processors deliver real-time, visual detection of vessels at sea. Detection events are fused with other data sources—radar, AIS, and acoustics—to deliver a fully informed picture of the surrounding maritime domain, providing situational awareness to remote command centers.

SBG Systems

https://www.sbg-systems.com/

SBG Systems is a manufacturer of inertial motion sensing solutions. The company provides a range of solutions, from miniature to high accuracy. Combined with calibration techniques and advanced embedded algorithms, SBG Systems products are found in maritime applications such as ship motion monitoring, SONAR, LiDAR, buoy orientation and position, ROV & AUV control, dredging, and platform stabilization. SBG Systems offers a complete line of inertial sensors, such as Attitude and Heading Reference System (AHRS) or Inertial Measurement Unit (IMU), based on the state-of-the-art MEMS technology. Combining MEMS tactical inertial sensors with a quad-constellation, dual-antenna GNSS receiver, Ekinox Micro is a choice for mission-critical applications, meeting MIL-STD-461, MIL-STD-1275, and MIL-STD-810 standards. Measuring just 4.2 x 5.7 x 6.0 cm and weighing only 165 g, Ekinox Micro is small and lightweight, yet rugged enough to handle any application. It includes pre-configured motion profiles for marine applications (as well as land and air), allowing the sensor and algorithms to be tuned for maximum performance in any condition. It has a dual-antenna GNSS receiver for heading.

Ekinox Micro is RTK compatible and based on a tactical 0.8°/h class IMU calibrated across the entire operating temperature range, with accuracy roll/pitch of 0.015° and accuracy heading of 0.035° and accuracy position of 1.2 m in without any corrections or 1cm in RTK. Ekinox Micro also embeds several technologies to fight against GNSS jamming and spoofing. Its dual-band, full-constellation GNSS significantly reduces the chance of an attack being successful, and its mitigation algorithms filter jamming and spoofing, with flags to inform the user whenever corrupted signal is detected. Furthermore, Ekinox Micro offers an automatic aggressive regression mode to fall back on inertial sensors and velocity aiding as soon as a potential jamming or spoofing event is detected.

SEAmagine Hydrospace Corporation

https://www.seamagine.com/

Since 1995, SEAmagine's fleet of subs have accumulated more than 12,000 dives with a perfect safety record. All SEAmagine submersibles are classed by the American Bureau of Shipping (ABS) that performs the full design reviews and performs all the required surveys of each submersible individually during their construction and testing.

SEAmagine is in the final stages in the construction of a new three-person scientific submersible model that will be owned and operated by a U.S.-based scientific organization that focus on the environmental research of our world's oceans. Using this 1,300m depth-rated Aurora-80 SEAmagine submersible, the organization will spend five years studying, documenting and identifying the potential for expanded protections in waters crucial to the survival of the oceans. The submersible is equipped with a series of subsea imaging and navigation tools as well as a seven-axis hydraulic manipulator, custom HD underwater camera, and even a custom E-DNA sampling system. Built for science, this ABS Classed three-person Aurora-80 is designed for harsh sea conditions, has a dry weight of 9,000Kg and can perform multiple dives per day.

The New AURORA-90 & AURORA-100 series

SEAmagine is completing its first vessel of the AURORA-90 and AURORA-100 series that offer an extra-large cabin with modular seating that provides seating for three to seven people, depending on the interior selected and the maximum depth rating required. Based on the same platform, the two models differ in the size of the acrylic bubble. An extra metal hull section behind the window of each model provides precious additional interior space and allows passengers to each have seats located inside of the bubble for a nearly 270-degree view, with the pilot located in the center rear section.

These models can be depth-rated between 100m (328 ft.) to 1,000m (3,280 ft.) targeting leisure or tourism – hosting four, five, or six passengers, plus a pilot.

Valeport

Totnes, Devon, UK
President/CEO: Matthew Quartley
# of Employees: 112
www.valeport.co.uk

Valeport is a manufacturer of oceanographic and hydrographic instruments. Based in the UK, the privately owned, independent family business designs, manufactures and services its own underwater measuring equipment. Valeport has a philosophy of keeping development and manufacturing of products in-house, which allows it to retain complete control over all aspects of its product range. Valeport is known for its high accuracy sensor technology. Highlights of 2023 include:

The SWiFT Deep CTD is the latest in Valeport's range of SWiFT profilers for CTD measurements to depths of 6,000m. Offering increased versatility and no compromise on accuracy, the new SWiFT Deep CTD has been designed with the intention of a seamless workflow and offers the highest quality CTD profiles in a compact, robust and portable package.

The new profiler provides survey-grade sensor technology, coupled with Bluetooth wireless technology, a rechargeable battery and an integral GNSS module to geo-locate each profile.

In addition, the SWiFT Deep CTD provides computed salinity, density and sound velocity, using the UNESCO international standard algorithm and Chen and Millero equation. Data can be downloaded wirelessly, and instantly shared in industry standard data formats.

The new SWiFT Deep CTD features Valeport's signature magnetic switch ring. The switch ring is easy to operate even with cold hands, it simply turns through 90 degrees and clicks into position. With LED status for GNSS, battery and communications, the user-friendly end cap delivers fully automated data transfer with no user input required. The SWiFT Deep CTD is constructed from titanium and the CTD sensors are housed in a strong acetal sensor guard. With an operational battery life of up to five days and the convenience of USB charging, problematic battery changes are a thing of the past.

Valeport technology is part of an ongoing collaborative project to develop a new, non-invasive method to measure and monitor seagrass biomass on the seabed. Trialed around England's South West coast, the new technique is a collaboration of Valeport and HydroSurv, working with the University of Plymouth and Natural England.

The trial builds on the concept of the acoustic reflectivity of seagrass providing information to characterize submerged aquatic vegetation. A full-stack solution consisting of a Valeport VA500 altimeter installed onto a HydroSurv REAV-28 Uncrewed Surface Vessel (USV), specifically developed for this project, provides a platform to survey seagrass sites. A large, validated signal library and deep learning algorithm, developed by the University of Plymouth, deciphers the survey data to predict seagrass distribution. The data is visualized and interpreted within a cloud application created by HydroSurv.

The USV platform facilitates accurate repeat surveys that can be compared to monitor temporal changes in seagrass coverage for the planning of protection and regeneration projects at biodiversity-rich worksites. The full solution was successfully demonstrated to project stakeholders for the first time last year, and complements traditional diver surveys to cover much larger areas and allows rapid re-survey work as required.

The central component of the USV's payload is a Valeport VA500 altimeter. Valeport undertook custom firmware modifications to the VA500, ensuring low noise and high-quality acoustic profiles sampling at up to 10Hz. Designed for underwater positioning, the VA500 altimeter is typically installed on autonomous, remotely-operated or towed underwater vehicles to provide precise measurement of the altitude from the seabed. Using advanced digital signal processing techniques, the VA500 effectively filters out ambient noise and focuses on signal returns.

Where the standard VA500 altimeter receives multiple signal echoes and must determine which echo corresponds to the seabed, the customised instrument used in this project provides the full echo response. Subsequently, all measured echoes, along with their strength and sharpness, are further analyzed in the processing algorithm.

TideWise

www.tidewise.io

TideWise is a Brazilian company that develops, integrates and operates robotic systems.

Between 2019 and 2020 Tidewise designed and built the USV Tupan, the first uncrewed vessel to be registered with the Brazilian Navy. The USV Tupan is an autonomous multipurpose vessel approximately five meters long, made of aluminum driven by a diesel-electric propulsion. The USV Tupan does not need a crew on board, which eliminates risks to human life; it also has a lower operating costs (OPEX) compared to conventional vessels performing the same services. In 2023 TideWise started the process of expanding its fleet, consolidating our solution to meet the demands related to the Economy of the Sea.

TideWise has also been innovating to increase new products for the offshore energy and defense area, with projects under development in partnership with Shell Brazil and EMGEPRON - Naval Project Management Company. Integrating high engineering attributes with robustness for the heaviest jobs at sea, she has been operating since 2020 and has already provided services to large companies such as Petrobras, Repsol Sinopec Brasil and Shell, Technip, in Brazil, and to the European electrical distribution company Elia Group, in Belgium. To date, TideWise has invested more than $6 million in research and development of new products and services.

Project "Transshipment between offshore units using USV," delivered to Petrobras in 2021: the first lifting of USV in the open sea to be carried out in Brazil, a milestone for national engineering. The project intends to support the offshore logistics of offshore energy production operations, especially in pre-salt fields. Offshore wind farm inspection operation using USV+Drone and onboard sensors, delivered to Elia Group in 2022: TideWise made history by performing the first operation of its kind worldwide, in North Sea waters, Belgium. The project was delivered on time and was planned and operated in stages and in two different countries, Brazil and Belgium.

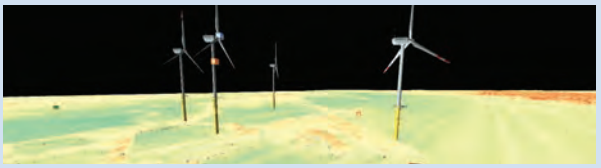
UTEC

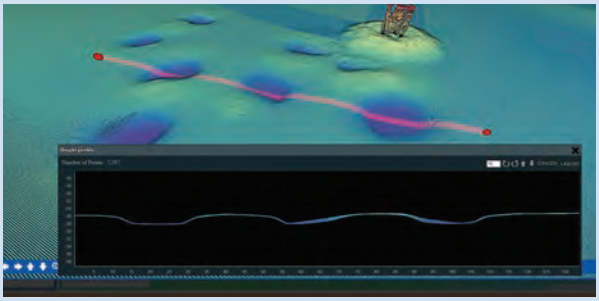
www.acteon.com

UTEC, a Geo-services brand in Acteon's Data and Robotics Division, provides a wide range of global survey, positioning and data management services.

Surveys performed by UTEC are designed and deployed to use less equipment and optimize personnel and vessel usage to reduce the length and cost per survey, and dedicated teams remain on a project from start to finish to ensure that knowledge is retained throughout the project cycle. UTEC also specializes in 3D asset management software solutions, land surveying, laser scanning, photogrammetry, and dimensional control services.

For more than 10 years, above-water asset owners have been enhancing safety and reducing costs using the iSite collaborative virtual asset and data management platform. UTEC has now developed a core technology platform, iSite Subsea, designed specifically to meet the needs of the offshore renewable energy market and oil and gas subsea asset owners. iSite Subsea is a cloud-based platform that gives users an intuitive hosting, accessibility and visualization service for their subsea assets and data. Using this platform, operators can source, view, manage and report on seabed, survey and asset data using a single, secure cloud-based interface. It enables interrogation and comparison of data over time, remotely, 24/7 and without specialist software knowledge. iSite Subsea helps to reduce costs, lower risk, enhance health and safety, and deliver better-informed decisions with increased operational efficiency. The platform facilitates the digital storage and delivery, throughout the lifecycle of a subsea asset, of geophysical, geotechnical, structural integrity monitoring, inspection and maintenance surveys, giving developers and contractors access to the data they need to plan, evaluate and solve safety, environmental and risk scenarios.





Sensor Technology Ltd

https://sensortechcanada.com/

Sensor Technology is a company that elevates underwater acoustic projects, crafting products that permeate underwater exploration and communication. At the core of Sensor Technology's ability lies its proprietary ceramic technology: meticulously sourced raw materials converging to form ceramics designed with a singular purpose: performance and acoustic clarity. Sensor Technology's skills also extend beyond ceramics alone. A diverse range of developed and refined hydrophones and transducers meet different needs of underwater acoustic projects. Whether it's capturing aquatic whispers or deciphering the echoes of the abyss, Sensor Technology's suite of hydrophones and transducers offer the precision and adaptability required to orchestrate aquatic symphonies.

Since its inception in 1983, Sensor Technology has emerged as a frontrunner in acoustic sensors driven by proprietary piezoelectric material formulations and technology. Its experience encompasses a wide spectrum of customization options, spanning from initial development to the assembly of both small and large product volumes.

The company is not reliant on external sources for piezoceramic materials; instead, it innovates by crafting its own ceramics, a commitment that has entailed substantial investments to ensure the production of dependable end products that cater to diverse customer needs and situations.

