MARINE TECHNOLOGY REPORTER

July/August 2019

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MTR100
Subsea leaders, innovators & technologies

Wendy Schmidt
Spearheading philanthropic oceanic investment

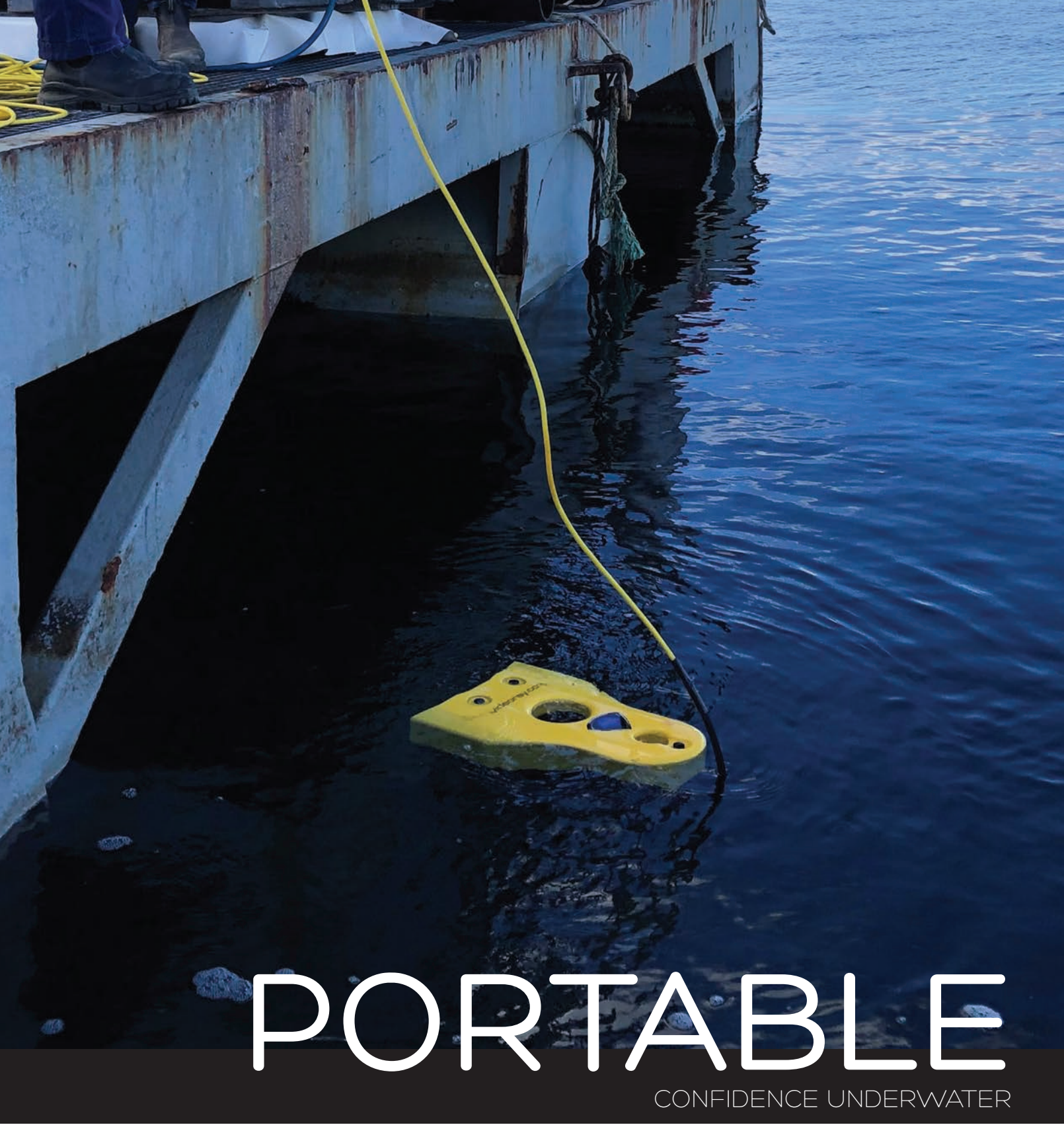
Adm. Karl L. Schultz
Connecting maritime to $5.4T in U.S. Commerce

Sven Lindblad
Explorer, photographer, environmentalist

Martin McDonald
Commanding world's largest workclass ROV fleet

Dr. Mark Abbott
Shaping the future @ WHOI

Volume 62 Number 6



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Editor's Note

Makin' a list ...

As we enter the dog days of summer, I am pleased to offer to you the 2019 MTR100, the 14th annual reporting on 100 leaders, innovators and technologies serving the subsea industry. Generally, you would expect the more times that you do something it becomes easier, but that certainly is not the case in regards to the MTR100. This year we saw a record number of applications from around the globe, and paring the final list to 100 was no small task. Again, this year we offer a feature focus on five prominent leaders, led in 2019 by our cover subject and chosen "Number One" Wendy Schmidt and the Schmidt Ocean Institute

As many of you already know, Mrs. Schmidt is part of an interesting movement of philanthropic oceanic investment. Philanthropy in this space is certainly now new, but Wendy and her husband Eric Schmidt have kicked this to a new plateau, led by Schmidt Ocean Institute's mobile research platform Falkor, the only international philanthropically-funded seagoing facility dedicated to year-round open ocean research, exploration, technology development and public outreach. By the end of 2019, Schmidt Ocean Institute's research vessel Falkor will have completed 64 expeditions and sailed a distance more than nine times around the world. Read more about the Schmidt commitment to all matters ocean, starting on page 6.

As always, I welcome your comments and constructive criticism on this year's MTR100. More importantly, I welcome your insights and requests for editorial coverage on new subsea business and technologies, now and throughout the year.

Gregory R. Trauthwein
Associate Publisher & Editor

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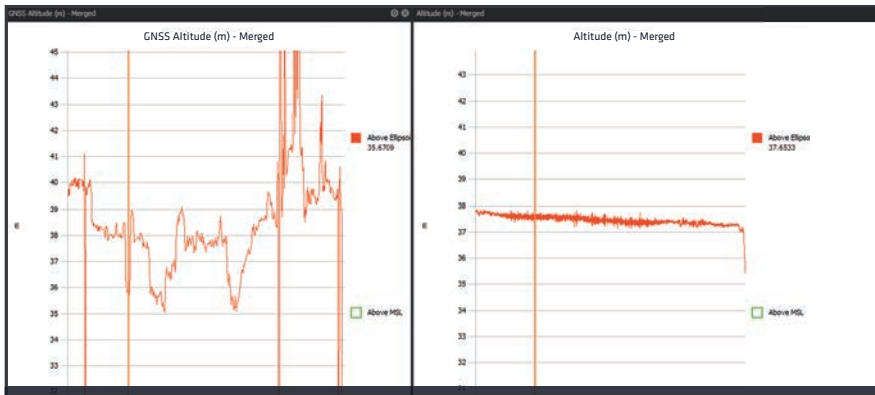

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Schmidt Ocean Institute

01

Schmidt

Wendy Schmidt

Schmidt Ocean Institute

According to Wendy Schmidt, we live in a pivotal time that requires us to re-examine humanity's relationship with the ocean. In a fast-paced and changing world, Mrs. Schmidt has emerged as an unlikely leader in an ocean revolution. Living and working for many years in the heart of Silicon Valley with her husband Eric, she witnessed the rapid evolution of technologies that have shifted the way we do almost everything. For some, the scale and pace of change provokes worry about our future. For others, like Schmidt, these advancements are a source of inspiration, resulting in financial and personal investment in a portfolio of programs that are not only driving increased awareness about the issues facing our oceans, but pushing the boundaries of current research to identify and implement solutions. Mrs. Schmidt's fearless attitude and hands-on approach is exemplified by the success of these programs.

Schmidt's focus on ocean health is propelled by her passion for sailing and love of the ocean. The breadth of her ocean philanthropy is expansive, from sponsoring two ocean health XPRIZE challenges to funding the development of new ocean-friendly materials for use in consumer goods. Schmidt has also extended her ocean-focused work to the world of sporting through 11th Hour Racing, partnering with global sailing races to put sustainability at the core of their operations and empowering athletes to be leaders in restoring ocean health.

"The ocean is under attack, and it is up to us to offer a path towards solutions, fostered by a clearer understanding of why ocean health matters to everyone,

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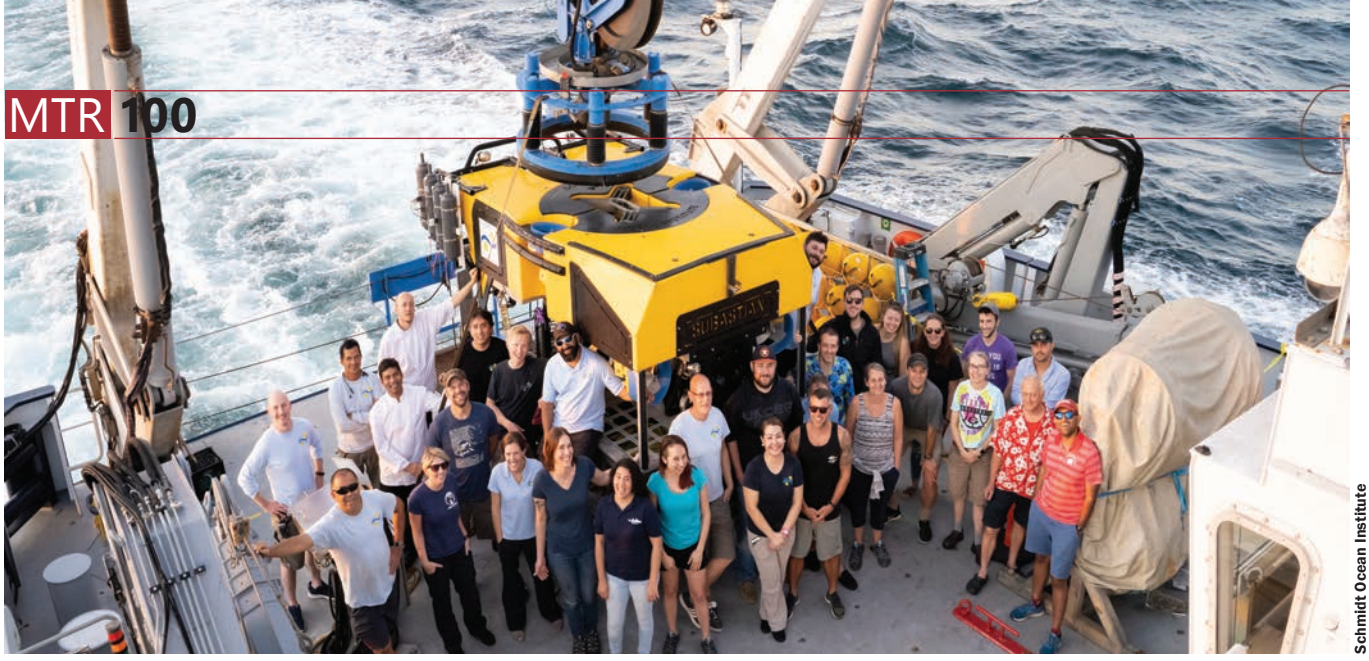

Schmidt Ocean Institute

no matter what they do or where they live," said Schmidt.