SENSOR TECHNOLOGY

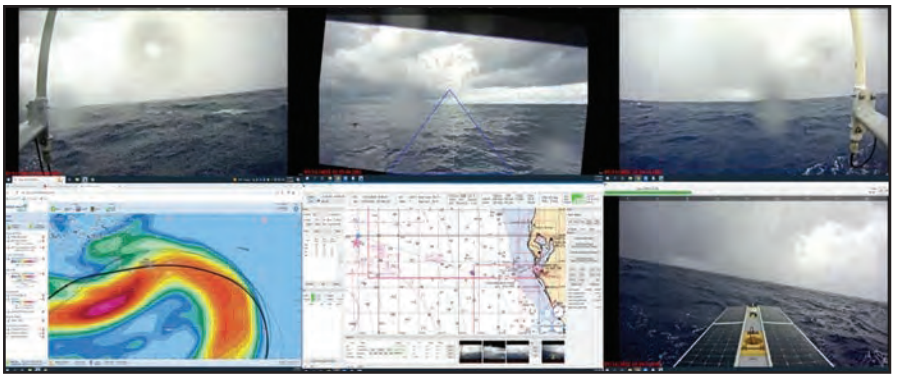
Silicon Sensing

www.siliconsensing.com

Silicon Sensing Systems Ltd is a leader in silicon MEMS gyroscopes, accelerometers and inertial measurement systems, focusing on products delivering high performance, ultra-reliability with affordability. The company has supplied more than 25 million MEMS sensors to thousands of customers worldwide and has a heritage in inertial sensing that can be traced back to the birth of the gyroscope over 100 years ago. A number of Silicon Sensing's products are particularly suited to the exacting requirements of the marine environment, combining low size, weight and power consumption. The DMU41 is a market disrupting, nine degrees of freedom (DoF) inertial measurement unit (IMU) that delivers inertial sensing performance that is directly competitive with far heavier, larger and more costly, fiber-optic gyro-based IMUs. Its volume, weight and power consumption are all a substantial reduction on the previous generation device. For customers looking for a single axis gyro, the CRH03, consumes significantly less power than its predecessor (CRH02) and incorporates improvements in both micro electro-mechanical systems (MEMS) and electronics, with new drive electronics and improvements to the sensor head. CRH03 is available in five rate ranges, including an option of 10 degrees per second. For use in severe environments such as subsea downhole drilling, the company's CRS39A upgrades the established CRS39 gyro. CRS39A includes a move to a single board from two, reducing the unit's mass by 40%. This simplifies installation in space-limited applications such as the 25mm diameter cylinders typically used in downhole drilling equipment. Supporting this latest generation of products is a family of established sensors and systems including the highly successful DMU11 IMU. Proven in maritime use, this low cost, six DoF IMU continues to deliver complete motion sensing in three-dimensional space with performance calibrated over its full rated temperature range.

SeaTrac Systems, Inc.

www.seatrac.com



Picture a 15-foot kayak with solar panels on top. Instead of people, the craft is outfitted with sensors, cameras and all manner of ocean observing instruments. Now picture sending this uncrewed platform off to sea for months at a time to collect its data far over the horizon, or alternatively cruising along shallow coastlines, lakes and estuaries while you sit comfortably at your desk and receive its findings and monitor its course in real time. This is the idea behind SeaTrac Systems, Inc., which manufactures, sells, and rents persistent, solar powered USVs from its headquarters in Marblehead, MA. Founded in 2017 by two MIT trained naval architect/serial entrepreneurs who spotted an opportunity in the market for a boat drone that was simpler, more reliable, and affordable than alternatives. SeaTrac's sweet spot is jobs at sea that are often dirty, dull, dangerous or expensive to perform with crewed boats—activities such as weather tracking, hydrographic surveys, eelgrass mapping, harmful algal bloom monitoring, persistent metocean data gathering, surveillance and reconnaissance, and mammal monitoring, among others. Customers include commercial, scientific and military end users who are looking to operate in the ocean more greenly, safely, and cost effectively.

The SeaTrac SP-48 Uncrewed Surface Vehicle (USV) is a 15 ft. platform capable of deploying a wide range of sensors. It uses an array of solar panels to charge a large internal battery pack that powers the USV and its payloads. The USV uses a brushless electric motor for propulsion, with a cruising speed of 3 kts and a maximum speed of 5 kts. Data can be streamed back in real time over the available redundant communications methods including RF for line of sight, cellular for nearshore when available, and satellite for over the horizon operations. The USV can also be equipped with custom communications equipment. The standard onboard sensors, including GPS, 360-degree cameras, AIS transceiver, and met station provide situational awareness to remote operations centers and enable effective remote piloting from nearshore coastal environments to over the horizon missions. The SeaTrac Dashboard Control Software allows the pilot to manage the flow of data based on the mission needs to provide key information about the system itself and the surrounding environment. The Dashboard software can be used to program and execute missions while monitoring the status and health of the USV. The SP-48 can be launched quickly from its trailer at any boat ramp or can also be deployed with a crane from a pier or ship using the center point lift.

SMD

https://www.smd.co.uk/

SMD is a subsea technology company that has been developing work-class ROVs for over three decades. For 2023, the company's latest products are the electric Quantum EV and Atom EV ROVs, which are more compact than previous generations, help reduce CO2 emissions, and can even operate autonomously when equipped properly. According to SMD, Quantum EV is a 270hp heavy construction vehicle with a high payload and powerful thrust output. Atom EV is a 130hp light construction vehicle suited to shallow-water, high-current work in offshore renewables. "Both vehicles are more compact than previous generations, so they will fit on smaller vessels or uncrewed surface vessels to help reduce CO2 and cut client costs," SMD shared. The ROVs feature a new DC power transmission system that is said to be far more efficient and environmentally friendly than previous generations. Further, the ROVs employ advanced flight control computers to help complete operations faster and maintain control in arduous conditions, such as high currents, SMD explains. The flight control system can also link to other SMART systems unlocking autonomous functionality. They use unique electric propulsion technology that offers extreme performance in fast-moving water, but not at the expense of fine control. "All this adds up to a range that can work where current generation vehicles can't, that opens up the operating weather window and delivers higher quality results. All while being more environmentally friendly," SMD says. Looking to the future of work class ROVs, SMD shared, "Work class ROVs are a multipurpose tool. And as with any tool there is always a focus on how well it does the job, its reliability, and its dependability. But the offshore energy mix is changing. And we are also seeing changes to the way people work (and go to sea) with much more emphasis on work-life balance and the environment. So the robotic tools that construct and maintain energy infrastructure need to evolve. In the future, the tools we today call work class ROVs will need to be suitable for uncrewed vessel and resident work; we may see less cabled connections to the surface and onboard power systems; we will probably see AI start performing tasks, with a move from person in loop to person on loop-command to control. It will be easier and faster to undertake tasks and see the results, with real-time information at the fingertips of stakeholders anywhere in the world."

SubSeaSail LLC

www.subseasail.com

San Diego-based SubSeaSail (SSS) is a six-year-old BlueTech innovative company aiming to develop unique, affordable, Uncrewed Surface/Subsurface Vehicles (USSVs) that will be able to function above and below water. To date, SSS has received three grants from US government agencies (US Dept. of Energy and National Science Foundation) to develop these vehicles. SSS has a small core team augmented by a number of outside support and technology firms that are world-class experts in their fields. SSS started selling vehicles in 2023 and plans to transition to contract manufacturing in 2024 to meet strong demand for its products.

SSS vessels are designed to be autonomous, affordable, 100% energy harvesting, long-duration, multi-usage, ultra-low signature (acoustic, heat, radar and visual). One major differentiation for SSS vehicles is that they do not have a traditional hull, which creates "hull slapping," wake and other discoverable characteristics. Vehicles have been designed as "edge computing" platforms that can gather data, process into actionable information onboard and exfiltrate that as exception-based reporting. The semi-submersible, monohull OBSERVATION vessel called HORUS (TRL 7-8) is an ultra-quiet vehicle ideal for Passive Acoustic Monitoring. With partners, SSS has developed unique PAM arrays that will attach directly to the lower, underwater HORUS tube to listen near the surface or further underwater when the vehicle is submerged. The HERMES multi-hull cargo vessel (TRL 5-6) will be able to deliver loads to the beach or harbor and represent secure, offshore, underwater storage, as needed. SSS is pursuing an active Intellectual Property program. As of June 1, 2023, it has five issued U.S. patents and five U.S. patents pending, plus additional pending patents internationally.

Subsea Tech

www.subsea-tech.com

Subsea Tech offers a wide range of equipment and technological solutions, from underwater robots (ROVs) to surface drones (USVs) and specialized accessories. Subsea Tech specializes in marine and underwater technologies with three main activities:

- A Research & Development division in charge of developing solutions to answer specific needs in underwater observation, intervention or monitoring, based on customer supplied specifications.
- A Production division responsible for the fabrication and support of small and medium series of standard products for underwater video and sonar inspection and monitoring such as ROVs, unmanned catamarans (USV) and underwater cameras. These systems are ultra-portable and are specially adapted for inshore and coastal waters (<500 m) and turbid environment.
- A Site Services division which provides inspection services such as underwater inspection and measurements with ROVs on submerged infrastructures like dams, bridges, harbor facilities, canals and pipelines, 3D modeling and bathymetric surveys with unmanned vessels.

Subsea Tech invests in research and development to develop technologically advanced products and solutions that meet the changing needs of the subsea industry. Its latest innovation is the SEACAT project, a fully integrated solution for the complete inspection of wind turbines (submerged and emergent parts) without any operator at sea. The SEACAT project consists of a multi-robot system featuring an autonomous vessel (USV), an underwater robot (ROV) and an aerial drone (UAV); the ROV and UAV are operated from the USV.

The SEACAT carrier vessel is a 6.8 m long, 1.2 T catamaran-type autonomous vessel (USV) deploying a TORTUGA inspection-class underwater robot (ROV) (40 kg, depth 500 m) and a DJI Matrice 210 RTK aerial drone. The SEACAT is powered by an electric propulsion system with a diesel generator, giving it a 7-day autonomy, with seakeeping up to sea level 4-5. The 3 robots feature automatic navigation modes with trajectory tracking, dynamic positioning, auto depth, auto altitude, auto heading, auto speed, etc., all supervised from a shore station. The vessel is equipped with high-resolution bathymetry sonar, RTK GPS positioning, obstacle avoidance and acoustic positioning. The underwater robot is equipped with two full HD cameras, an imaging sonar, a thickness measurement probe, a cathodic protection control probe, a cavitation cleaning lance and a photogrammetry sensor.

UNDERWATER CAMERAS, LIGHTS AND OCEAN LANDERS

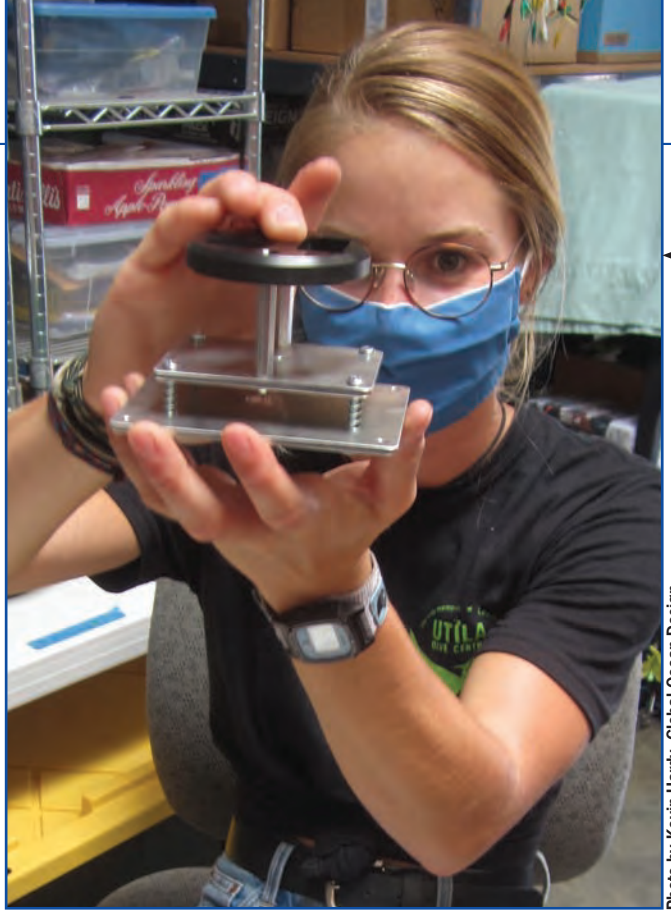


Photo by Kevin Hardy, Global Ocean Design

By Kevin Hardy, Global Ocean Design LLC

Observation is the first step of the Scientific Method. "What's that?", leads to research, hypothesis, and then all the rest that ends in "discovery". When we can't send humans to look, we send the robots.

Scripps Professor John Issacs developed his first deep sea "Monster Camera" in the 1960's from surplus WWII aircraft nose cameras. His observations lead him to realize that photographs identify species, while film shows behaviors. It was another Scripps professor, Richard Rosenblatt, who counseled Issacs to look at fish from the lateral side view, not the dorsal top-down view.

Jacques-Yves Cousteau spoke of undersea vistas as "a world without sun". A fair point, even if filming is being done within the photic zone, night creates the need for artificial light. Deep water is perpetually dark.

Cameras, also called "imagers", are almost exclusively digital. The mission goals define the required camera features. An ROV reading gauges may only need black-and-white images from a monochromatic red LED so fish are not attracted to the front of the vehicle, obscuring the pilot's view.

Underwater camera applications run from ocean landers (this column's focus), AUVs (closely related to ocean landers), ROVs, fish farms, IOOS Nodes, inshore service, and many others.

Camera features include choice of power source (battery or tether), intervalometer or topside control, low light sensitivity, and self-recording or remote recording.

CAMERAS AND OCEAN LANDERS

Landers have unbeatable persistence on the seafloor. Landers can be placed at the junction of undersea canyons and ravines that act as trails and pathways for undersea animals. Measurements of environmental conditions, such as oxygen, turbidity, and temperature, can be correlated to animal populations, distribution, behavior, and potential speciation.

Baited lures bring animals in for better images. Short term deployments may have baited traps to collect species for DNA typing. Images give the context of those collections.

Cameras and lights can be hard mounted to a frame, held by a single-axis rotator, or mounted to a 2-axis pan-and-tilt. Vehicles such as ROVs and AUVs change views using the mobility of the vehicle itself. Landers can be made to pirouette on the seafloor, rotating up to 720°, to capture an entire panorama of its landing site. This was dramatically shown during James Cameron's DEEPSEA CHALLENGE Expedition with DOV MIKE in the Sirena Deep of the Mariana Trench in 2012.

EXPERIMENTATION

Landereans can inexpensively explore camera systems by building their own. The path to discovery and understanding

Figure 1

Stony Brook University PhD candidate, Ashley Nicoll, assembles the interior mount for a GoPro Hero/CamDo Blink controller time lapse underwater camera. The springs are used to gently press the camera against the interior face of the acrylic viewport. Read about Ashley's MS project in Lander Lab #2, MTR, Vol. 65, #3, March/April 2022.

can begin with a simple system based on a board camera or POV (Point-of-view)/Action camera, such as a GoPro. Keep It Simple, Sailor (KISS). Start with the camera, add the recorder, add the lights, add the intervalometer add the housing. Packaging and PCBs come after you work out the circuit details.

CAMERAS

Board cameras come with optical devices and CMOS image sensors mounted directly on a circuit board, providing an integrated, small volume design. You'll find a variety of choices, including resolution, auto-exposure, sensitivity, frame rate, video output, color/black-and-white, and others. Some are specifically made to interface with Arduino, Raspberry Pie, or other programmable boards. Prices vary, but start as low as $6. Many have the CMOS imager dead center on a square mother board, perfect for fitting into a cylinder. A shallow water housing can be as simple as a PVC cap with a flat acrylic viewport bonded to the front as often seen in the MATE ROV contest.

A "bullet" or "lipstick" camera is a very small video camera roughly the size and shape of a tube of lip balm. A USB digital 50-500X magnifying bullet camera sells for around $20 that could be used for extreme close-ups of in-water or seafloor objects.

POV/ACTION CAMERAS

Action cameras, such as the GoPro Hero, are small, rugged digital cameras designed for capturing first-person action shots. Newer models include image stabilization, autofocus, and high-speed processors. MicroSD card storage is common, with capacities up to 1Tb. Though the GoPro Hero internal battery has a short life, the camera can be powered through the CamDo from an external battery.

TIME LAPSE CONTROLLER/INTERVALOMETER

I highlight the CamDo BLINK controller <https://cam-do.com/> as one I have had good experience with. There are others, such as Group B (see below) that look interesting. Some hacker work could be done to interface other camera models through their WiFi and Bluetooth remotes.

BIOFOULING

Long term deployment of cameras in the photic zone will certainly suffer from marine growth. Severn Marine Technologies (MD) <https://clearsignalcoating.com/> is developing clear biofouling solutions for undersea optical instruments. Other solutions, like wiper brushes and UV LEDs, have been demonstrated.

Photo courtesy of e-con Systems

Figure 2

A 13MP high resolution board camera.

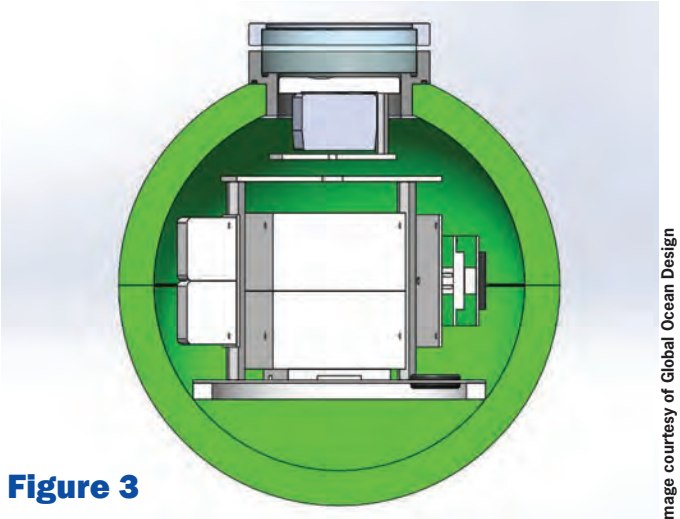


Image courtesy of Global Ocean Design

Figure 3

A GoPro/Hero 4 Black with CamDo controller fits inside a 10" polyamide sphere with viewport. There is room to spare for two 4S 10,000mAh LiPo batteries with individual BMS, two LED drivers, two MOSFET power transistors, and a voltage regulator to power the CamDo and GoPro. Not shown are through-hull penetrators, the vacuum/purge port and equatorial o-ring in the bottom hemisphere. The housing as shown can hold a Sony A7Sii with a 12.2MP full frame 35mm CMOS sensor with a lens. The Sony offers ISOs of 50,000 and higher. There is room inside the sphere for an Arduino controller, LED drivers, and voltage regulator to power the Arduino and Sony camera. A second 10" sphere would contain the LiPo batteries. Thanks to Larry Herbst for pursuing the Sony camera application.

Photo by Kevin Hardy, Global Ocean Design

Figure 4

A Global Ocean Design Picolander carries a GoPro Hero 4/CamDo self-powered, self-recording camera with two external lights to depths up to 2km. Lights are best located away from the camera to minimize backscatter in cloudy water. The expendable anchor and dual burnwire release elements are not shown. The vehicle is approximately 13" wide x 24" tall, and hand deployable.

LIGHTS

LEDs are ubiquitous. Light goes out the front, while heat goes out the back, making the housing design straightforward. Various approaches to covering the LED in clear materials have been devised, from acrylic flat plates to clear silicone rubber sheets. Some cast the LEDs in a block of clear acrylic. Heat is the principal enemy of LEDs. Much has been written about topside luminaire design, including the use of

Commercial firms that manufacture self-powered/self-recording underwater camera and light systems include:

Arctic Rays (FL)
https://arcticrays.com/products/customsystems/
Group B Inc (FL)
https://www.groupbinc.com/
SubC Imaging (NL)
https://www.subcimaging.com/autonomous-camera

Commercial firms that manufacture tethered underwater lights and cameras include:

Arctic Rays (FL)
https://arcticrays.com
Barlus (CN)
https://barluscam.com/
Birns (CA) https://birns.com/
DeepSea Power & Light (CA)
https://www.deepsea.com/
Deep Trekker (ON)
https://www.deeptrekker.com/
Deepwater Exploration (CA)
https://dwe.ai/
Imenco (UK)
https://imenco.no/technology/camera-lights
J.W. Fishers (MA)
www.jwfishers.com
MacArtney/Luxus
https://www.macartney.com/what-we-offer/systems-and-products/cameras-and-lights/
Outland Technology (LA)
https://www.outlandtech.com/
Remote Ocean Systems (CA)
https://www.rosys.com/
ROVSCO (TX)
https://www.rovsco.com/
Sidus Solutions (CA)
www.sidus-solutions.com
SubAqua Imaging (CA)
http://www.saisweb.com/
SubC Imaging (NL)
https://www.subcimaging.com/
Teledyne Marine/Bowtech (DK)
https://www.teledynemarine.com/products/product-line/cameras-lights/a

heat transfer material behind the PCB to carry the heat away from the LEDs (google "CREE LED Luminaire Design Guide"). LEDs are completely pressure tolerant as they have no compressible volume. A pressure compensating fluid, such as mineral oil may be used. Avoid silicone oil has the cast dome on an LED is often silicone, and may be affected by immersion in a fluid of a similar nature.

Tip: A reasonably good 30-watt, 2600 lumen LED array is <$10 and 12-24vdc input LED driver is <$9 plus shipping at <www.mpja.com>.

If using a MOSFET as a high-power switch to control the lights, look for the RDS(ON) value, "Static Drain-to-Source On-Resistance." This is the voltage (VGS) that needs to be applied to the gate to fully switch the MOSFET on. Depending on the part you select, this will be between 4v to 10v. I look for MOSFETS that fully saturate at logic levels of 5v, such as the IRL540. A helpful review of MOSFET circuits is found at <www.electrical4U.com/mosfet-circuits/>. A useful MOSFET worksheet is at <www.addohms.com/mosfet-guide/>

CONCLUSIONS

Building you own underwater imaging system provides insight to what manufacturers have faced, and what questions to ask sales reps. You can see the engineering behind a commercial design because you've done it. You can also spot mistakes. Cameras for ROVs, which are in and out of the water frequently, can get away with some dissimilar materials, such as a 316SS snap ring to hold a viewport into an anodized aluminum body, as the vehicle gets rinsed off after every dive. Not great design practice, but manageable. The same camera on an IOOS node will see constant exposure right through to failure by galvanic corrosion. I've also seen a manufacturer who laser engraved the company logo and serial number right through the black anodize layer to the aluminum substrate. Those shiny silver letters are bare aluminum.

Many parts can be purchased by an experimenter very cheaply. Those are the best to learn with. One failure doesn't cost a lot. When it really matters, though, spend the money on better components, and do lots of testing pre-deployment. Cree LEDs produce more light per watt, so less heat, and their footprint is smaller, so the housing is smaller. LUXdrive and Meanwell make small and efficient LED drivers. Check out www.ledsupply.com.

Further Reading

DeepSea Power & Light (San Diego, CA) has published numerous articles on undersea lighting and imaging.
Go to: https://www.deepsea.com/knowledgebase/

Other good references (Tip: try www.bookfinder.com):

- Christ, Bob; Wernli, Bob, The ROV Manual, Second Edition, Waltham, MA, Butterworth-Heinemann, 2014

- Moore, Steven; Bohm, Harry; Jensen, Vicki, Underwater Robotics, Hong Kong, Marine Advanced Technology Education (MATE), 2010

- Cross, E.R., Underwater Photography and Television, New York, Exposition Press, 1954, a seminal early text

Readers are encouraged to share their experience, inventions, and feedback by writing the author at khardy@marinelink.com

COOL NEW TECH

*While the **MTR100** is all about new and emerging technologies, here are a few that the editorial staff found particularly compelling from companies large and small, new and old.*

Courtesy Balmoral

Balmoral unveiled a new scour protection system that integrates seabed protection and flow reduction to minimize operational costs and potential cable failure in the offshore wind industry. The HexDefense structure eliminates the requirement to dump rock, instead providing a non-invasive approach to protecting the monopile and the immediate surrounding area. The light-weight advanced composites construction and streamlined installation method makes it easy to install without the need for additional vessels. Additionally, the system is capable of use with antifouling coatings and does not require special equipment for end-of-life recovery. The interlocking panels are generally 10m long and custom-sized to fit varying monopile diameters and feature integrated lifting and access points. The installation process involves sinking the foundation, sleeving it with HexDefence, fitting the transition piece and assembling the pylon and blades.

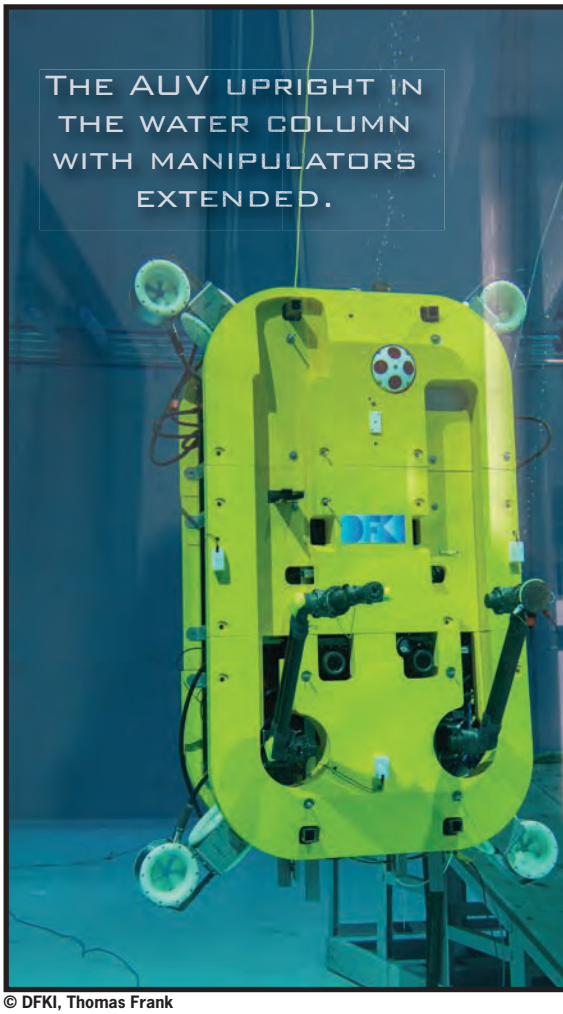
Framework Robotics was founded in 2020 in Rostock in Germany when Nico Günzel and his colleagues do what innovators in the subsea space do: they take their knowledge and experience, envision a better way to explore the world's waterways, and start a company, literally in a basement. "We didn't have a lot of money for the first prototype, we didn't have the tools or the variety of 'stuff' we needed," recalls Günzel, "but we had a 3D printer and our know-how." With the vision of designing and building a modular, scalable and transformable family of vehicles for work on and below the waters, Framework Robotics was off to the races, investing "thousands of hours" in designing and building its first prototype. "We wanted to build a platform for different solutions and different missions. Emerging from the basement, Framework Robotics today employs 13, with plans to offer its first market-fit ROV by the middle of 2023.