Schmidt has made figurative and literal waves with Schmidt Ocean Institute and its mobile research platform Falkor, the only international philanthropically-funded seagoing facility dedicated to year-round open ocean research, exploration, technology development, and public outreach. By the end of 2019, Schmidt Ocean Institute's research vessel Falkor will have completed 64 expeditions and sailed a distance more than nine times around the world. In collaboration with some of the world's best ocean scientists and engineers, they have tested new technologies in the deep sea for exploring other ocean worlds, demonstrated multiple vehicles using AI for real-time decision making at sea, identified countless new species, and discovered and named 12 underwater features including Schmidt Seamount and Falkor Seamount.

Many of these expeditions have not only collected important data for characterizing the ocean in remote regions, but they have also increased understanding of fragile ecosystems for protection. In 2014, Falkor's high-resolution maps of the Papahanaumokuakea Marine National Monument, northwest of the Hawaiian Islands, contributed to a significant expansion of protection for the area. In 2018, another expedition increased knowledge of the deep-sea ecosystems in the Cocos Islands providing justification for the extension of protected waters to include seven never-before-surveyed seamounts.

Beyond the expeditions of discovery and development, Schmidt Ocean Institute continues to bring the ocean to people in their communities, schools, workplaces, and recreation groups. High-resolution imagery from the owned and operated ROV SuBastian can be viewed in real time on its YouTube channel, sharing footage and connecting with the public. Schmidt Ocean Institute's maturing Artist-at-Sea program has also become a model emulated by others, hosting a total of 27 artists who have participated alongside scientists on Falkor and communicated their research through unique art.

Further innovation in ocean technology has been showcased by Schmidt's early investment in Saildrone, unmanned surface wind and solar powered vehicles that are now engaged in a wide variety of research and observation missions for clients like NOAA. It was Schmidt's willingness to take a risk on the company's commercial debut in 2016, which allowed them to get the support needed to become what it is today. This model for early start-ups is unique and has accelerated the pace of ocean technology development.

Schmidt Marine Technology Partners is an early detector of these ocean startups that is helping to make a difference with companies like Pelagic Data Systems, who developed a new way of monitoring illegal fishing and aiding in managing boat activity. Another one of these companies, Mantaray microplastics, has built the first automated, low-cost microplastic sensor that can identify and remove microplastic particles from the water. Transformative innovations supported by Schmidt Marine illustrate how you can scale technology to better conserve the ocean. "I am driven to find ways to change our world, and doing so by taking the risks that others won't. Using transformative technology funding we can impact the scale of solutions and impact our future ocean," says Schmidt.

What has made Schmidt a truly transformative influence is her vision and execution in solving the really hard problems associated with ocean health. She inspires people to care by illustrating what science and technology can do while communicating these advancements in ways that illicit excitement and wonder. She has looked at the state of ocean research and development, and asked, "what can we do differently?"

Schmidt ties all of her philanthropic work together with a systems thinking approach that sees the world as interconnected. She unites people around the ocean through science, technology, circular economies, sailing, and wonder; but really it is her curiosity and willingness to try that makes the difference. Schmidt and her entities act as the catalyst to find systemic solutions to the greatest issues facing our oceans by propelling agents of change with the right opportunities and incentives. And this is just the beginning.

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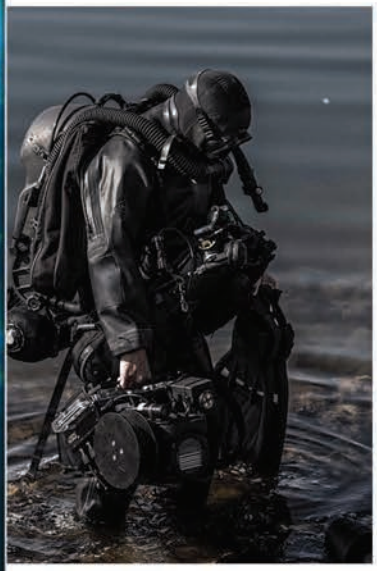

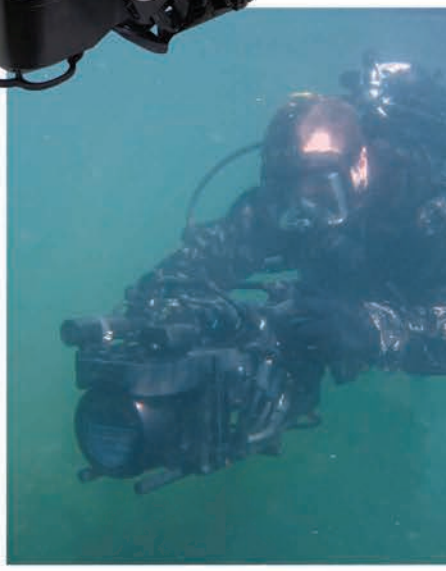

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U.S. Coast GUard

02 Schultz

Adm. Karl L. Schultz

Commandant, United States Coast Guard

The career biography of Admiral Schultz is predictably impressive for an officer that has ascended to the top of the United States Coast Guard. Admiral Schultz, who become the 26th Commandant of the United States Coast Guard on June 1, 2018, hit the ground running and has been on a mission since day one to not only stress the importance of the maritime industry as a whole, but to inextricably link the U.S. maritime industry – inland, Great Lakes and coastal – to the current and future success of the U.S. economy. He and his leadership team have been tireless advocates to ensure that Coast Guard operation and asset budgets as well as maritime infrastructure needs are kept 'top of mind', firmly entrenched in the 'vital infrastructure' discussion.

"I think it's important to have the conversation that links $5.4 trillion in annual commerce to the marine industry," Admiral Schultz shared with MTR during an exclusive interview on his jet returning from a maritime event in New Orleans. "And I think it's important to have the conversation in government that when you talk about investment in infrastructure, maritime infrastructure and the Coast Guard need to be a part of that conversation and a part of the equation."

Keeping the commercial maritime waterways humming means business for the subsea community, and a quick 'by the numbers' look at the U.S. maritime industry is enlightening and puts the Commandant's mission in perspective: 95,000 miles of shoreline, 25,000 miles of navigable channels, 361 ports, 50,000 federal aids to navigation, cumulatively

Greg Trauthwein

support more than 30 million jobs and $5.4 trillion in economic activity.

A key document for Admiral Schultz's is the "Maritime Commerce Strategic Outlook" released in October 2018. "We are committed to the Maritime Commerce Strategic Outlook as a 10-year plan to raise the visibility of the importance of the Coast Guard to our nation's commerce and economic prosperity," said Admiral Schultz. "When it comes to conversation about infrastructure, the Coast Guard needs to be a part of that conversation."

The Commandant is clearly passionate about all matters maritime, and he realizes too that tomorrow's Coast Guard must be in-step with the world at-large in terms of technology, as an efficiency measure but also to hold serve in the fast-evolving realm of cyber security. "We can't be 10 years behind general society in terms of technology," Admiral Schultz told *MTR*.

"Think about automated ships and facilities. With those automated ships and facilities comes risk, technical and cyber risk. With all of the technology comes increased vulnerability. We're building out our cyber capability at the Coast Guard. I have about 300 positions today on cyber at the Coast Guard, and the 2020 budget has about another 60 bodies as we have to defend Coast Guard networks from attack and we have to bring a cyber regulatory face to the waterfront. We need to build our own technical experts in this area" and to that end there is a new cyber major at the Coast Guard Academy, with the class of 2022 being the first with graduates with a cyber degree.

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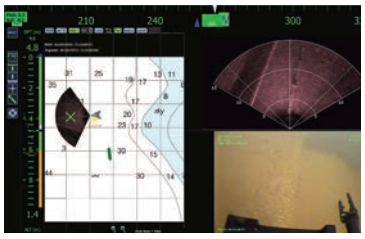

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03

Lindblad

Sven Lindblad

Lindblad Expeditions

Intrepid explorer and wildlife photographer Sven Lindblad blazed the trail for environmentally sensitive travelers to Antarctica on Lindblad Expedition's fleet of cruise ships with National Geographic.

You can tell a lot about a man by whom his heroes are, whether famous athletes, virtuoso musicians, brave warriors or movie stars. As we age, we choose our heroes by their moral compass, seeking wisdom, inspiration and truth about our world during our dwindling time on this planet.

As adventurers who led men in adverse conditions, explorers Capt. James Cook (1728 - 1779) and Sir Ernest Henry Shackleton (1874 - 1922) are Sven Lindblad's heroes. Risking their lives in search of scientific and geographic knowledge, each explorer made epic trips to Antarctica, a destination now within the grasp of the average traveler on an expedition cruise ship led by Sven Lindblad and National Geographic.

While Lindblad's not risking his life like explorers of yore, he does feels the weight of the world upon his shoulders. As a new niche bringing scores of travelers to Antarctica and the most fragile, remote areas of the globe, the dawn of expedition cruise ships created a seismic shift in quest of the earth's most outer limits.

"I never thought in my lifetime I would see too many people in Antarctica," said Lindblad. "It is at risk of becoming commoditized, which is psychologically unfortunate. It has not happened yet, but I see a distinct possibility."

Wrestling with the concept of leaving no footprints, Lindblad's responsibility

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is to change people's behavior, educating everyone that the environment is an essential partner, not some alien creation that is merely tolerated.

"How do you get people to think differently?" said Lindblad. "To protect our asset? We must commit to eliminating plastics in our supply chains. The amounts of plastic in our oceans is horrible and we must face essential change." Capt. Cook would likely advocate the world quit dumping plastics and garbage in the oceans he crossed in three epic expeditions around the globe, including first to cross the Antarctic Circle in 1773. Sailing thousands of miles across largely uncharted areas in voyages of discovery, Cook navigated and mapped lands, islands and coastlines during the first recorded circumnavigation of New Zealand.