Today Framework Robotics already has a broad palette of products in the works, all built on the modular/reconfigurable/scalable mandate, and including:

- Companion, a Remotely Operated Towed Underwater Vehicle (ROTV)
- Buddy, a Remotely Operated Vehicle (ROV)
- Scout, an Autonomous Underwater Vehicle (AUV)
- Tracker, a Remotely Operated Crawling Vehicle (ROCV)

The ROTV is on the market as of 2022, and recently, Günzel shared that the company has its first pilot customer for Companion. The ROV Buddy, which is built with a 1000m depth rating, with an optional 6000m depth rating, debuted at Ocean Business 2023 in the test tank. Günzel said that still today 95%

Courtesy Framework Robotics

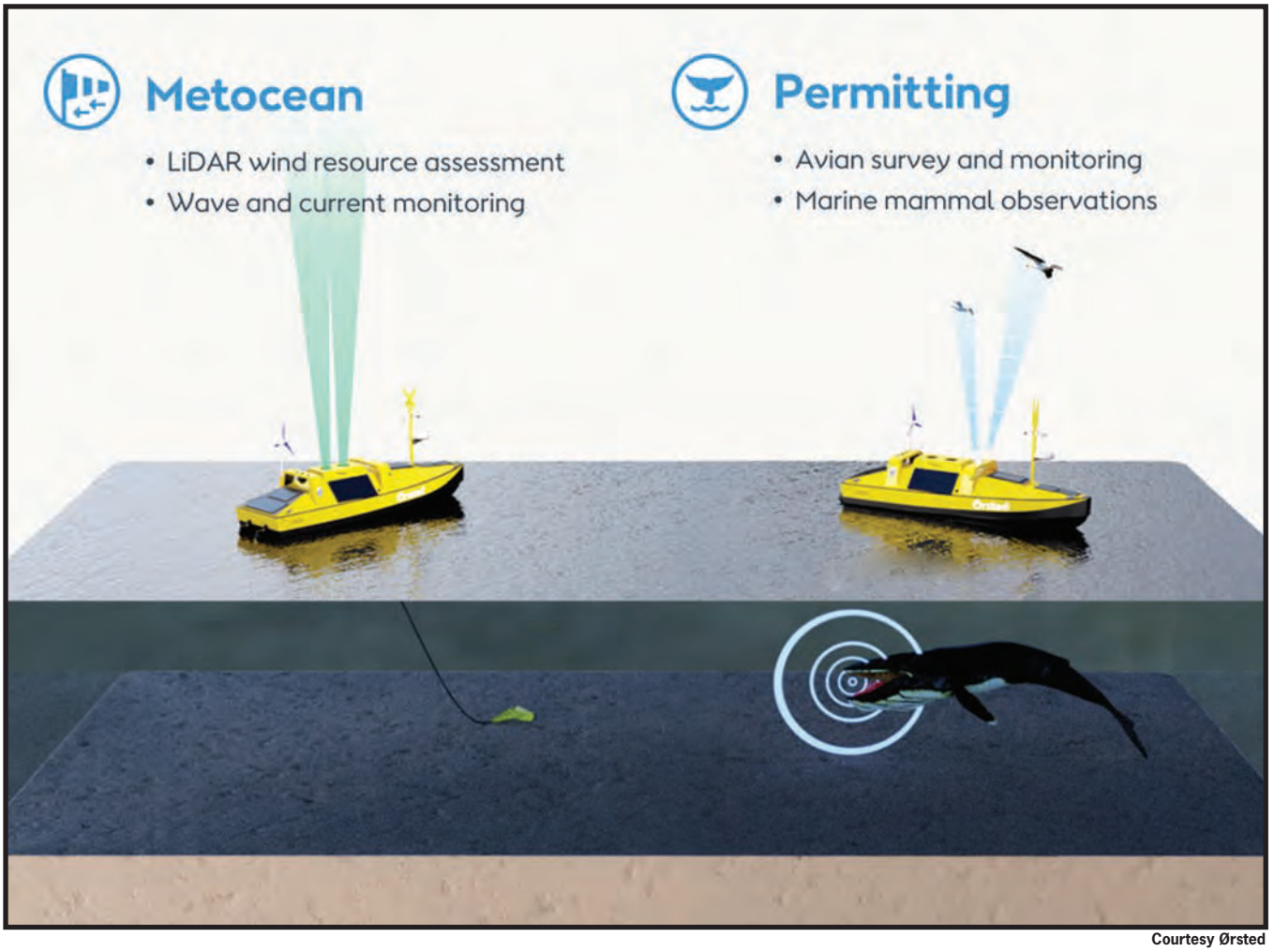


© DFKI, Thomas Frank

of its vehicle components are made on its 3D printer, specifically an industrialized multi-jet fusion HP 3D printer. While the 3D printer is core to the company's value proposition, Günzel stresses the importance of modularity—in using the same components across multiple vehicle types and size configurations, allowing Framework Robotics to build and maintain vehicles that are custom designed and built but the mass market approach of being able to repair and replace components somewhat seamlessly via 3D printing. "We want to be a game changer for ROVs and for all robots underwater," said Günzel.

As the discovery and recovery of unexploded munitions grows in importance globally, technologies are being developed by many organizations, including the **Robotics Innovation Center of the German Research Center for Artificial Intelligence** (DFKI), headed by Prof. Dr. Frank Kirchner. The CleanSeas project, funded by the German Federal Ministry of Education and Research (BMBF) until December 31, 2025, aims to create the technological basis which enables robots to autonomously detect and handle critical infrastructures underwater. To that end, DFKI's Robotics Innovation Center is developing AI solutions for the following three areas: precise navigation in the close range of critical objects, 3D reconstruction of objects using various sensors, and whole-body control for (partially) autonomous object manipulation. The autonomous underwater vehicle (AUV) Cuttlefish, developed at DFKI, serves as the robotic test platform. The AUV has two deep-sea capable gripping systems for flexible handling of objects underwater. Thanks to its design and AI-based control, it can change its center of gravity and buoyancy during a dive and assume any orientation. Comprehensive environment perception thanks to sensor fusion and generative AI In the case of recovering munitions from oceans, the AUV must be able to approach its target object without colliding with it. For this purpose, the vehicle is equipped with a variety of sensors such as sonars, cameras, laser scanners and magnetometers.

The technologies developed will initially be tested under controlled laboratory conditions. For this, the researchers have



Courtesy Ørsted

access to the DFKI's Maritime Exploration Hall in Bremen.

Ørsted designed, developed and patented an uncrewed surface vessel (USV) named Hugin USV for offshore met-ocean measurement campaigns. The USV has a built-in navigation system, which enables it to travel from shore at various degrees of autonomy, and it can be controlled both in line-of-sight or from a beyond-line-of-sight remote control center. The USV is designed as a generic sensor platform and can collect data on wind conditions, the state of the seabed, and biological and ecological measurements (among other things), depending on the chosen sensor instrumentation. The prototype USV was built by the Danish shipbuilder Tuco Marine Group, and the USV control system is delivered by the innovative Norwegian company Maritime Robotics AS. "What's so special about our USV concept is that it can bring our measurement equipment to and from our offshore sites without the need for large, specialized support vessels, and, while on site, it can operate autonomously for extended periods of time, measuring large amounts of data that can be sent onshore and processed in real time," said Frederik Søndergaard Hansen, Program Manager and co-inventor of the USV concept. The prototype vessel has been tested in Danish and Norwegian waters and has been operational during hurricane conditions, where it experienced waves up to nine meters in the North Sea. Hugin USV has also achieved type validation as a floating LiDAR system by DNV, enabling it to be used for commercial operations related to wind farm development. The results are so good that Ørsted has started a serial production of a new class of USVs. The plan is to produce five new USVs by the end of 2023.

Created by a group of five engineering seniors from the University of Pennsylvania for their capstone project is **Popeye Labs** which invented a device which combines AI and video to help a ship's captain predict anchor drag before it begins.

During the team's phone interview with a Greek captain, he brought up the current practice of anchor-watch: the deckhand, "let's call him Popeye," walks every hour all the way to the

front of the vessel to report back to the bridge the direction and tension in the chain. Popeye does this rain or shine, even on a moonless night at 4am, on a frozen deck. And that happens every hour at this moment on every anchored vessel worldwide.

The safety hazard for the deckhand, let alone the myriad risks from re-active anchor dragging, seemed quite profound, inspiring the search for technology that can help boost safety and productivity, while reducing risk and cost.

Taking advantage of accrued knowledge plus guidance from professors like Sid Deliwala, Nick McGill, Micheal Carchidi and Kostas Daniilidis, the five students were able to redefine the problem from first principles and come up with a novel solution.

Using state of the art Computer Vision techniques, the team developed a chain-recognition model. By pointing a camera placed at the bow of the ship directly on the anchor chain, it's possible to extract the tension and direction of the chain. Using that, they model the shape of the catenary and back-out the static friction coefficient at the specific geolocation at the anchorage. This allowed the ability to predict anchor dragging before it happened. Knowing this, the captain can save fuel by avoiding unnecessary re-anchorings as well as protect Popeye. Storing the footage provides also a system of record for insurance purposes.

The team was invited to present at the US Coast Guard's HQ in Washington DC, after which additional potential uses for the technology were proposed: Pirate mode, Overboard mode and Perimeter mode.

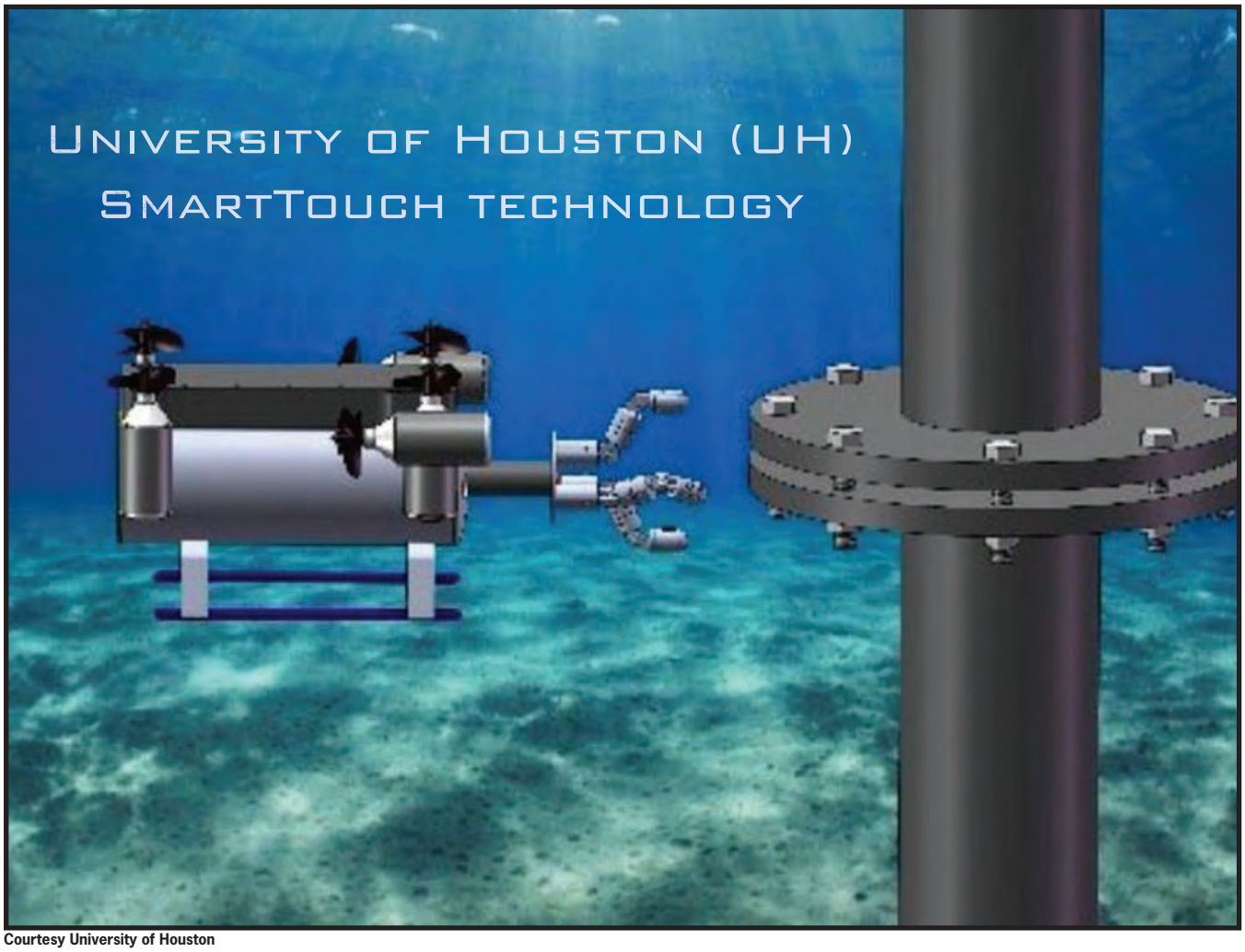
Prevco developed the use of Heat Sink Pipes to address the problem of how to get heat out of a subsea enclosure. They work by using a thermodynamic working fluid which is inside a sealed hollow thermally conductive tube, lined with a capillary structure or wick. This method can transmit thermal energy at rates of one hundred times faster than through solid conductors.

Heat pipes are essentially a closed evaporator-condenser sys-

tem comprising sealed hollow tubes. When heat is applied to one end of the heat pipe, the highly volatile liquid in the wick evaporates and the gas fills the heat pipe hollow center. This diffuses throughout its length where the external portion of the heat sink pipe or radiator, releases heat into the ambient water. Condensation takes place at the point of heat transfer and capillary action within the wick returns the condensate to the evaporator (heat source) and completes the operating cycle. The PREVCO dual pipe design has a Copper Beryllium radiator exposed to sea water with approximately a ~250W capacity.

The heat sink pipe method has proven to be effective, with a better energy-to-weight ratio and more cost effective.

Subsea7 reports a major advance in its pioneering remote piloting technology offering by fully operating a workclass ROV from Scotland to carry out operations 9,400km away off the coast of Brazil. The success of the project has proven that the technology and capabilities developed by Subsea7 can



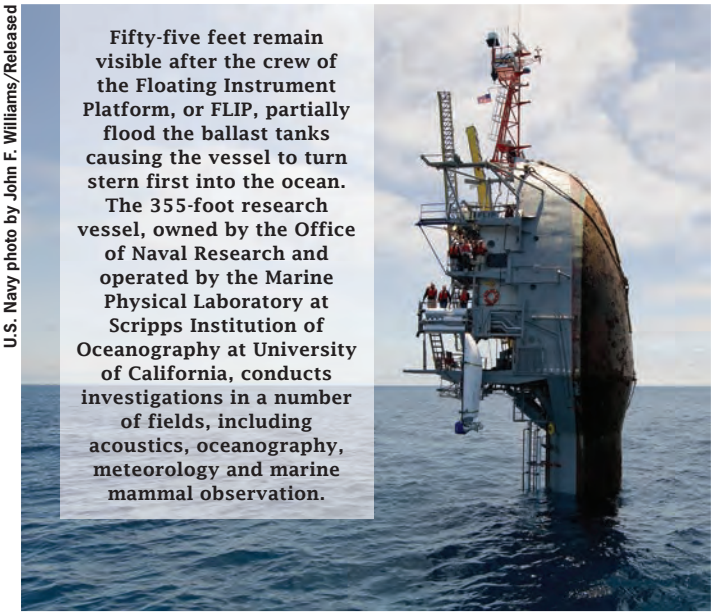
Courtesy University of Houston

perform key inspection repair and maintenance (IRM) tasks precisely and safely under remote control with the potential to increase operational flexibility. The operations phase, which included pipeline inspection and light intervention tasks, was part of an ongoing contract to provide IRM services for Petrobras. The project involved a remote piloting upgrade of the workclass ROV system on board an ROV support vessel. Real-time remote control was achieved via a secure, high-speed, communications link to Subsea7's Aberdeen Onshore Control Center. Subsea7 also has two onshore control centers in Stavanger, Norway.

University of Houston (UH) researchers are developing an autonomous robot to identify potential pipeline leaks and structural failures during subsea inspections. The technology will aim to make the inspection process safer and more cost effective. The SmartTouch technology in development at UH consists of ROVs equipped with multiple stress wave-based smart touch sensors, video cameras and scanning sonars that can swim along a subsea pipeline to inspect flange bolts – bolted connections have accelerated the rate of pipeline accidents that result in leakage, according to the Bureau of Safety and Environmental Enforcement (BSEE).

The BSEE is funding the project with a grant to UH researchers Zheng Chen, Bill D. Cook Assistant Professor of Mechanical Engineering and Gangbing Song, John and Rebecca Moores Professor of Mechanical Engineering, who are working in collaboration with Oceaneering International and Chevron. "By automating the inspection process with this state-of-the art robotic technology, we can dramatically reduce the cost and risk of these important subsea inspections which will lead to safer operations of offshore oil and gas pipelines as less intervention from human divers will be needed," said Chen, noting that a prototype of the ROV has been tested in his lab and in Galveston Bay. The experiments demonstrated the feasibility of the proposed approach for inspecting the looseness of subsea bolted connections. Preliminary studies were funded by UH's Subsea Systems Institute.

FLIP – The 'Cool Tech' Standard Bearer for 60 years – RETIRED



U.S. Navy photo by John F. Williams/Released

Fifty-five feet remain visible after the crew of the Floating Instrument Platform, or FLIP, partially flood the ballast tanks causing the vessel to turn stern first into the ocean. The 355-foot research vessel, owned by the Office of Naval Research and operated by the Marine Physical Laboratory at Scripps Institution of Oceanography at University of California, conducts investigations in a number of fields, including acoustics, oceanography, meteorology and marine mammal observation.

A dynamic era in naval oceanography recently ended as the iconic Floating Instrument Platform — popularly known as FLIP — was officially retired from service. Built in 1962 with funding from the Office of Naval Research (ONR), FLIP helped generations of scientists and oceanographers better understand the mysteries of the sea, including internal waves, air-sea interaction and long-range sound propagation. Sadly, age and exorbitant life-extension costs resulted in the platform being disestablished.

On Aug. 3, a solemn gathering of well-wishers watched as FLIP was towed, at sunset, to a dismantling and recycling facility. Last month, a formal good-bye ceremony was hosted by the Marine Physical Laboratory at the University of California, San Diego (UCSD).

Still, FLIP — which was owned by the U.S. Navy and managed by Scripps Institution of Oceanography at UCSD — boasts a proud legacy and represents a golden age of oceanography that saw a renewed focus on ocean exploration, the creation of new fields of study, and greater public appreciation of the scientific and strategic importance of the ocean.

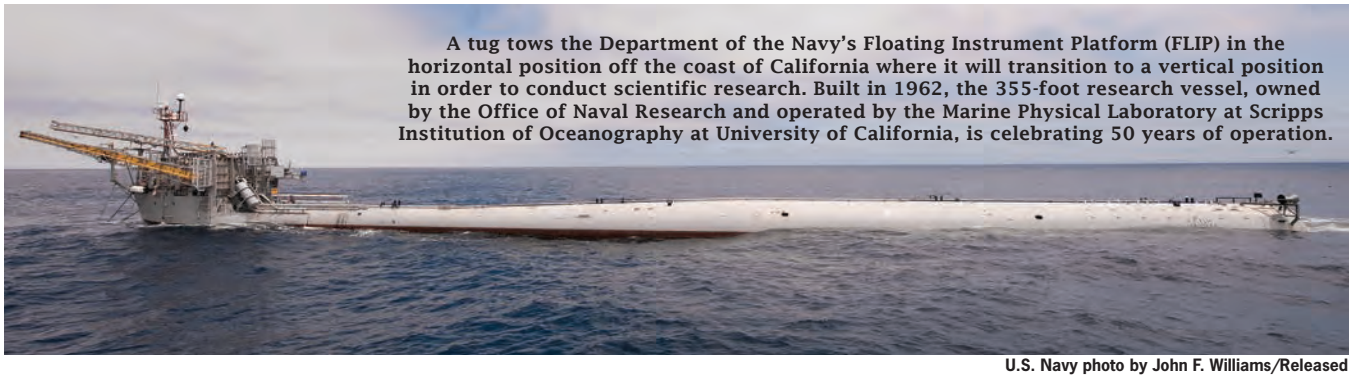
Shaped like a spar buoy, the 355-ft. FLIP resembled a giant baseball bat. When horizontal, FLIP was towed out to sea where on-board hydraulics and ballast tanks "flipped" the platform (in about 30 minutes) to the vertical — producing a stable, mobile at-sea experimental laboratory, capable of riding out swells while providing sensor data 300 feet into the water column.

FLIP could carry a research team of 11 people and a crew of five, and sustain research operations for up to 30 days without resupply. Also, everything mounted on the platform turned 90 degrees when it "flipped" at sea. All fixtures — from generators to toilets — turned at right angles, and there were separate passageways, doors and platforms for every major space inside and outside.

Because FLIP had no propulsion system of its own, it had to be towed by ship to a location. This quiet design made FLIP perfect for recording ocean acoustics and sounds as well as observing tidal forces, internal waves and small-scale turbulence. Such data gathering fostered greater knowledge of ocean currents and acoustics, air-sea interactions and marine mammal sounds.

In addition, FLIP was crucial to groundbreaking naval basic and applied research, much of which was sponsored by ONR. This includes oceanography, meteorology, ocean acoustics and the development of hydrophones (underwater microphones) — as well as how the upper part of the ocean interacts with the lower part of the atmosphere and how that interface affects things like sonar.

Another aspect of FLIP's design that enabled it to be relevant for six decades was its lack of built-in sensors that could become obsolete. This allowed generations of researchers and scientists to install cutting-edge equipment and technology for testing.



A tug tows the Department of the Navy's Floating Instrument Platform (FLIP) in the horizontal position off the coast of California where it will transition to a vertical position in order to conduct scientific research. Built in 1962, the 355-foot research vessel, owned by the Office of Naval Research and operated by the Marine Physical Laboratory at Scripps Institution of Oceanography at University of California, is celebrating 50 years of operation.

U.S. Navy photo by John F. Williams/Released

BLUEPRINT SUBSEAS

www.blueprintsubsea.com

Designing and developing underwater acoustic sensors since 2006, Blueprint Subsea are innovators within the subsea and global defense markets. Blueprint offers 2D imaging sonar, sidescan sonar, acoustic positioning beacons, and military diver navigation systems.

Blueprint serves the subsea market with three distinct product ranges. Oculus 2D multibeam imaging sonars are available in multiple configurations, including several dual frequency systems. Each option has an identical form factor, all easily interchangeable to suit the task at hand. With three depth variations on offer, there is an Oculus for any subsea application. As well as multibeam sonar, Blueprint manufactures StarFish sidescan systems, a compact, lightweight solution which delivers exceptional image quality for shallow water surveys and search and rescue missions. They also produce SeaTrac acoustic positioning systems, which can be integrated onto an ROV, AUV or attached to a diver for precision asset tracking and data collection. Designed specifically for military divers and special forces units, Artemis diver navigation systems are built to meet the complex requirements of the global defense sector. Engineered for mission planning, covert navigation, target detection and acoustic underwater communication, the Artemis systems offer advanced capabilities through cutting-edge technology and intuitive software. Helping to support operators in the most hostile environments.

BLUE VENTURE FORUM

www.blueventureforum.org

The Blue Venture Forum is a program that connects existing blue technology companies, investors, and resource providers with emerging blue technology firms. This forum assists corporates (primes) to identify new technologies for partnership or acquisition, helps scale-up companies to connect with funding and resource partners, assists investors to connect with investable blue technology firms, and provides start-ups with access to experienced mentors. The Blue Venture Forum is dedicated to creating a global community that fosters and supports entrepreneurs and innovators in blue technology, ocean-related enterprises, and related deep tech verticals. Blue Venture Forum has brought high-value, blue tech focused, programming to over 1,000 participants, supported dozens of promising blue technology startups through mentorship and matchmaking, and helped investors to better understand the trends in blue technology investment and connect them with blue tech founders. Their Blue Innovation Symposium, going into its ninth year, has become one of the largest blue technology event in New England, regularly attracting a global audience of leaders in business, science, and from key governmental and academic organizations, including NOAA, BOEM, and the US Navy. In 2023, Blue Venture Forum launched several new initiatives including the first ever Blue Venture Investment Summit, and its In-Water Demonstration Day.

CELLULA ROBOTICS

www.cellula.com

Cellula Robotics achieved a milestone with the commencement of sea trials for its Solus-XR XLUUV project. The project, which was initiated in early 2023, signifies a pivotal step forward in the company's quest to develop long-range autonomous underwater systems powered by hydrogen fuel cells. The Solus-XR XLUUV project builds upon the success of its predecessor, Solus-LR, and has been engineered to achieve unparalleled operational capabilities, boasting an range of 5,000 km. One of the defining features of Cellula's Solus-XR XLUUV is its stature, spanning an impressive 40 feet in length. This substantial size accommodates the incorporation of two highly customizable payload bays, each with a capacity of 2,500 liters. Such versatility ensures that the Solus-XR XLUUV can be adeptly tailored to suit a wide spectrum of mission requirements, ranging from intricate surveillance ventures to intricate equipment deployments.

Notably, the system's port-to-port mission capacity eliminates the need for auxiliary support vessels, greatly enhancing access to challenging and remote environments often encountered in Arctic sub-ice missions. The hydrogen fuel cell technology integrated into the Solus-XR XLUUV not only extends its operational range but also aligns with Cellula's commitment to environmental sustainability by minimizing its ecological impact.

COPENHAGEN SUBSEA

www.copenhagensubsea.com

Copenhagen Subsea A/S is a pioneering force in thruster technology, offering powerful and silent subsea thrusters. With cutting-edge manufacturing techniques like 3D printing for propellers, Copenhagen Subsea ensures the highest quality and performance in its thruster technology.

Latest innovation from Copenhagen Subsea is the enhanced Gorilla ROV, now equipped with an advanced 3D camera system. By integrating a 3D camera from Danish UVision, Copenhagen Subsea have unlocked a new level of subsea exploration and inspection capabilities. With this technology, the Gorilla ROV now has the ability to capture highly accurate and detailed 3D scans of underwater environments.

The 3D camera, mounted on the Gorilla, enables the creation of precise 3D models, providing invaluable insights for various applications. The 3D camera delivers exceptional image quality and resolution.

Its advanced scanning capabilities allow for rapid data acquisition and precise measurements, ensuring accuracy in subsea mapping and inspection tasks. With the Gorilla ROV and its integrated 3D camera, subsea operators can now visualize underwater structures, assess damages, and plan interventions with greater precision than ever before.