"Capt. Cook was not an exploiter," said Lindblad. "He was a true explorer with a variety of remarkable qualities," he enthused, continuing, "Cook was a great navigator, curious and deeply concerned about the future of places he visited, like Tahiti or Australia. He worried about what would happen to these pristine areas when westerners bringing disease and destruction would come and settle. Places he visited had generally happy social structures, far more so than Europe."

Lindblad Expeditions' alliance with National Geographic allows Lindblad to take people to the Arctic on cruise ships filled with teaching moments that transform passengers into stewards of our planet, exchanging ideas amid natural beauty and wonder.

"We're broadening guests' understanding," said Lindblad. "We're not trying to keep it all to ourselves. Clearly, there is growing interest to visit remote parts of the world. Clearly, people will try to capitalize on this. Every month, I hear some new entity coming from somewhere. The ship is only part of the equation. I know how our ships behave, but others who mimic, will they take the same level of care?"

Lindblad is concerned the expedition cruise ship category could get a bad reputation harming pristine places, by not being prepared. Unnecessary accidents could accelerate.

"It's hard to believe all these companies will be successful because they underestimate how hard the work is," he said. "I am delighted when someone comes into the market and does their job to elevate the category. There are few opportunities in life for perfect solutions. Everything becomes a scale with positives and negatives, and when positives outweigh negatives, proceed with good conscience."

Now 68 and living in New York City's

Photo: Michael Nolan/Lindblad Expeditions

West Village, Lindblad hails from Sweden. Early adulthood was in Kenya where he lived until from 1969 to 1977. Nature, wild places and people who understood real survival challenges in Africa shaped his formative years.

A young Sven's company was originally a division of his father's enterprise, Lindblad Travel. It became independent a few years later. Now Lindblad Expeditions is an innovative travel company offering marine-focused expeditions aboard a fleet of eight owned ships (nine in 2020) and five chartered with over 70 itineraries. "My father, Lars Lindblad, had a deep sense of conservation and believed there are new possibilities for human experience and understanding," said Sven. "He built his business incorporating these values and was an accidental entrant into the travel business, he wanted to explore the world. Of course, he is one of my great heroes, with what he did with Lindblad Travel."

The renowned adventure-travel pioneer, Lars Lindblad, led the first laymen traveler groups to the Galapagos, Antarctica and other regions, all of which need careful care for future generations.

"Think about coral reefs disappearing entirely, the whole food chain of the ocean interrupted and ceasing to function," he said. "That's scary, motivating stuff. The greatest wonder on earth are coral reefs. The temperature of the world is heating up, and our environment is threatened by that. Coral reefs depend on water temperatures that don't rise above certain levels."

Lindblad believes contributing to scientific knowledge and communicating are our assets; this allows us to help people interconnected in balance in a sacred place.

"We can't be ostriches, can we?" said Lindblad. "I am not being pessimistic, I am realistic. We must be proactive and leave value. We must protect our asset and avoid destructive intrusion. A surfer doesn't want to go to Bali and surf through plastic bags."

Lindblad is a member of the General Assembly of the Charles Darwin Foundation for the Galapagos Islands; serves on the Board of The Safina Center, on The Hubbard Council of the National Geographic Society, and on the Board of Trustees of RARE; was named commissioner of the Aspen Institute's Commission on Arctic Climate Change in 2008, is a founding Ocean Elder of the nonprofit organization, Ocean Elders, which brings together global leaders to pursue the protection of the ocean's habitat and wildlife, and serves on the Board of Advisors for Pristine Seas.

Martin McDonald

SVP, Oceaneering

04

McDonald

Oceaneering International

Directing the **world's largest fleet** *of work class ROVs.*

Oceaneering is a pioneer and leader in the world of subsea robotics, and a 'by the numbers' look at the company provides a staggering view. Oceaneering operates a fleet of 275 work class ROVs – the world's largest– as well as 60 observation class ROVs. The ROV division has approximately 2,400 full-time personnel, with about 2,000 of these people in the field. And with ROVs diving daily it conducts more than 100,000 missions in a year. While the numbers are impressive, Oceaneering is not immune to the prolonged downturn in the offshore energy sector, and it has retired units that have come to the end of their working life, trimming the ROV fleet from its peak of 318 work class ROVs in 2014.

With its leadership, Oceaneering has been and remains a driving force in the technological and capability development of ROVs. "We've identified some gaps in the market. As we move forward, autonomy, remote operations, speed, and reliability are all coming into play," said McDonald. "We see more remote and autonomous operations taking place that are in line with the industry focus of reducing risk to personnel and lowering carbon emissions with fewer assets at the worksite.

Additionally, there is a need for more specialized equipment. Today, ROVs are working in deeper waters on increasingly complex work scopes and also in harsh shallow-water environments with high-current, low-visibility areas, so it is essential to have higher-powered units with high-specification and reliable intervention capabilities that are able to work efficiently through the full range of environmental conditions in the frontier oil and gas, and renewables sectors."

Specifically, the company has a team dedicated and specializing in technology and new product development that is working on the next generation of vehicles, which will encompass residency, robotic, and autonomous functions, according to McDonald. "We're developing this technology at an advanced stage now, and we expect to be trialing one of our next-generation vehicles in Q3 2019."

Significantly, the company conducted a demonstration of remote operations and autonomous docking in the Gulf of Mexico, where it remotely piloted an ROV, which was stationed on board a drilling rig, from its operations center in Houston while also performing autonomous docking functions. "Remote piloting technology is maturing and is currently operational in the North Sea, where we have a number of contracts. We're piloting ROVs remotely from our mission support center in Stavanger, Norway. This center has enabled us to complement ROV operations offshore with onshore operations," said

McDonald.

When McDonald and his team look at emerging technology trends, they see software and control systems technology – which go hand-in-hand – as the most pivotal to move the market forward faster.

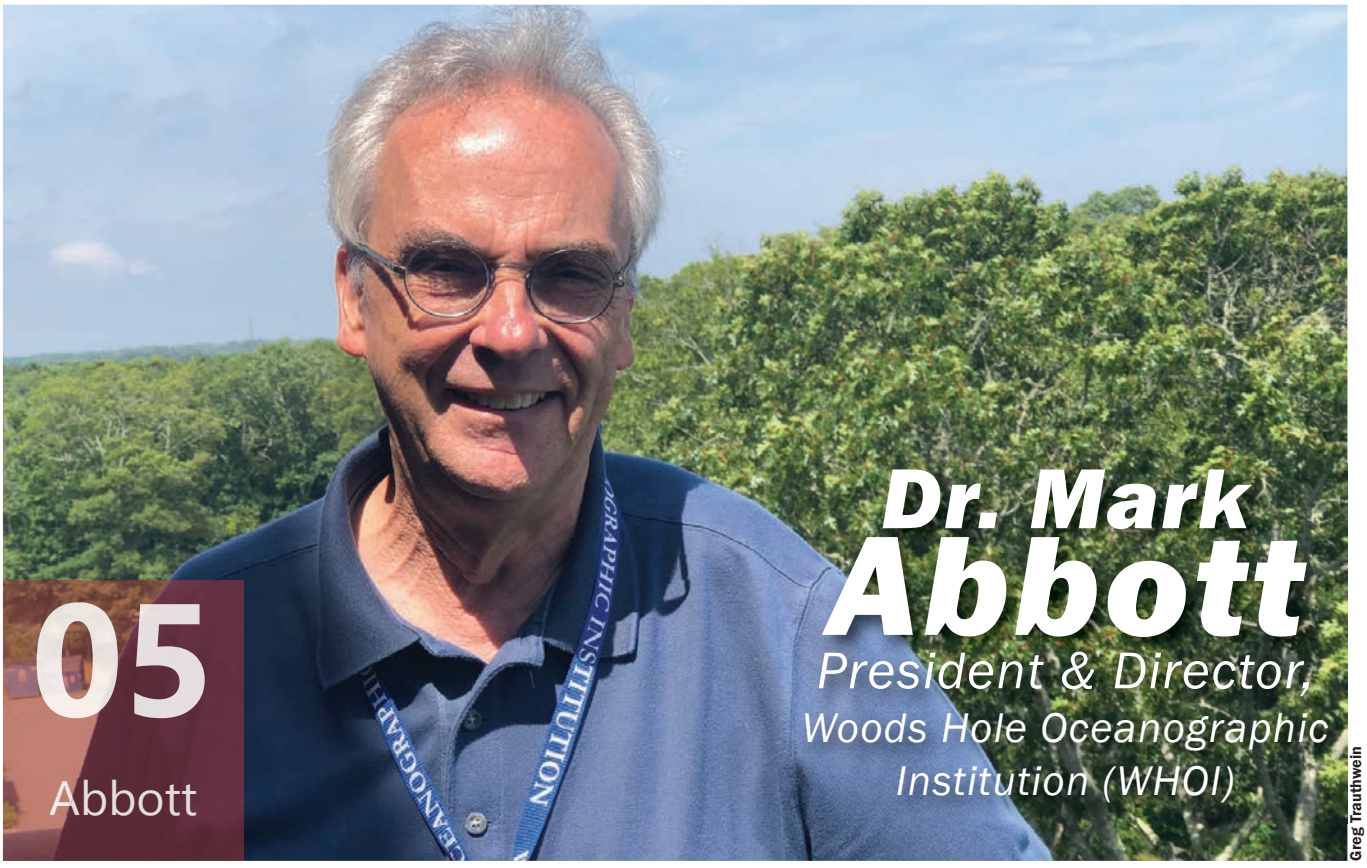
"They allow us to optimize the ROV power management systems, along with navigation, station keeping, manipulator tasks, sensors, intervention tooling, and system diagnostics, which leads to improved performance and efficiency gains. Continued software and control systems development are key components to enable subsea residency and autonomous interventions."

But he noted that machine learning and machine vision are important, too. "We have been working on automated operations, such as auto docking, where the ROV pilot can direct the ROV to move autonomously to a docking point by moving a cursor on the screen, without any intervention on the joystick. It is the machine vision recognition software tied into the control and inertial navigation systems that allows it to perform those tasks consistently. This is still an emerging technology, and it takes a little time to dock autonomously. Finally, he notes that the telemetry, control systems, and communication links for ROVs have come a long way, too.