D-2 INC.

www.d-2.com

D-2 Inc is a precision industrial sensor manufacturer with expertise in liquid conductivity. The D2 CTD utilizes a new Hybrid Conductivity Sensor. The hybrid sensor is a completely new concept in a high precision conductivity sensor. It combines the performance advantage of the traditional three-electrode sensor where the end electrodes are electrically tied together ensuring there is no external electric field. That electrode system, coupled with a novel inductive drive, eliminates the need for additional center electrodes, or other electrodes in the measurement field. The inductive drive creates a current that flows through the center measurement region; the current flows in direct proportion to the conductivity of seawater. This current is collected by the end electrodes and passed through a simple current to voltage transformer, as it is in direct proportion to the conductivity of sea water and the magnitude to the drive signal. The drive signal level can be precisely controlled, and the collection electrodes and shorting path can be constructed to have very low impedance as compared to the external sea water path. The sensor can free pass water through the cell without the need for a pump in almost all applications. In applications where a pump is needed, like for biological control, this can be easily added as the sensor measurement volume is 100% enclosed in the sensor and the addition of tubing a pump will not affect the calibration. US Patent #9,410,910.

GEOACOUSTICS LTD

https://geoacoustics.com/

GeoAcoustics is a pioneer in interferometric sonar for bathymetry and a supplier of Sub-Bottom Profilers and Side Scan Sonars. It has been providing subsea sensors and equipment since 1978, and in 2023, GeoAcoustics received one of the first ever *King's Award for Excellence* for its performance as an independent UK company in the context of international trade. GeoAcoustics provides products under three core categories:

• **Bathymetric Sonar:** It offers accurate, efficient simultaneous swath bathymetry and side scan sonar mapping for shallow water environments. With versatile hull mounting options as well as USV integration, the GeoSwath 4 product line is suitable for a wide array of survey tasks and applications, including hydrographic surveys, environmental assessments, infrastructure inspection and inland waterway and seabed mapping.

• **Side Scan Sonar:** The Pulsar provides for simple deployment and intuitive operation, capturing high resolution images of the seabed using a rugged tow fish which can be easily operated with a water-protected deck unit and a portable cable hand reel. It operates within a 550KHz to 1MHz frequency with selectable FM and CW pulses.

• **Sub-Bottom Profiling:** GeoPulse Sub-Bottom Profilers provide accurate data, producing repeatable, high-quality results time after time. Application specific, ruggedized and towed or over the side use make GeoPulse suitable for a wide range of applications including geological surveys, marine archaeology, pipeline, and buried structure detection, and dredging surveys.

HYDROCOMP INC.

www.hydrocompinc.com

Since 1984, HydroComp has been a leader in providing hydrodynamic software and services for resistance and propulsion prediction, propeller sizing and design, and forensic performance analysis. Through its array of software packages and services, HydroComp now serves over 1400 naval architectural design firms, shipyards, yacht owners, ship operators, propeller designers, universities, and militaries around the globe. Our tools — NavCad, PropElements, PropCad, and PropExpert — provide the critical capabilities necessary for vehicle designers and researchers to better understand and simulate vessel hydrodynamics, propulsion performance, power requirements, vehicle range, and energy budgets. Using HydroComp's fully integrated design and analysis tools allows designers to avoid multiple disconnected spreadsheets, utilities and other a-la-cart solutions. HydroComp has pushed hydrodynamic analysis of submersible vehicles to new levels for its community of UV designers and builders. In-house research on analytical methods for critical regimes is supporting new development for its software tools. In particular, HydroComp's PropElements propeller design code has been enhanced with new settings and methods for geometries typical in the small UV space. Support for CFD analysis now allows PropElements users to directly develop and export STL mesh geometry for blades, hub, and a variety of standard nozzle styles.

TRITECH INTERNATIONAL

www.tritech.co.uk

Tritech International Limited is dedicated to providing reliable imaging and ancillary equipment for use in underwater applications. In the past 12 months, Tritech has gone through a period of development and growth. Since joining General Oceans AS in October of last year, it has formed more partnerships within the industry and shared more expertise than ever before. Tritech continues to innovate and develop new underwater technology to support the subsea working environment by making it less hazardous. Tritech aims to help preclude any loss of life or injury during underwater operations and to prevent harm to the environment both subsea and otherwise.

For more than 30 years, Tritech have provided the subsea industry with robust, reliable solutions for the harshest environments and most difficult applications.

Its product portfolio consists of a suite of Mechanically Scanning and Multibeam Imaging sonar, profiling solutions and oceanographic bathymetric and depth sensing products. Tritech also sells navigation and tracking solutions for small subsea vehicles. All Tritech products go through rigorous production testing, both in-house and on open water, and regularly remain in use for decades, surviving and thriving in the most challenging environments on the planet.

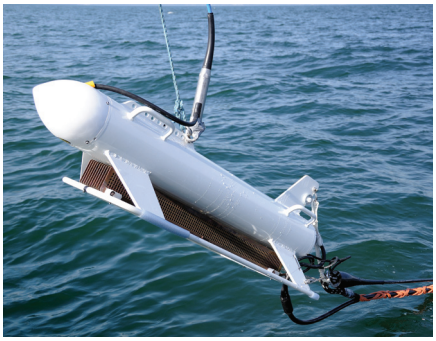
IMPACT SUBSEA

www.impactsubsea.com

Impact Subsea was founded by Ben Grant and Alastair Mclennan-Murray. With experience in the design and manufacturing of underwater sensors and systems, they were keen to create a new standard of ROV & AUV sensor. The company specializes in a range of high-performance sensor solutions for underwater vehicles and associated applications used in the oil and gas, renewables, underwater research and defense sectors.

Since the last MTR100 edition, Impact Subsea has expanded its sonar range. The ISS360HD offers more than twice the angular resolution and higher range capabilities. In addition to this, the company has launched their online Subsea Academy.

This platform provides an accessible collection of resources and technical guides to help users make informed decisions about sensor solutions for their respective projects. The Academy covers a wide range of topics, addressing FAQs, technical overviews and more. The latest release looks to enhance the features of the company's flagship product, the ISA500, now offering Echogram capabilities. This development further demonstrates the company's commitment to ensure their product portfolio remains at the forefront of innovation. Despite being over seven years since the ISA500's market release; this feature will be made available from both new and historic users.

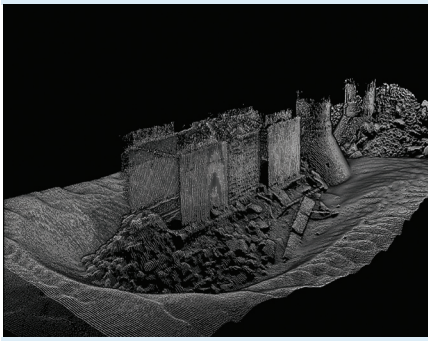


MAPPEM GEOPHYSICS

www.mappem-geophysics.com

MAPPEM is a spinoff from the University of Brest (France) that offers a unique perspective into the marine subsurface using tailor-made electromagnetic instruments and expertise forged along the coast of Brittany, France.

MAPPEM's focus is on marine electromagnetic site surveys and investigations. After several years of academic research, the MAPPEM team continues to research and develop different electromagnetic systems adapted to the marine environment, providing new and alternative subsurface information. MAPPEM's original, perpetually refined, deep-towed marine electrical resistivity tomography system continues to reap praise from the industry because it can image to a depth of <40 m and can see where other systems can't. For example, it can distinguish subsurface heterogeneities (rock types, porosity, cavities, boulders) and images beneath acoustic masks, helping to decipher the lateral extents of shallow gas and its origin (i.e., geologic, biogenic). The adapted (3D) object detection system can image to a depth of <7 m and has a swath of 5 m. MAPPEM has recently completed a cable route survey off the coast of the Netherlands. Using the object detection system, the aim of the project was to locate the non-ferrous UXO within the potential cable corridor. At project completion, the system detected and localized the non-ferrous UXO, helping to mitigate the risk and identify the appropriate routing for the buried cable.



NORBIT

https://norbit.com/subsea/

NORBIT Subsea is part of the NORBIT ASA, an industrial corporation with companies in Subsea, Intelligent Traffic Systems and Original Design Manufacturing of industrial electronics. NORBIT Subsea designs and develops wideband multibeam sonars for hydrographic and forward-looking applications. Its solutions are based on the latest in analog and digital signal processing and our products provide wide coverage monitoring combined with high sensitivity and accuracy.

NORBIT Subsea launched its latest fully active stabilized multibeam sonar system in April 2023. Building on the WBMS platform, the new "iWBMSh Stabilized" system was launched at the NORBIT Subsea Global Partner Day event held in Southampton, UK prior to the Ocean Business 2023 exhibition. This cylindrical high-resolution curved array bathymetric system is designed to function effectively in extreme operational environments with high vessel motion. It offers rapid mobilization at any location and time, providing active roll, pitch and yaw stabilized bathymetry. Additionally, it delivers standard imagery and backscatter outputs, ensuring the highest quality survey data performance. The iWBMSh is a compact, high-resolution broadband multibeam sonar solution that includes a curved array and tightly integrated Applanix OceanMaster GNSS/ INS, specifically designed for demanding environments.

OCEAN ALPHA

www.OceanAlpha.com

OceanAlpha Group is a commercial unmanned surface vehicle (USV) company. It has grown from a single small office in 2010 to a workforce of over 569 employees today, with more than 200 R&D engineers and 430+ pieces of USV related patents. OceanAlpha's business involves inland & offshore surveying, environmental monitoring, marine engineering, security & rescue, transportation, and recreation.

To support humans in getting closer to the ocean with lower cost, higher efficiency and enhanced safety, OceanAlpha serves professionals from various fields with integrated USV solutions. Its products are influencing data acquisition, life-saving, auto-piloting and swarm controlling in the marine sector. A recent seabed survey featured a fleet of five 7m L25C USVs was deployed. Each USV was equipped with an automatic lifter, multi-beam echosounder, IMU, and sound velocity profiler. The USVs were remotely controlled using cooperative control software, allowing for mission planning, autonomous navigation, and data collection.

OceanAlpha's cooperative surveying technology for USVs liberates technical personnel from simple and repetitive tasks. This innovative operational approach offers a range of benefits, including cost-effectiveness, efficiency, safety, accuracy, and ease of equipment replacement.

The USV cooperative control technology has decreased the labor intensity in marine surveying operations, enhanced operational safety, and lowered operating costs. This technology is particularly well-suited for rapidly and accurately acquiring extensive seabed mapping and other data within a short time frame.

OSIL

www.osil.com

Ocean Scientific International Ltd (OSIL) bridges the gap between academic research and development and turnkey products for all customers, both large and small. OSIL offers a bespoke service, providing innovative solutions, flexible services and unique products to customers' specific environmental monitoring issues. Based in the UK, OSIL was established in 1989 to take over operation of the IAPSO Standard Seawater service from the Institute of Oceanographic Sciences, but quickly incorporated the sale of oceanographic instrumentation into its business model. As the company's knowledge and skills base increased, OSIL began to offer its own integrated monitoring systems, having identified a gap in the marketplace and being in the singular position of being able to offer its customers the best selection of instruments and technologies available from top manufacturers.

OSIL is able to identify customer requirements and opportunities in the marketplace and has delivered several new products to meet these needs, including a range of profiling winches for deploying instrumentation from Uncrewed Surface Vehicles and the mini vibrocorer for shallow/coastal water off-grid sediment sampling.

RS AQUA

https://rsaqua.co.uk/

RS Aqua provides sensors and systems for monitoring ocean environments. Based in Portsmouth, England, it recently celebrated its 40th anniversary.

RS Aqua is positioned to serve the different core "oceantech" markets within the maritime sector; energy, defense, science and fisheries.

Its innovations have led to the creation of new technologies that we now sell throughout the world, like the ARC (Acoustic Release Canister) for seabed projects (customers include government agencies like NASA), and its WaveRadar REX, which is installed in about 1,000 locations globally to monitor sea state from platforms such as wind turbines.

Its Porpoise OB1 also adds Passive Acoustic Monitoring capability to almost any ocean going platform—static, mobile, surface or sub-sea—using its subsea noise recorders. This technology is also constantly being developed to meet customer demands, such as a new motion compensated REX for use on moving vessels.

All this technology is supplied via our Port Solent head office, in Hampshire, UK. More recently, the company has won funding from Innovate UK for a new project to use AI to protect marine mammals and marine protected areas.

It hopes to revolutionize how we monitor, use and protect our ocean environment for generations to come.

RTSYS

https://rtsys.eu/

RTsys is a French company specializing in underwater acoustics (passive and active) and autonomous underwater vehicles for both civil (industrial and scientific) and defense sectors. The company is part of the SEA VORIAN group, which has more than 15 years of experience in supplying equipment for maritime and naval industries. A decade of research and development, combined with a close cooperation with the French Navy, enabled RTsys to develop Anti-Submarine Warfare innovative systems (ASW), portable equipment for EOD divers and Manned-Unmanned teaming ecosystem in Mine Counter Measures field (MCM), Autonomous Underwater Vehicles (AUV) and Passive Acoustic Monitoring Systems (PAM) such as acoustic recorders, buoys, data logger and stations.