Last, but certainly not least, McDonald points to the development of Oceaneering's "Empowered ROV" – or E-ROV – as an indicator of its view on the future of subsea robotics. "E-ROV is a resident, battery-powered ROV that will go subsea with a surface buoy. It's a work class electric vehicle with a hydraulic power pack to support its manipulator functions, and it is controlled remotely from our onshore mission support center with communications via the 4G broadband network, using a self-deployed surface buoy," said McDonald. "We believe (E-ROV) is a significant technological advancement to the next stage of subsea ROV residency. Our next generation of vehicle (the Freedom ROV) will be supported by a docking station at seabed and will have a hybrid functionality that will enable it to operate in two modes: remotely piloted via tether to provide real-time control – or operated in an autonomous and tetherless mode, using battery power."

To read the full interview with Martin McDonald, visit:

www.marinetechnologynews.com/news/martin-mcdonald-division-oceaneering-587529



Helping to bring "these exquisite solutions" to scale

Dr. Mark Abbott is the tenth director and president of Woods Hole Oceanographic Institution (WHOI), and he presides over what is arguably the most prestigious institutes on the planet for the study of the world's oceans.

Abbott has had a lifelong passion for all things environmental, stating when he was a young boy. "It started when my grandfather took me bird watching," where he first became interested in the environment. Over time, he melded his aptitude in math and interest in the environment, becoming interested in applying mathematics to ecological issues.

Founded in 1930 and located in the picturesque Woods Hole, Massachusetts, WHOI is an independent nonprofit organiztion which gets its funding from government grants and contracts, foundation and private donations and industry contracts, and has an annual operating budget of $215 million

In total there are six research departments and more than 40 centers and labs, employing approximately 950 employees, including more than 500 scientists, engineers, ship's crew, and technicians. WHOI operates three ships, the global class research vessel Atlantis; the ocean class research vessel Neil Armstrong; and the coastal vessel Tioga, small boats. It also have several underwater vehicles, from the human-occupied submersible Alvin; to ROVs, AUVs, hybrids and towed vessels.

But the value proposition of WHOI far transcends the numbers, as WHOI serves as a hub for technology, business and finance, a rallying point for organizations of all sizes and individuals to colloborate on next generation solutions to some of the world's most pressing problems in and around its waterways. This was on full display in July 2019 when some of the brightest minds in vehicle autonomy spent two days at WHOI's Center for Marine Robotics at the *5th Annual Marine Robotics Entrepreneurs Forum.*

A common theme for the day was the need to increase the volume and scale of ocean-specific technology solutions. "The challenge (we have) is how to bring these exquisite solutions to scale, to get the numbers in the thousands, or the hundreds of thousands," said Abbott. "We need to move from these hand-made solutions to build out the size and scale" to increase the numbers and "to build networks of smart devices."

While Abbott comes to work every day surrounded by cutting edge technology, the greatest satisfaction he admits is seeing the enthusiasm each year of the new crop of students, scientists and engineers that are dedicated to helping solve some of the world's most pressing problems.

Kongsberg Maritime

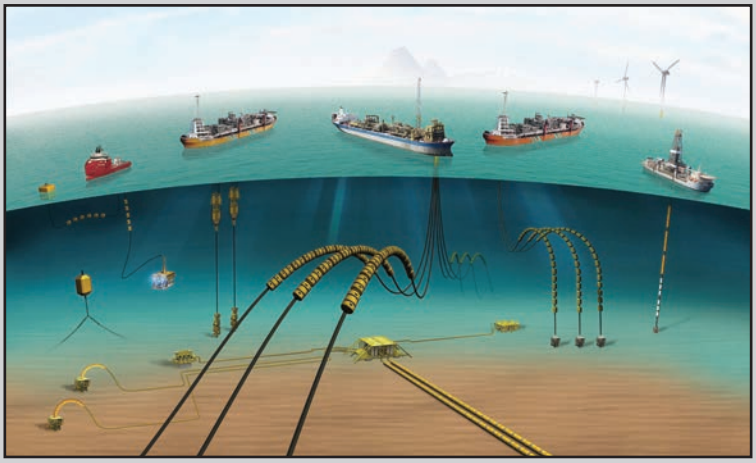
Horten, Norway
President/CEO: Egil Haugsdal
No. of Employees: 11,000
www.kongsberg.com/maritime

Kongsberg Maritime's subsea portfolio includes everything from underwater robots and transponders to hydroacoustic sonar systems and cloud-based infrastructure for data storage and analysis. The company's subsea portfolio includes single and multibeam echo sounders, sonars, underwater vehicles and subsea transponders and positioning systems, in addition to software and solutions for defense customers. In line with other marine sectors, Kongsberg Maritime is also at the forefront of digitalization for subsea applications. Mapping Cloud, which provides easy storage of different types of data within the Cloud, offers an accessible and practical means of uploading and distributing real-time data, which can be subsequently made available to use in diverse applications and products. The company continues to excel with new developments, having unveiled two advanced USVs and a new generation of its HUGIN AUV, between December 2018 and July 2019.

Kongsberg Maritime completed the acquisition of Rolls-Royce Commercial Marine on April 1, 2019 and today covers a fleet of more than 30,000 vessels.

The Tech

The latest Kongsberg AUV, HUGIN Superior is its most advanced, with significantly enhanced data, positioning and endurance capabilities. KONGSBERG's new Sounder USV is a uniquely versatile multipurpose platform designed to work across different market segments. Alongside class-leading operational, digital, power and propulsion systems for diverse vessels, Kongsberg also offers field-proven hydroacoustic systems including; multibeam beam echo sounders, synthetic aperture sonars, fishing sonars, naval sonars, positioning and subsea communication equipment, heading/motion sensing instruments, and sound velocity sensors and processing software. Kongsberg also offers Mapping Cloud, a new digital platform offering an accessible and practical means of uploading and distributing real-time data, which can be made available to use in diverse applications and products. With Mapping Cloud, data uploaded in e.g., Australia could be processed in Paris and the results displayed in San Francisco on a user's favorite application. By sharing secure data that can be worked on simultaneously, colleagues in different locations can share the workload and potentially generate invaluable insights. Mapping Cloud also negates the need for local disk storage: data files are securely transferred, managed, shared, processed and archived on servers hosted in Kongsberg's cloud-based Kognifai open digital platform.



Balmoral Offshore Engineering

Balmoral Offshore Engineering

Aberdeen, UK

President/CEO: Jim Milne

No. of Employees: 500

www.balmoraloffshore.com

Established in 1980 by chairman and managing director, Jim Milne CBE, Balmoral Group is a privately-owned company comprising several divisions including Balmoral Offshore Engineering, Balmoral Tanks and Balmoral Business Park. Balmoral Offshore Engineering provides buoyancy, elastomer and composite solutions including drilling and distributed riser buoyancy, thermal insulation, cable protection, bend restrictors, stiffeners and riser protection guards. Installers and operators are seeking to deploy the latest technology to achieve efficiencies throughout the life of a project. The company's purpose-built production facilities, subsea test center, R&D continuous improvement program, experienced HSE, engineering and commercial departments all play their part in delivering safe and successful projects time after time on a global basis.

Balmoral aims to be the 'first choice best solution' supplier through a combination of track record, innovation, technical and manufacturing prowess. Balmoral is renowned for its pioneering spirit and by introducing a dedicated resource, known as the 'Balmoral R&D Team', the company has broadened its horizons to focus on supported markets, product solutions and routes to market.

The Tech

With a rich history of industry firsts, including a ground-breaking hybrid buoyancy/insulation material that was used in the Girassol field, to a combined buoyancy/VIV suppression system developed more recently for a project offshore Guyana, Balmoral continues to be an industry leader. Subsea materials and product development lie at the core of what Balmoral does; clients are demanding higher performing, lighter, stronger products for their deepwater projects. Coupled with an industry-leading subsea test facility that is capable of extrapolating materials performance for a field life of 25+ years, Balmoral's expertise has helped the viability of many projects by way of collaboration and early intervention.

Chelsea Technologies

West Molesey, Surrey, UK

President/CEO: Elizabeth Paull

No. of Employees: 40

www.chelsea.co.uk

Sea Sentry, Chelsea Technologies' wash water monitor, has increased its sales in response to the imminent imposition of the IMO 2020 Sulfur Cap regulations. Initial sales of the product were to European manufacturers but Chelsea is now a major exporter to markets in the Far East, including China, Korea and Japan. Also, FastBallast, is a technology leader in the supply of compliance testing of treated ballast water. During 2018/19 sales have begun to Port Authorities, ship owners and ballast water treatment equipment manufacturers. A new, flow throw adjunct for the equipment was introduced in the early part of 2019.

The Tech

Sea Sentry is an exhaust gas scrubber, wash water monitor that measures pH, PAH, turbidity and temperature to ensure that IMO set regulations are being met. The company has developed signal correction algorithms that are unique and that have been accredited by class societies such as DNV-GL. Fastballast, the ballast water compliance monitor, again uses technology unique to Chelsea that has established it, via third party testing, to be the most accurate method to meet the specifications set down by the IMO in their D2 regulations.

Chelsea Technologies


Ohmsett

Ohmsett

Leonardo, NJ

President/CEO:

Paul Meyer, BSEE Technical Representative

Website: www.ohmsett.com

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. Managed by the Bureau of Safety and Environmental Enforcement (BSEE) under a contract with Applied Research Associates, Inc. (ARA), it is the largest outdoor facility of its type in North America. Ohmsett conducts research, testing, and training with full scale equipment using real oil in a repeatable and controlled simulated marine environment. **Ohmsett's most notable feature is the above-ground concrete test tank measuring 667 x 65 x 8 feet deep filled with 2.6 million gallons of crystal clear salt water.** The wave generating capabilities include programmable amplitude, frequency and wave length, creating random waves that more closely approximate waves in the ocean, and waves that can be break at specific locations within the tank. By providing independent and objective performance testing of full-scale oil spill response equipment and marine renewable energy systems (wave energy conversion devices), customers are able to use the facility to conduct tests on skimming vessels, sorbents, dispersants, sunken oil detection, oil emulsions, oil-in-ice recovery, remote sensing, marine hydrokinetic turbines, marine debris removal technology, and much more. Ohmsett partners with industry to offer first responders the most realistic hands-on training available. Training using real oil provides participants the opportunity to practice operational methods and use of response technologies that are critical to successful oil spill response operations.

LinkQuest

San Diego, CA

President/CEO: Ning Xiao, Ph.D.

www.link-quest.com


LinkQuest

LinkQuest Inc., San Diego, California, manufactures precision acoustic instruments for offshore oil exploration, construction, drilling, survey, environmental study and other oceanographic applications. The company's acoustic communication and positioning products are based on the innovative Broadband Acoustic Spread Spectrum (BASS) Technology and are widely used worldwide. LinkQuest's high speed underwater acoustic modems transport more than 95% of the world's acoustic communication data. These systems have set a series of technical performance records in field deployments all over the world. LinkQuest's line of Track-Link Acoustic Tracking Systems provide highly robust, accurate and cost-effective Ultra Short Baseline (USBL) solutions.The FlowQuest Acoustic Current Profilers, FlowScout Acoustic Flow Meters and NavQuest Doppler Velocity Logs (DVL) were designed to provide solutions for current profiling, wave measurement, flow measurement or precision underwater navigation applications. These products offer significantly longer range with high accuracy. LinkQuest also manufactures PinPoint LBL acoustic positioning systems, Precision Marine Geodetic Systems and EchoSweep systems.

Kraken Robotic Systems

Mount Pearl, Canada

President/CEO: Karl Kenny

No. of Employees: 50 • www.krakenrobotics.com

Kraken designs and develops high performance, software-centric sensors and underwater robotic systems. Kraken has a full line of underwater products including KATFISH Actively Controlled SAS Towfish, ThunderFish AUV, SeaVision 3D Laser Imaging system, and pressure tolerant components such as thrusters and batteries. Kraken's R&D of advanced Synthetic Aperture Sonar (SAS) systems and underwater robotics has led us to be the only Canadian company to successfully develop SAS technology, deployed in over 10 countries by military and commercial operators. Kraken is continuously focused on R&D, seeking to improve industry processes and products.

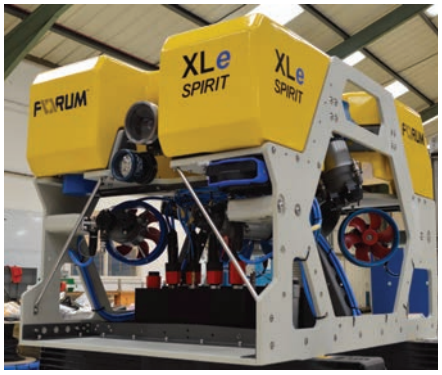
By its own reckoning, Kraken has had "an amazing year." It moved its headquarters into a state-of-the-art 19,000 sq. ft. facility in Newfoundland and established the Kraken Unmanned Marine Vehicles Facility in Nova Scotia. Several strategic relationships with prominent firms were established including: Ocean Infinity, ThayerMahan, Leeway Marine and NOAA. It received a $9 million order from Ocean Infinity for our deep-sea batteries, shipped its first commercial SeaVision and received a $2.1 million order from ThayerMahan for a KATFISH-180 system. Kraken has also been approved by the Ocean Supercluster to move forward with its OceanVision project. OceanVision is a new business model that supports Robotics as a Service (RaaS). The company's pipeline is robust and the company is confident "we will double revenues in 2019."

The Tech

Kraken has the unofficial motto of "innovate or die," as constant innovation is the key to its success. Every Kraken employee is encouraged to develop, try new things and even fail. According to the company, its SAS provides the highest resolution with the lowest cost per pixel in the market – all in real time. SeaVision is the world's first full color, underwater laser imaging system that offers resolution, range and scan rate with millimeter resolution in real time. KATFISH provides the industry's highest resolution seabed pixels at the lowest cost. Kraken has developed a new method of creating cost and space efficient pressure tolerant electronics and batteries. By using Lithium-Polymer cells encapsulated by a durable silicone polymer that remains flexible, yet stable under pressure. As such, the battery design can be contoured to fit the shape of the vehicle, improving packing efficiency and increases volumetric density. This technology reduces the size of battery packs for underwater vehicles and reduces the cost and weight versus traditional subsea batteries while providing longer battery life.

Forum Subsea Technologies

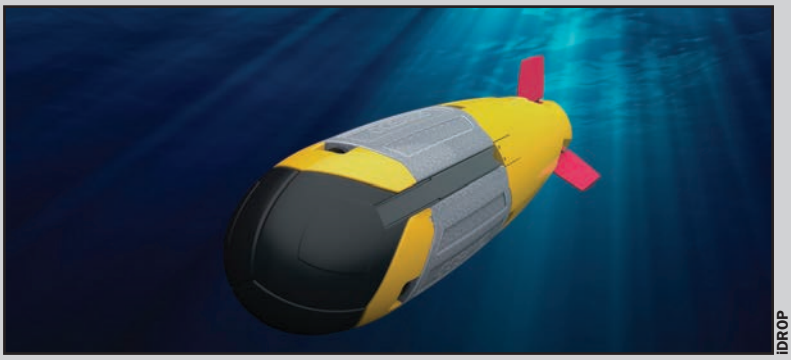
https://www.f-e-t.com/



Forum Subsea Technologies' launched XLe Spirit, the first observation-class ROV to use Forum's Integrated Control Engine (ICE) to bring greater functionality commonly only found in larger work-class vehicles. The control electronics pod fitted to all Forum XLe observation class vehicles enables superior connectivity and expansion capabilities when compared with other ROV's on the market. Ethernet interfacing allows for seamless integration with other industry sensors using common IP architecture and ease of remote data transfer.

"As the subsea market continues to recover from a sustained downturn, cost efficiency is high on the agenda for the industry," said Kevin Taylor, VP of Subsea, Forum. "Forum recognized the opportunity to apply our leading software to a more compact vehicle to enhance capabilities and meet the changing demands of the sector. "By utilizing the same system across all vehicles, pilots only have one interface to learn as the skills are transferrable between the smallest observation vehicle and the largest trenchers. This means training can concentrate on operational tasks opposed to control systems, providing further efficiencies."

The XLe Spirit incorporates a number of features to maximize its stability for use as a sensor platform, including regulated propulsion power, optimized thruster orientation and location, accurate thruster speed control and a wide range of auto-functions for positioning and flying. The XLe Spirit completed a 12-week test program at Forum's test tank in Kirkbymoorside, Yorkshire, and was sent for sea trials in the first quarter of 2019.



iDROP

iDROP is aiming to disrupt the seabed seismic technology market with its autonomous Oceanid nodes. iDROP's system is based on individual cylindrical sensor nodes (named after Greek sea nymphs) that are drop-fall deployed, using gravity and ballast shift for propulsion and position control, to land at specific pre-planned positions on the seabed where they land on aluminium legs which pop out before they land.

The idea is that they can be deployed in groups, falling to form grid patterns on the seabed for seismic surveys. Onboard batteries power the descent control (using just 5% of the battery doing so), data harvesting (for 180 days) and trigger a mechanism that releases the 30kg ballast – made of salt slurry – allowing the units to glide back to the surface, again, under control so they aim towards an expected target. A surface system with a floating conveyor belt type arrangement would then collect them.

"There's a variety of seismic acquisition technologies out there that are mainly towed," says Kyrre J Tjøm, iDrop's founder and CEO, who has previously worked at Schlumberger and consulted for Equinor and Seabed Geo Solutions. "There are also nodes that are placed on the seabed by an ROV. There are others where you dump them over the side with concrete ballast and some propelled alternatives. Our system will remove the necessity for large specialist vessels with heavy handling machinery and time consuming ROV operations."

Groups of Oceanids can be deployed fast and sensor point granularity (i.e. area coverage and therefore how much data be retrieved) can be increased, he says. This is thanks to 69 degrees to vertical autonomous lateral displacement capability, with each node "falling" to a pre-set position. "If you want to deploy a sensor in 1200m water depth, you can reach 2km away from the surface vessel and install a patch of sensors, rather than a line," he says.

Batches of nine nodes, each with an inductive modem, transponder and seismic sensor payload, could be deployed in 15 minutes, a 10-fold time saving compared with established methods, Tjøm says. A Digital twin, based on extended modelling and testing, would be used to help identify any environment impact, eg. waves, current, depth, etc., and therefore enable control of the descent.

"We are looking at revolutionising the way ocean bottom nodes are installed on the seafloor," says Tjøm. "The competitors do 40-170 a day per and need two ROVs, DP-controlled node handling systems, a large vessel and specialized crew. The deeper you go, ROVs are slower as they need more thrust to pull the umbilical. We would do just less than 1000 per day with a standard marine crew."

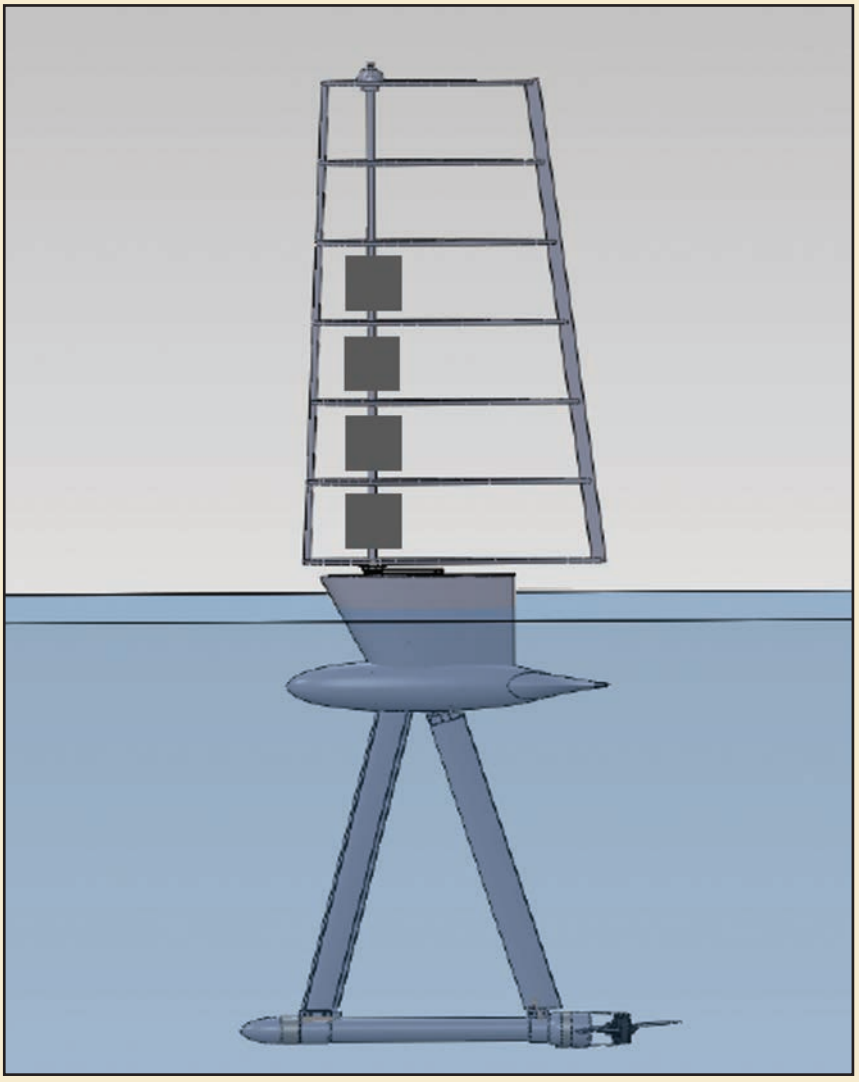
SubSeaSail

www.subseasail.com

SubSeaSail LLC (SSS), based in San Diego CA, designs and manufactures unique unmanned semi-submersible sailing vessels (USSVs) that are wind-propelled and solar-powered. The platform is the most economical long duration system available and is capable of autonomous or manual missions, individually or swarming. The key tenant is "Engineered for Simplicity" with significant, patented and patent-pending technologies.