RTsys specializes in micro AUV (less than 1m, less than 10kg) and has been providing a very wide range of units worldwide in multiple varieties of configurations. However, one specific project in collaboration with NOAA led to the supply of NemoSens micro AUV, a fully-integrated, geo-referenced, still and video imaging system payload designed by a third-party partner in order to deliver photo mosaicking of the seabed. With Still image capturing at 12.3 MP and at a rate of 4 Hz, NemoSens can provide very high-resolution data at highest accuracy of positioning for seabed imageries of coral and any other targets of interest on seabed.

SEATRONICS

https://acteon.com/electronics-tooling/seatronics

Seatronics provides marine electronic equipment to the global subsea market via rental/hire and purchase options. In addition to subsea equipment rental and sales, Seatronics offers a number of trusted services including manufacturing subsea connector and cable assemblies, asset management and state of the art calibration facilities.

The VALOR ROV has the ability to manage complex tooling and sensor packages. It can carry out tasks that were previously only possible from significantly larger platforms. VALOR has been deployed around the world—Brazil, USA, Baltic Sea, UKCS, and Asia Pacific and has successfully completed various scopes of work, including UWILD, diver monitoring, scour assessment, anchor deployment and general visual inspections. It can inspect and clean steel and concrete platforms, inspect offshore assets for corrosion, damage and debris, without the need for divers, and enable lower cost pipeline surveys. It combines light weight with maneuverability and serious connectivity.

- 3-knot station keeping capacity and more thrust than any other vehicle in its class
- 20 Gb/s to 5 user-configurable sensor ports
- 300m water depth rated but adaptable for 1000m It is customizable and can manage a huge array of complex tooling and sensor packages.

SEAVIEW SYSTEMS INC.

www.seaviewsystems.com

Founded in 1998, SeaView Systems, Inc. is a provider of oceanographic and underwater technologies and services which designs and builds custom ROVs targeting specialized applications. It provides services such as ROV tunnel or structural inspections using precisely located HD video, 3D sonar mapping, or other techniques. Our engineering capabilities include expertise in electronic, software and mechanical design. Incorporated into these capabilities are electro/mechanical assembly and integration, machining and fabrication. SeaView Systems designs and sells a range of specialty electronics for various oceanographic, ROV, and survey applications tailored to the underwater technology industry. SeaView's custom electronics are used to advance the state-of-the-art capabilities for ROV communications, metrology and oceanographic industrial and research applications around the world. Its SVS-603HR wave sensor is widely used on a variety of platforms, including buoy hulls ranging in size from about 0.3 to over 6 meters, as well as autonomous surface and submersible vehicles. The SVS-603HR has become the standard bearer for a new generation of compact, semiconductor-based wave sensors due to its power-efficient design, small form factor, and sophisticated algorithmic support for capabilities including 9-DOF platform motion, offset and non-ideal platform motion correction as well as Response Amplitude Operator (RAO) support.

SUBSEA EUROPE SERVICES

www.subsea-europe.com/

Established at the beginning of 2020 with the goal to "simplify marine data acquisition" and make it possible for every organization to collect and evaluate marine data professionally, Subsea Europe Services provides easy access to precision sensors and equipment, complete survey systems, and innovative marine data acquisition solutions as turnkey deliveries with unified technology, autonomous platforms and support.

The company's "systems, services, solutions" capability, enabled through partnership with leading technology innovators, has evolved to the point that it is now a pioneering technology provider for diverse customers seeking to push the boundaries in marine data acquisition. Subsea Europe Services continues to be an agile subsea technology company dedicated to optimizing the availability, deployment and operation of new and innovative survey and inspection platforms and the high-performance hydroacoustic products that enable the collection of precise marine data for commercial and maritime security clients. While serving a diverse customer base from offshore wind farms, to governmental organizations and marine survey companies, Subsea Europe Services continues to develop innovative solutions that simplify and automate the collection of marine data, including fully-integrated autonomous survey platforms developed in collaboration with specialist partners including Florida-based MARTAC Systems inc., and autonomous vehicle specialist from Singapore, BeeX. Subsea Europe Services also enjoys closer partnerships with leading subsea sensor and technology manufacturers, making equipment from e.g., R2 Sonic, Sonardyne, GeoAcoustics and RTS readily available for users in Europe.

SOUTH BAY CABLE

https://southbaycable.com/

For more than 65 years, South Bay Cable has been a leader in custom cable engineering and manufacturing. South Bay Cable works closely with clients to achieve a shared goal: engineering, building, and delivering a cable that does the job and lasts. South Bay Cable was founded in 1957 in the South Bay of Los Angeles. Gordon and Joyce Brown, the founders and owners, started by building custom cables, assemblies, and connectors in their garage in Gardena, California. Beginning with three divisions under the parent corporation of Consolidated Products, the Browns set out to provide a service that went beyond the catalogs. In the late 1960s, the Browns moved their operation to the mountains of Riverside County, in Idyllwild, and eventually added a second manufacturing facility in Temecula. As businesses in the industry changed and evolved, the demand for custom cable eclipsed the need for connectors and assemblies, and the South Bay Cable division became the sole manufacturer and name. Advances in material chemistry have increased SBC's ability to build cables that are lighter and stronger than ever before, which allows for exploration at greater ocean depths. A game-changer for the cables is the data rate of fiber optics (versus coax and analog). SBC's role in the marine technology industry can be credited to their expertise, cutting-edge innovations and ability to deliver solutions that withstand challenging marine environments.

SUBCTECH

www.subctech.com

SubCtech offers underwater power solutions and ocean monitoring systems. Li-Ion batteries PowerPacks, pCO2 analyzers OceanPack and system solutions are our core products and a one-stop service.

SubCtech GmbH "Subsea Technologies for the Marine Environment" is the producer of Li-Ion PowerPacks and OceanPack measurement systems used for scientific research and industrial monitoring of water quality and oceanographic parameters. SubCtech reaches all target markets with the product family of subsea Li-Ion batteries in the division "Ocean Power".

In particular, the oil and gas offshore industry requires increasingly autonomous systems for greater and greater depths; for example, large energy storage systems, which are being built right now.

Complete systems are projected together with data loggers and the implementation of sensors. A constant level of high quality is ensured thanks to certification and periodic audits by the oil and gas industry.

Projects in depths of up to 6000m are realized in the division of "Ocean Monitoring" with the adaptation of sensors for pCO2.

The pCO2 analyzers are used for maritime surveillance and research on buoys and ships. The exclusive production of LI-COR pCO2 analyzers enables it to offer competitive solutions.

HOHONU

https://www.hohonu.io/

Hohonu provides actionable real-time data and insights from a comprehensive environmental sensor and data delivery network for more than 100 sensors in 13 states. The company was started in Hawai'i in 2014 while trying to help understand the chemistry involved in reconstructing healthy fish ponds using cost-effective sensors. Hohonu sea level sensors now measure water depth and provide precision forecasting to help communities prepare for and respond to emergency flooding. Hohonu's process was designed with three pillars: adaptation and resilience consultation, installation best practices, and community data sharing. Hohonu is working with an existing network of 30 fishponds to install sensors gathering insights on the biggest environmental, climate, or technological barriers to effective fishpond restoration. Hohonu can provide low-cost regional instruments and data networks, driven by coastal community needs, and will allow for quantifiable comparisons of biogeochemical processes for restoration activities to promote resilience and capacity to adapt to adverse events.

Hohonu sensors are solar-powered and cell-connected, small enough to be out of sight, and fit well on fixed land-based structures. Installation is about the same difficulty as assembling bedroom furniture and takes as little as a few minutes. Hohonu's proprietary Tidecast model uses machine learning to predict tides up to 80% more accurately than standard tide predictions.

SUNFISH

https://sunfishinc.com/

Sunfish Inc is an underwater robotics company, and its flagship product is the SUNFISH AUV, which stands out for its maneuverability and advanced navigation capabilities.

It is designed to excel in real-time 3D mapping and autonomous decision-making, even in communication-denied and intricate underwater scenarios.

Its proprietary AI code powers the SUNFISH AUV, and is designed to enable real-time 3D mapping and autonomous decision-making in complex, communication-challenged environments, making it an ideal solution for asset inspection and exploration across industries.

Its achievement this year is our collaboration with NOAA Ocean Exploration and the Seaalaska Heritage Institution to explore submerged caves and rock shelters in southeast Alaska.

This multi-year project not only pushes the boundaries of exploration but also transforms our understanding of human migration to the Americas, with sites dating back to the late Pleistocene era. Together, we've uncovered uncharted ocean areas and made groundbreaking scientific, economic, and cultural discoveries, including the discovery of fish weirs dating back 11,100 years ago.

ZF MARINE

www.zf.com

ZF manufactures and supplies marine propulsion components, as well as complete systems for all types of vessels. ZF Marine provides transmissions (reversing, non-reversing and hybrid), propellers, thrusters, steering systems and electronic control systems for a comprehensive range of applications with a power range from 10 to 12,000kW in commercial and fast crafts as well as in pleasure crafts and yachts.

ZF Marine supplied four well-mounted azimuth thrusters (AT) for the construction of two Reach Remote unmanned offshore surface vehicles (USV) built by Kongsberg Maritime for Reach Subsea. The Reach Remote project uses an unmanned offshore surface vehicle in conjunction with a next-generation remotely operated vessel. The remote and autonomous platform will transform the market for remotely operated vessels surveys and inspections services. Thus, it dramatically lowers operational costs and the environmental footprint of subsea operations.

Two fully electric driven ZF ATL 4014 WM-FP per vessel ensure unmatched and reliable maneuverability. The compact and efficient design of the thruster helps to reduce the life cycle costs (LCC).

CSIGNUM

www.csignum.com

CSignum demonstrated its new RadiEM Modem earlier this year. The company touts RadiEM as the first platform to use low-frequency electromagnetic (EM) fields to transmit more data wirelessly. According to CSignum, RadiEM is the only technology that can transmit data through the water-air boundary, water column, seabed and subsea structures, as well as connect digital devices in networks below the water with those networks on land and in the air. "EM signals are resilient sustaining their integrity where sound and light scatter: at the surface; in shallow splash zones; aerated, turbid and bio-fouled waters; and, anywhere ambient light, line of sight and noise interference is an issue. Because EM fields are also silent and invisible, they are more secure as well as safer for the environment and marine life," CSignum shared. "We expect RadiEM to become the cable-free gateway for marine data through the surface of the water," said Chris Brooks, CEO of CSignum. "RadiEM is already successfully deployed in a multitude of use cases from AUV/ASV (HESS and Ocean Aero) and tidal water data recovery to offshore structural and met ocean data transmission to real-time ADCP data. RadiEM has reliably sent data at a range of 28-30m via underwater modems to topside receivers transmitting at 200bps. The battery life is phenomenal, too, enabling up to 3 months on standard external rechargeable batteries before needing a recharge or replacement.

NOVACAVI

https://www.novacavi.it

Novacavi

Specialist in custom electrical cables design and manufacturing for the most varied and challenging applications since 1975, NOVACAVI develops specific solutions as reliable high-quality accessories to any form of innovative equipment and evolving system. Novacavi has recently supplied a special underwater hybrid cable to be deployed for Nemo's Garden, a farm experimental project. **This world's first underwater cultivation system of terrestrial plants located off the coast of Noli, Italy, southwest of Genoa, consists of an array of suspended, transparent, dome-shaped greenhouses called biospheres, anchored to the bottom of the sea.** Since everything is monitored on land through cameras and sensors, Novacavi's underwater cable will enhance this innovative system of exploring the benefits of the sea for farming.

HYDRO HULL CLEANING

https://www.hhcleaning.dk/

The SeaBadger Mk2 is a hull cleaning technology equipped with sonar capabilities, aiming to deliver:

- **Robotics Precision:** The SeaBadger Mk2 boasts a robotic system engineered to navigate a vessel's hull with precision, delivering consistent and thorough cleaning.
- **Advanced Hydrodynamics:** Through extensive research in fluid dynamics and hydrodynamics, Hydro Hull has optimized the SeaBadger Mk2 for maximum cleaning efficiency with minimal water consumption..
- **Sonar Integration:** To tackle challenging conditions with poor visibility, SeaBadger Mk2 is equipped with sonar capabilities.
- **Environmentally Responsible Filtration:** Environmental preservation is at the core of our mission. The SeaBadger Mk2 is equipped with a filtration systems, effectively capturing and containing fouling and debris during cleaning operations.

Teledyne Marine

Osprey Autonomous Underwater Vehicle

Teledyne Marine is a leader in marine technology, specializing in providing a comprehensive suite of subsea solutions. With a history spanning decades, Teledyne Marine has consistently pushed the boundaries of what is possible in underwater operations. By leveraging cutting-edge technology and an unwavering commitment to excellence, they have earned a reputation as a trusted partner for scientific institutions, government agencies, and commercial enterprises worldwide.

One example of Teledyne Marine's more recent breakthroughs in underwater technology is the **Osprey Autonomous Underwater Vehicle (AUV).** The Osprey represents the latest evolution in AUV design and capabilities with a unique dry design rated to 2000m depth in a portable 12.75-in. form factor, setting new underwater exploration and data collection standards.