SSS has received a patent for a sailing vessel with the hull below the surface and the wingsail above. This reduces friction (drag) while producing little-to-no wake and a significantly reduced Infrared, radar and visual signature. A second patent is for a revolutionary Passive Mechanical Wingsail Control Mechanism that sets the wingsail at the optimum angle with respect to the wind direction and the desired direction of travel without the use of electronics, pulleys or lines. This feature significantly reduces complexity and cost while increasing reliability. A servo for the rudder is the only electromechanical component in the platform required for sailing control. An optional thruster can be added for navigation out of harbors, away from hazards, or to augment control in low wind conditions.

A key feature of the SSS platform is that it can take various form factors and is highly scalable. A catamaran version demon-



SubSeaSail

strated that it can sail above or below the water and, while on the surface, could perform missions such as deploying and/or recharging unmanned aerial systems or to deliver cargo without need for a deep-water port. The Gen5(S) variation is designed to sink to 10m to avoid bad actors, bad weather, or ship traffic. Systems are being developed with various solar panel configurations to maximize power generation or stealth. Applications are broad and include ASW, C4ISR, cargo re-positioning and delivery, communications gateways, mine delivery/counter measures, ocean sensing, protection of exclusive economic zones and marine protected areas, targets and decoys, UUV delivery/launch/landing/recharging, and UXO detection.

SubSeaSail was founded in 2017. The business model includes sales, leasing, service and SaaS. The SSS team consists of the following personnel: Managing Partner Michael Jones, Founder of The Maritime Alliance and listed in MTR's "Top 10 Ocean Influencers: for 2018"; Partner Chris Todter, the Technical Director/Design Coordinator for seven America's Cup campaigns including winning with the Oracle Trimaran in 2010 and an extensive patent holder; Partner Mark Ott, a founder/CTO of three marine robotics companies and 22 years' experience in marine technologies; and Director of Business Development Sean Newsome, with 20+ years of successful BD experience in unmanned systems and sensors.

RBR

Ottawa, Ontario, Canada
President/CEO: Greg Johnson
No. of Employees: 60
rbr-global.com

Photo: RBR

RBR has maintained a year-over-year growth rate of over 20%. RBR customers are actively using Generation³ products from the ocean abyss to the polar ice caps to make great discoveries. RBR has expanded product offerings to sensors, loggers, systems and OEM components. The past year has been busy with new engineering, sensor design, and ocean deployments in collaboration with global commercial partners to enable innovations in Argo floats and autonomous vehicles AUVs and gliders. RBR is always striving for innovation and has expanded its Generation³ instrument product line to include the RBRlegato³ C.T.D, offering a new world of measurement opportunities for gliders and AUVs. Optimized for flow dynamics, the RBRlegato³ power requirement is 90% lower than traditional pumped CTD sensors due to modern electronic design and the lack of moving parts. Improving integration efficiency, the RBRlegato³ is designed to seamlessly integrate and control additional sensors. In addition to product development, RBR continues to establish global offices in active regions. In the past 12 months, RBR has established a regional office in Seattle and in Qingdao. The regional offices allow RBR to provide more attentive sales and technical support and enter into closer collaborations in project development.

RBR makes high-precision instruments used for measuring the blue planet. Designed with the user experience and flexibility in mind, RBR's instruments measure up to 10 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 Gen-eration³ instruments run on AA batteries. By having one cable that fits all, with widely available batteries, preparing for deployments has never been easier. The Wi-Fi connectivity allows the user to control, download, and view data via Ruskin Mobile. Other Generation³ features include reduced power consumption and faster sampling. The lower power platform also enables vertical profiling floats, such as Argo, and autonomous underwater vehicles, such as ocean gliders, to sample more frequently or extend their mission duration, greatly reducing costs or enabling ex-tended missions. By increasing the sampling rate up to 32Hz, RBR instruments can be used for mixing studies and to resolve thin layers in the ocean.

Houston Mechatronics

www.houstonmechatronics.com

Houston Mechatronics is a vertically integrated service provider that is committed to innovating and delivering world class robotics in both oil and gas and defense. It builds and uses robots on land and at sea that are revolutionizing the way over the horizon autonomous work is done. Aquanaut is its transforming tetherless AUV/ROV. The vehicle conducts automated inspections and surveys common in the ROV and AUV service industries. The vehicle is currently undergoing sea trials and a commercial service will launch in 2020. Houston Mechatronics is also launching a workclass all electric ROV arm in Q4 2019. The 7 DOF arm is designed to lift 275 kg at full extension and will feature safety and automation systems similar to what Aquanaut uses today. The Olympic arm will afford users all the strength of a hydraulic arm and all the accuracy, precision, and automation of a cartesian controlled electric arm.

Houston Mechatronics

Picotech

www.picotech-ltd.com

Picotech Ltd. launched PicoPOD, a turnkey multibeam package for USVs and small survey vessels with a very simple mechanical interface. It is supported by industry standard acquisition and processing software and is ideal for use in surveying ports, harbors, tidal barriers, bridge footings, dams and reservoirs. CEO Allan Willcox said, "We're very excited about unveiling our PicoPOD which is built on the back of a decade of research and product development. Combined with a small COTS USV, such as Seafloor Systems' HyDrone USV, PicoPOD is the only man-portable multibeam USV on the market." Picotech Ltd. aims to see its 'low-power, low-cost' multibeam sonar systems reach new sectors in the market. The PicoPOD system operates to a sounding depth of 240m and has a maximum swath width of 408m. Its features include a PicoMB-120 Multibeam with Integrated Applanix POS MV, Windows 10 IoT Embedded PC, Valeport UltraSV, a hydrodynamic enclosure plus optional extension wings for larger USVs, built in support for RTK via VRS Now (with user's subscription), RTK via base station with optional UHF modem, optional mounting points for tracking prisms and an optional Lidar. PicoPODs have been deployed in the U.K., U.S., Japan and Italy for hydrographic survey of ports, tidal barriers, rivers, tailing ponds, SAR and multibeam training courses.

Picotech

Greensea Systems, Inc.

Richmond, Vermont,

President/CEO: Ben Kinnaman

No. of Employees: 23

www.greensea.com

Greensea Systems, Inc. is a leader in advanced robotic systems for high-level tasking, interoperability, and intervention. Greensea's OPENSEA operating platform provides a fully distributed, open software framework for highly integrated systems across all brands of sensors, devices, and equipment while cutting-edge technologies for navigation and autonomy elevate system intelligence. One cohesive operator interface, Workspace, fuses system data into a comprehensive command and control center for streamlined workflow and improved productivity. Greensea's commercial products are customizable and all are fully supported with documentation and field-experienced engineers.

Core competencies include:

- Interoperability, intervention, and high-level tasking for advanced robotic systems
- Full & supervised autonomy for surface, subsea, and diver vehicles including over-the horizon communications
- Systems integration and payload management
- Simultaneous Localization and Mapping (SLAM)
- SWaP-C optimized navigation customized by application for heightened accuracy.

Differentiators include:

- Open, modular, brand-agnostic technologies
- Proprietary Extended Kalman Filter and patent-pending heading algorithms
- 800+ systems fielded across manned, unmanned, surface, and subsea
- Navigation and control

Greensea Systems

"A Breakthrough Year …"

2018 has been a year of breakthroughs and advancements for Greensea Systems, all based on the continued integration of OPENSEA as a platform for easy and cost-effective development of marine robotics. The highlights:

- Development of ACOMMS subsea texting accessory for the RNAV2. The ACOMMS accessory enables combat divers using the RNAV2 to text, share data, and track team members/other submerged assets within a 2km radius.
- EOD Workspace released. Built upon OPENSEA, EOD Workspace provides vehicle and sensor agnostic navigation, control, and workspace for ever smaller ROVs (like VideoRay's Mission Specialist series or Seabotix vLBV).
- SBIR/STTR Phase 1 funding to develop an Autonomous Hull Grooming Vehicle. This is based on the development of a multi-modal aided Inertial Navigation System (INS) specifically for hull-relative orientation, localization, and navigation combined with a proven autonomous control architecture for miniature water-borne robots and an intuitive mission-planning, quality assurance, and visualization Human Machine Interface (HMI) for supervising the hull grooming robot.
- OPENSEA is becoming widely accepted as a way for developers and OEMs to further their development process faster. Houston Mechatronics, Kraken, and Seatronics have adopted the OPENSEA platform.

The Tech

Greensea's core technology, OPENSEA, is designed to reduce cost, reduce risk, and accelerate technology insertion within the marine industry. Its library-based, open architecture is fully distributed and includes the interfaces and utilities essential to robotics and the unmanned systems community including navigation, autonomy, and mission planning. New vehicles, equipment, and devices are easily integrated, minimizing risk and expense, by leveraging the OPENSEA library which confines new software to small, independent applications that are separate from proven, robust software. Deriving from the OPENSEA library, the OPENSEA application suite provides hundreds of distributed independent applications that work together as building blocks for a complete system.

These applications communicate with each other through the OPENSEA network and provide discrete capabilities required to integrate a system that is scalable, flexible, and severable.

Shark Marine Technologies

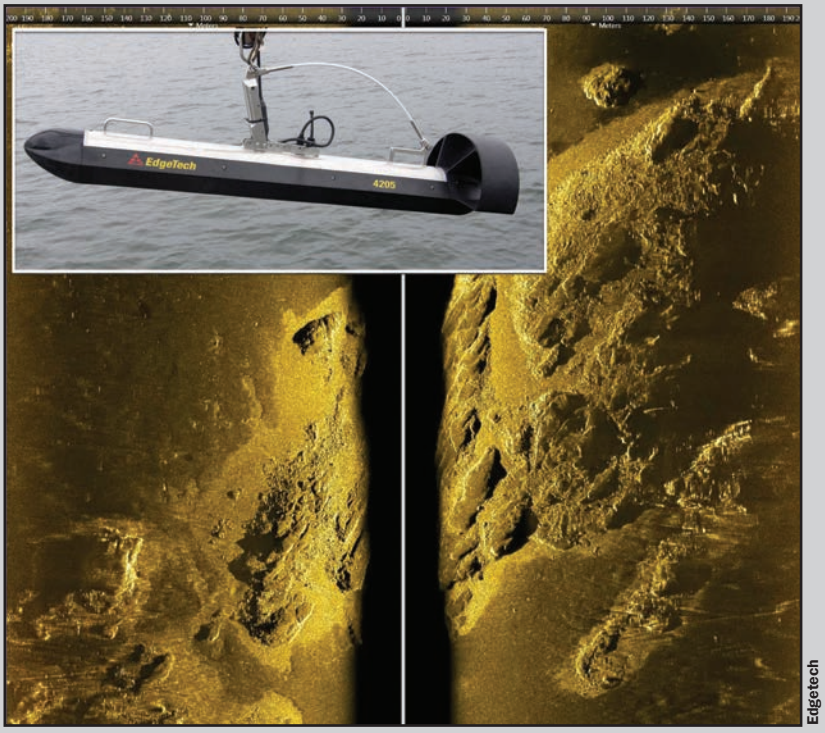
www.sharkmarine.com

In 1984 Shark Marine Technologies Inc. was founded on a mandate to produce innovative, high quality underwater products that were both dependable and cost effective. Today many of these products are relied on by a large selection of the world's navies as well as underwater scientists, archaeologists, search and rescue organizations, power generation authorities, the oil and gas industry and many others responsible for underwater operations.

Its products include, the Barracuda and SeaWolf remotely operated vehicles; the MAKO Diver Delivery System with fully autonomous capabilities; Imaging systems both sonar and video; Tether management systems, software and our Diver Held Sonar Imaging, Navigation and Communication Systems, the Navigator, DiveTablet 2 and its new E-TAC (pictured below). The Navigator was developed to allow Search and Recovery and Mine Counter Measures Divers the ability to accurately navigate and see its surroundings, no matter the visibility. It is now in use by more than 20 Navies worldwide with an ever-increasing list of accessories and capabilities such as the Sub-NET communication system which allows communication and position sharing up to 1 km underwater. The Dive Tablet 2 followed the success of the Navigator but offered a smaller lighter platform for those in shallower water, or focused mainly on navigation, while still capable of using many of the Navigator's accessories. The latest addition to this line of products is the E-TAC which has been designed specifically to meet the needs of Combat Divers, giving them precise underwater navigation in a small, lightweight unit that is not only rated to operate 50 meters (165 ft.) below the water, but also 15,000 meters (50,000 ft.) above.

Its Divelog "mission control software" covers all aspects of mission planning, underwater data collection and navigation, and provides an automatically generated report which georeferences all the data collected into an easily exportable, interactive HTML file. Divelog's capabilities have been expanded to control all of Shark Marine's underwater applications. One single program for video systems, ROVs, AUVs, towed arrays, diver navigation, sonar and communication systems as well as its diver delivery vehicles.

Shark Marine Technologies



EdgeTech

W. Wareham, Mass.

President/CEO: R. Jablonski

No. of Employees: 100

www.edgetech.com

EdgeTech develops, manufactures, sells and supports underwater technology solutions including side scan sonars, sub-bottom profilers, bathymetry systems, USBL acoustic tracking and positioning systems, transponder beacons, deep sea acoustic releases, shallow water and long life acoustic releases, underwater acoustic command and control systems and custom-engineered acoustic products. The company traces its history back to 1965 when it started out as a division of EG&G Marine Instruments. In 1995, EdgeTech became a private company and selected its name in part to honor the late Dr. Edgerton, an MIT professor, marine instrumentation pioneer and a founder of EG&G. In 2012 ORE Offshore, a provider of acoustic releases, transponders and USBL systems, adopted the EdgeTech name after more than 10 years operating as an affiliate organization within the company. In 2018 EdgeTech announced a number of new products and the company has been busy fielding those new and innovative solutions throughout 2019. New systems include side scan sonars, sub-bottom profilers, bathymetry systems, combined sonar systems and acoustic releases.

In the side scan sonar product group, the new 4205 began shipping in 2019. It is available in either a tri-frequency side scan sonar configuration or motion tolerant and multi-pulse configuration. The tri-frequency version allows surveyors the option to operate any two frequencies simultaneously from the tri-frequency system. The 4205 motion tolerant configuration with multi-pulse provides surveyors the ability to operate either at faster survey speeds or in more adverse weather conditions while still obtaining high quality underwater imagery. Building on the long running success of the EdgeTech sub-bottom profiler product line, the new EdgeTech 3400 provides users many enhancements to current sub-bottom profiler systems. The system generates high resolution images of the sub-bottom stratigraphy in oceans, lakes, and rivers and provides excellent penetration in various bottom types. The EdgeTech 3400 comes in a dual 2-16 kHz transducer configuration. The towfish is configured with new PVDF receiver arrays segmented for standard sub-bottom profiling operations or a unique “pipeliner” mode for optimal location and imaging of buried pipelines.

The Tech

The new 6205s is the only shallow water wide swath bathymetry system to now offer EdgeTech’s motion tolerant side scan sonar feature for operation in more adverse weather conditions. The EdgeTech 6205s is a fully integrated boat/pole-mounted Swath Bathymetry and Dual Frequency Side Scan Sonar System that produces real time, high resolution, side scan imagery and 3D maps of the seafloor. EdgeTech’s new combined sonar platform is the 2300 system. This deepwater system integrates the highly successful line of side scan sonars, sub-bottom profilers and (optional) MPES bathymetry into one fully integrated 2,000-meter rated system. In the acoustic release line, EdgeTech recently introduced the Ropeless Fishing System with embedded acoustic release technology developed to eliminate vertical lines connecting a surface buoy to bottom fishing gear. The system was designed from the ground up with the intent of alleviating possible whale entanglement and other negative effects of seafloor-to-surface fishing and trap lines.

EvoLogics GmbH

EvoLogics GmbH

Berlin, Germany

President/CEO: Dr. Rudolf Bannasch, Dr. Konstantin Kebkal

No. of Employees: 35

https://evologics.de/

EvoLogics GmbH is a German high-tech enterprise, founded in 2000 by a group of scientists and R&D experts. The company's mission is to develop innovative technologies for maritime and offshore industries through interdisciplinary cooperation between engineering and life sciences. The company designs and manufactures underwater information and communication systems based on bionic concepts, combining state-of-the-art engineering with the best ideas found in nature. Advanced product features have become enabling technologies for deep water exploration and production. EvoLogics are experts in cutting-edge underwater communication and positioning systems, as well as novel robotic solutions. The company's advanced spread-spectrum technology allows to deliver data in most challenging subsea conditions. EvoLogics products include several series of underwater acoustic modems, underwater acoustic positioning systems (USBL, LBL), as well as the Sonobot - autonomous USV for bathymetric surveys.

EvoLogics' developments are based on the patented S2C (Sweep Spread Carrier) technology - the 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 to control 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 extensive experience with sensor integration allows it to provide customers with turn-key solutions ranging from initial deployment up to recovering the equipment.

... the ones to watch ...

Completely new modes of operation are entering the underwater domain for oil and gas operations and the tools that are being used could also be used across the ocean space. It's been called a subsea space race – and it is a little like a Mars mission, with similar communications challenges and questions around power supplies. Various players are working to make it happen. The idea is to have subsea resident vehicles, eliminating the need for manned surface vessels and the limitations on launch and recovery posed by bad weather.
Elaine Maslin takes a look at five companies operating in this space.

Blue Logic: A new era

One is Blue Logic, based near Stavanger in Norway. While it's not the only firm producing inductive subsea connectors (WiSub, near Bergen is doing similar), Blue Logic has been heavily involved in building a key piece of the infrastructure that will enable so-called resident subsea vehicles to remain subsea for long periods performing inspection and intervention operations. It's the subsea docking station (SDS) for Equinor's underwater intervention drone concept (UiD – a name trademarked by Equinor). Two have so far been built, with one now installed in 365m water depth offshore Trondheim, at an open test lab run by the Norwegian University of Science and Technology (NTNU), and another due to be installed at the Aasgard field offshore Norway, following a detour to Sweden, where it was trailed with a Saab Seaeye Sabertooth AUV. Equinor not only outsourced the creation of these SDSs, but it's also making the design freely available – because it wants all vehicle vendors to use it (open innovation).

Blue Logic's founders produced their first inductive connector for power and high-speed communication in 2006, following 12 years work. In 2010, they founded Blue Logic and since then the company has been improving their inductive connectors, for power and communications transfer, and new power alternatives ranging from 50W to 2.3kW, all with ethernet and serial communication speeds up to 80 Mbps and 230kbps respectively. It's also working on a next generation 9.2kW connector, as well as other types of mechanical and hydraulic connectors for drones.

Blue Logic has also developed a new torque tool for AUVs and ROVs. Its previous torque tool weighed 23kg in water, which would have been too heavy for a vehicle like the Eelume snake robot, says Helge Sverre Eide, Blue Logic's business manager. So engineer Lars Gunnar Hodnefjell worked on a lighter version - 7.5kg in fact (improving the world record by 50% weight reduction) using titanium and plastic – producing 3000Nm of torque. It's since been used by the Eelume, which is due to operate out on the SDS at Asgard on a tethered trial.