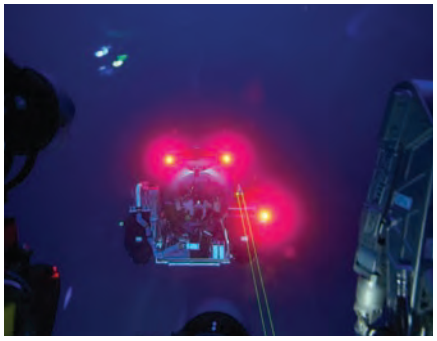
With unparalleled versatility, the Osprey AUV boasts a modular design that allows easy customization to meet the unique needs of various missions. Its versatility makes it suitable for multiple applications, including hydrography, oceanography, environmental monitoring, and offshore energy exploration. With exceptional mobility due to its advanced propulsion systems and precise navigation controls, the Osprey can navigate challenging underwater environments with remarkable agility. Its maneuverability enables researchers to access remote or complex underwater areas easily.

The Osprey has state-of-the-art imaging technology with high-resolution imagery, including high-definition cameras, Side Scan Sonar systems, Synthetic Aperture Sonars, and multibeam sonar systems. These advanced sensors provide detailed, real-time visual and acoustic data, enabling scientists to capture the finest details of the underwater world. With extended mission durations, the Osprey AUV can operate autonomously for extended periods, collecting valuable data and imagery.

Teledyne Marine has focused on making Osprey easy to deploy and recover, reducing the complexity of mission planning and execution. The Osprey AUV represents a significant leap forward in autonomous underwater exploration and research. Its adaptability, mobility, and data capabilities make it an indispensable tool for any organization involved in subsea missions.

Teledyne Marine continues to shape the future of underwater technology by introducing groundbreaking innovations like the Osprey AUV. Teledyne Marine provides cutting-edge solutions that drive discovery and progress in underwater science and exploration.

ARCTIC RAYS



XEOS TECHNOLOGIES

SEAFLOOR SYSTEMS

SAAB SEAEYE

ARCTIC RAYS

https://arcticrays.com

Arctic Rays specializes in deep-sea lighting, imaging and surveillance systems and other subsea technologies, custom-engineered for use on AUVs, ROVs, manned submersibles and other offshore and underwater structures.

Its portfolio includes video and still-imaging cameras and payloads, lighting, positioners, sensors, telemetry and more.

- **The Alpheus Subsea Surveillance System** is a turnkey asset monitoring system designed to simplify integration for underwater asset monitoring. At the heart of the system is Alpheus, a fiber optic gigabit smart ethernet hub and multiplexer telemetry system.
- **The Mako Autonomous Imaging System**, a programmable, autonomously powered video+lighting system for low-powered, standalone operation, with an internal, programmable intervalometer to create preset recording schedules, onboard 4K UHD recording/storage and integrated battery pack. The lighting component of this system comprises two ViperFish torch lights with lasers and a low power-draw.

SEAFLOOR SYSTEMS

https://www.seafloorsystems.com/

Seafloor Systems is a small, veteran owned business with more than 24 years in the surveying industry. With partners globally, Seafloor has a wide range of vessels and platforms to fit any job. Its team of engineers and former surveyors realize the need for innovative tech out in the field. From hydro-acoustic sonar equipment to our growing fleet of unmanned survey vessels, we have an array of products and services to ensure the success of your hydrography project, large or small. Seafloor Systems focuses on unmanned and autonomous survey vessels for remote hydrographic surveying, both inshore and offshore.

SAAB SEAEYE

www.saabseaeye.com

For more than 35 years, Saab Seaeye technology has led the industry with innovative solution. A wholly owned subsidiary of Saab UK, more than 80% of its systems are exported, with vehicles operating in more than 75 countries in a dozen market segments. At the core of its all-electric technology ecosystems are intelligent control architectures that enable real-time system control and feedback from the heart of every subsystem. Its robotic systems range from the top-rated and highly-portable Falcon, to its newest deep-rated work system eWROV, fitted with two seven-function all-electric work-class manipulators, and the hybrid tethered/autonomous Sabertooth, renowned for finding Shackleton's ship *Endurance.*

VIEWPORT3

https://viewport3.com

Aberdeen-based 3D scanning specialists, Viewport3, have become the first business in the UK to be approved for Remote Inspection Techniques (RIT) using underwater photogrammetry by Lloyd's Register (LR). The certification was granted to Viewport3 following a successful offshore project along with an onshore validation trial, which involved using photogrammetry to verify

mooring chain link critical dimensions to a sub-millimetric level – a level of accuracy and data density that far exceeds those attained by traditional approaches. As a result, the Viewport3 team have developed new reporting methods that better suit the high-resolution 3D replica of mooring links, that meet the requirements of both field operator and statutory inspection regulations.

DIGITAL EDGE SUBSEA

www.digitaledgesubsea.com/

Digital Edge Subsea develops and manufactures digital video recording (DVR) products for use throughout the offshore industries. Leading the industry with our innovative products and unparalleled technical support. There are now over 800 EdgeDVR systems in use offshore, demonstrating our proven record of reliability. Its range of hardware options is designed and tailor-built to optimize the power of our Version 5 EdgeDVR software. We offer 4U rack-mounted, laptop and workstation variants, providing flexibility for different job requirements. The EdgeDVR system is capable of recording simultaneous High Definition and Standard Definition video, together with auto-creation of Dive, Video, Photo and Anomaly logs. Multi-channel digital overlay is also available for all recorded channels, logos and real-time survey data can be displayed. Version 5 EdgeDVR software is designed to meet your needs and your budget, with 3 versions available EdgeDVR Lite, EdgeDVR Standard and EdgeDVR Pro. Edge Archive is a separately licensed application that creates a real-time data mirror of the project allowing for media to be removed from the DVR, whilst maintaining the structure and integrity of the project. This means the project does not have to be deleted to free space on internal storage.

XEOS TECHNOLOGIES

www.xeostech.com

Xeos Technologies is a leader in designing & manufacturing low-power oceanographic tracking beacons, sensors, and accessories. From GPS & AIS location beacons, LED flashers, data relays, wave height sensors, current drifters, water quality sensors, and more. It has been designing and manufacturing oceanographic recovery beacons and sensors since 2004. Our products are used all over the globe with a large footprint in North America, Europe, and Asia. We work very closely with some of the most prestigious oceanographic institutions across the world to protect their valuable equipment and data. In the spring of 2023, Xeos released the first ever submersible AIS compatible recovery beacon. The Petrel operates analogously to an AIS Aid to Navigation (AtoN). Designed for short range tracking and recovery, the Petrel automatically displays its location on nearby vessels AIS chartplotter when within sufficient range. With no additional devices, software, or data plans required, the Petrel is the most convenient recovery beacon on the market.

Markey Machine

www.markeymachine.com

Markey is a leader in production of deep-sea, oceanographic, hydrographic, and traction winches. Markey has won more than 30 major deep-sea and research vessel contracts since 2000. Most significant in recent years are high-profile outfittings of complete winch suites or upgrades for AGOR-class vessels like the R/Vs Neil Armstrong, Sally Ride, and Roger Revelle. In addition, Markey recently won a major refurbishment contract for NOAA's R/V Ron Brown, and also completed a major mid-life retrofit of winches aboard the R/V Tommy Thompson.

Markey is the oldest privately-held winch manufacturer in the U.S., founded in 1907 by Charles Markey as an industrial manufacturer of both marine and timber industries of Seattle, WA. Markey's first award dates all the way back to 1943, followed by a 2006 Innovation Award for Asymmetric Render/Recover for winch control.

Markey's CAST-6 Two-Sheave Level Wind is, like earlier electronic models, the most highly engineered subassembly on the CAST-6 model winch, a true example of precision-level winding, engineered to 6 figures. The Cast-6 Two-Sheave unit simplified varied processes at work in earlier three-sheave units, while enhancing safety features. For example, the unit has no reverse bends in the cable path, thereby lengthening cable service life. In addition, the need for a winch turntable (platform) is eliminated by use of rotating flagging sheaves.

Vertical rollers are also not necessary, and, as the name indicates, there is a reduction of a single sheave. The Two-Sheave unit also retains the popular drum-driven, chain-and-sprocket features of earlier models, and can spool both plated and jacketed synthetic ropes. Actuation can be achieved by one of two approaches. AC electric motors and a VFD can be utilized, with a precision-encoder communicating pulses back to a VFD; this electric approach also eliminates the necessity of manual change-outs of sprockets needed when cables need to be changed and cable diameters change. Markey has already provided six of these electrically-powered options, for AGOR-class vessels in particular.

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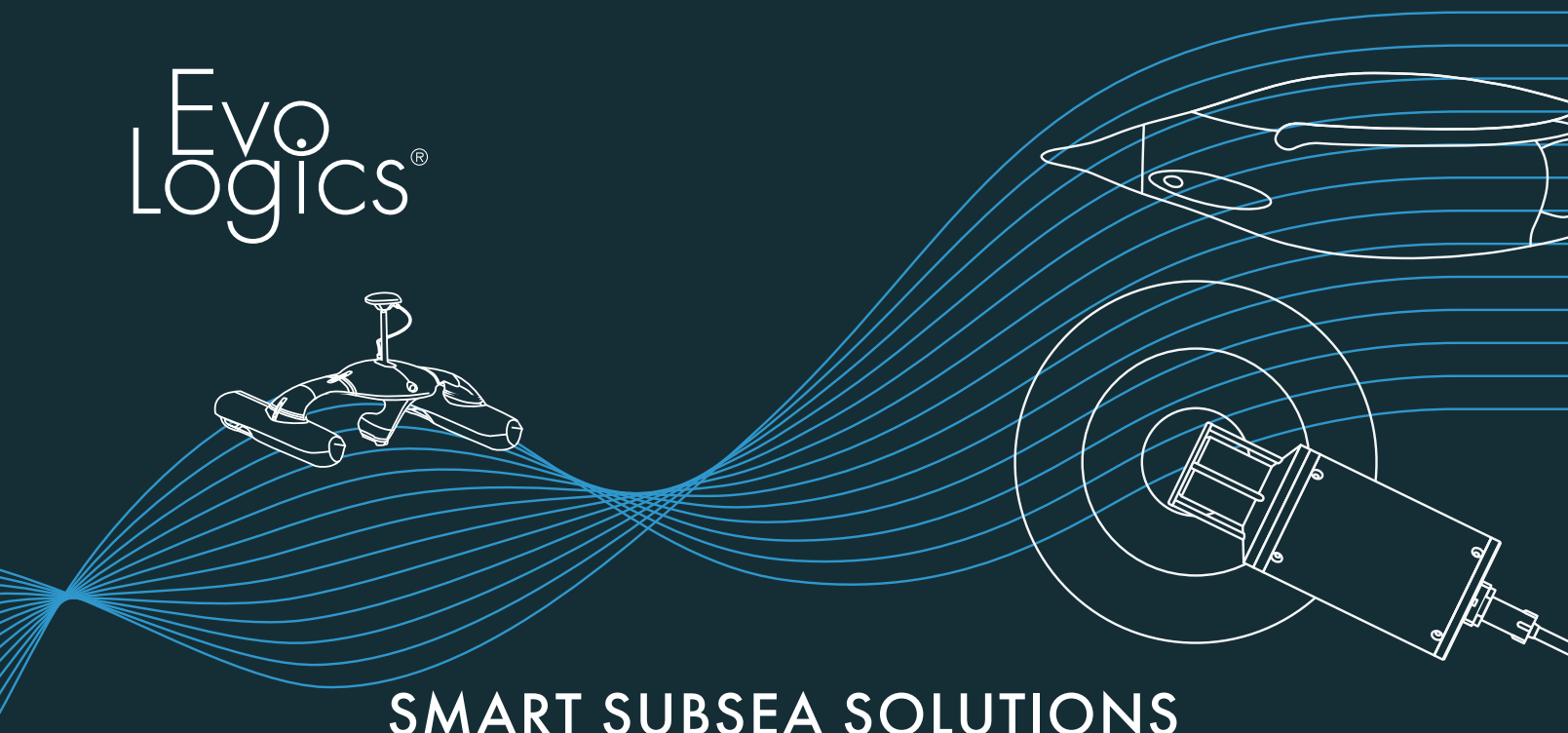

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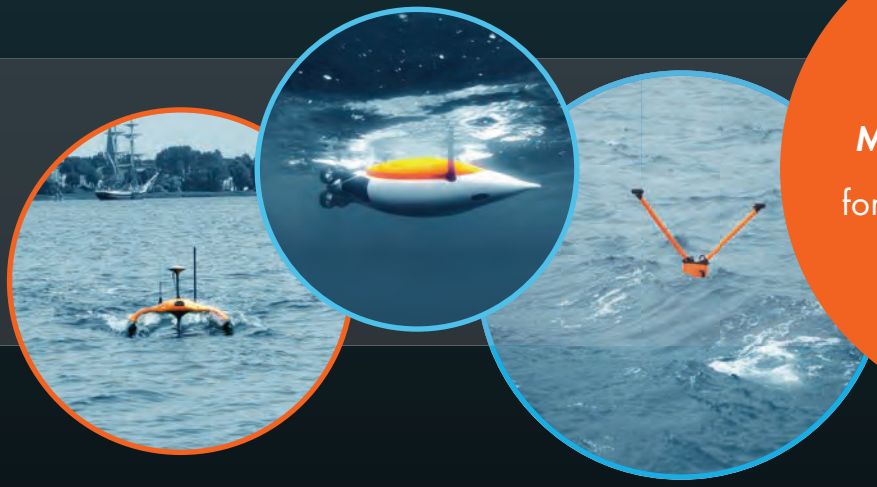

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