But, "For this (subsea resident vehicles) to be economical, you need to increase the scope of work for drones," said Eide. "So, you need new tools and you need to adjust or change the subsea production system. You need to change both sides of the equation. New tools must be lightweight so a drone can fly them. Subsea maintenance of systems needs to change to smaller portions to change out sensors and other components by use of drones."

The current SDS design has two 2kW, and two 50W Blue Logic connector and one 250W WiSub connector, markings – AruCo and ChaRuCo – which drone cameras can see and from which they can decide their position relative to them, and acoustic positioning from Trondheim based Water Linked. In future, the magnetic field of Blue Logic's the inductive connector could also be used to guide the drone on to the SDS, says Eide. Blue Logic is in the Subsea Wireless Group (SWiG), which is working to standardise subsea wireless communications also.

Saipem: From concept to reality

Another vehicle operator has been testing its new system; Saipem with its Hydrone. In June, the Hydrone R started a six-month trial in Saipem's underwater "play park" near Trieste, northeast Italy. Later in the year, or early next year, its FlatFish design is also expected to enter the water, ahead of deep-water trials in 2021. Flatfish is under license from Shell

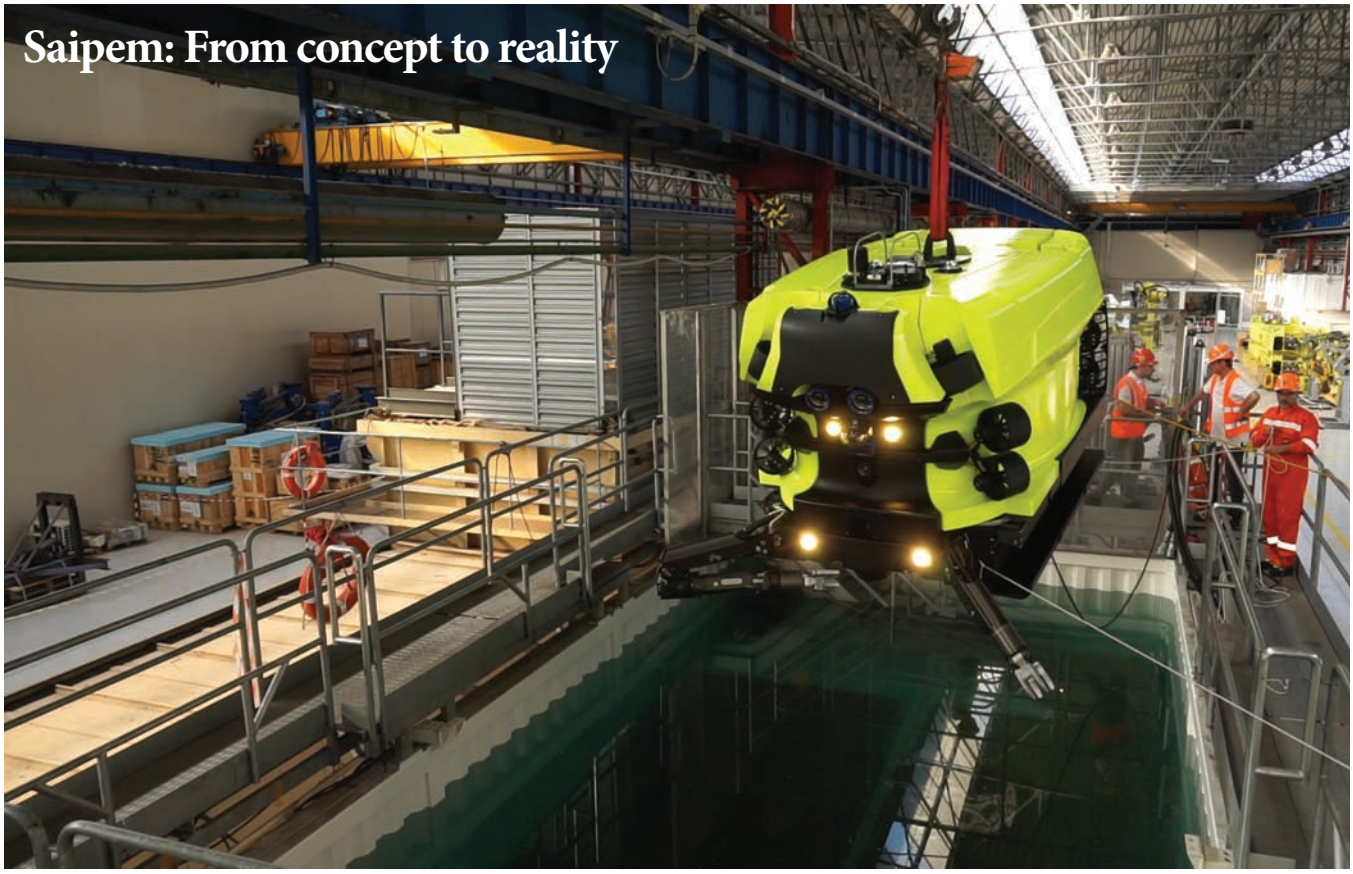


Image: Saipem

Saipem's Hydrone R – in the flesh and ready for real world testing.

(which bought BG Group, which had in turn been developing the FlatFish concept with Brazilian and German institutions).

Hydrone is in fact part of a family of electric subsea vehicles – from tethered resident work class vehicles through to hybrid AUVs with station keeping features, ranging from high bandwidth real-time control and communications through to low band-width acoustics and autonomous operations – rather than having one vehicle that can do everything. The designs encompass seabed resident systems as well as surface deployed systems, e.g. from a vessel or floating production system. Hydrone R (for resident) is the first out of the box. It's described as a hybrid ROV with AUV capabilities, e.g. it will have manipulators, for intervention work, and can work on a tether (up to a radius of 300m), but also travel distances between subsea fields, untethered, like an AUV, and both either from a seabed garage or a surface deployed system on a mission basis but also able to recharge subsea, Stefano Meggio, Subsea Robotics Technical Manager at Saipem told the energy: connected (aka Subsea Valley) conference in Oslo earlier this year. Rated to 3,000m, it could operate for 8-10 hours without a tether, and out to 10km, when it's returning to the same base, or 20km, if it's transiting to another base.

Saipem is also developing a range of HyTool skids, suitable for all its vehicles, so they can swap them subsea. It's also developing HyBases; docking stations that would be deployed to provide a communication interface via a subsea production system or to onshore with a direct link or via a surface vessel, and access to those interchangeable payloads where needed. Furthermore, a HyLars, a flying garage deploy from surface host (possibly unmanned), would provide a garage suspended subsea or deployed at seabed for recharging or recovery. Then, HyBuoy, using buoy, with renewable power generation, where subsea infrastructure is unavailable, could provide power and communications to a Hybase on the seabed. There's also the HyVessel concept, an autonomous surface vessel which could make the subsea system aware of situation and provide supervision capability to an onshore control center.

Meggio says that the commercial solutions for recharging and underwater communications – "acoustic, optical, or whatever the market will bring" – are in now the market. "It's just a matter of integrating them." Then, it's just a case of integrating them.

Saab Seaeye: Doing it for real

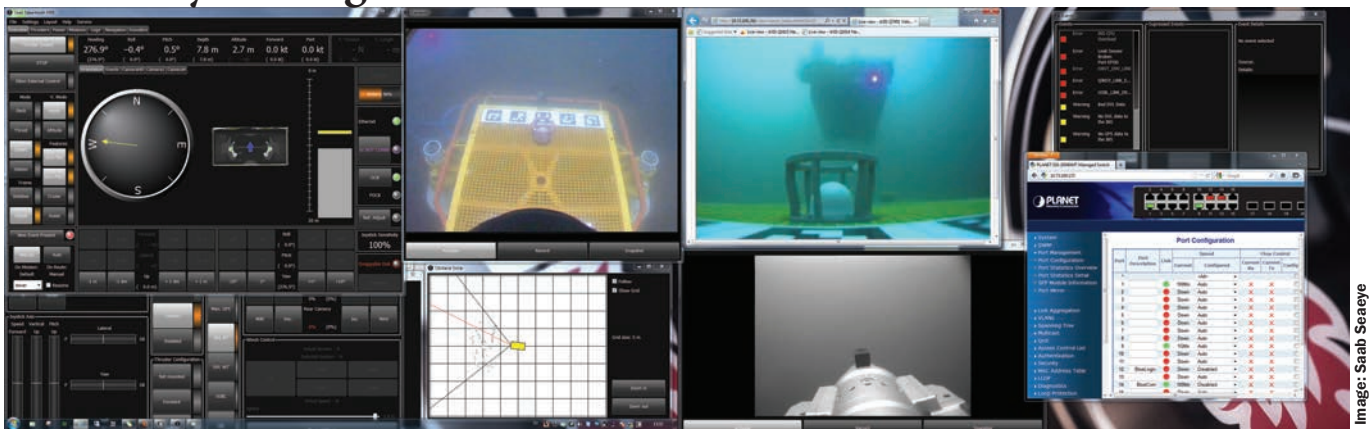


Image: Saab Seaeye

Saab Seaeye's Sabertooth during a demo with Equinor's subsea docking station.

Saab Seaeye: Doing it for real

Saab Seaeye has been one of those driving the vehicle side of the equation – for at least 10 years.

The firm has some 50% of the world market of electric remote operated vehicles (ROVs) and it has delivered more than 1000 electric autonomous underwater vehicle (AUV) and ROV and hybrid vehicles. Earlier this year, during its eRobotics Spring Campaign, Saab Seaeye demonstrated its Sabertooth AUV's ability to dock in a safe and controlled manner at a remote sub-resident docking station, where it could access tooling packages, be recharged and transfer data, including new mission plans, using Blue Logic inductive connectors. It could do this automatically, without the need for human control.

In June, the firm performed docking, charging and communications on Equinor's SDS, in Lake Vattern, Sweden. While the final part of the docking during this exercise was via semi-automated controls, with a bit of programming the vehicle would be able to dock autonomously, says Jan Siesjö, Chief Engineer, at Saab Seaeye.

The firm has been working on this concept for more than 10 years, developing the 3000m-rated Sabertooth's now advanced capability and control systems. The idea has since been supported by the likes of ENI, while parallel developments in inductive underwater charging and data transmission technology, and underwater video capable communications, and the development of standardised docking stations, have helped see the market start to catch up.

"It is the only hovering autonomous system that can operate in both AUV and ROV modes and handle connections in both the horizontal and vertical plane," says Peter Erkers, sales director at Saab Seaeye. "And it is the only vehicle currently on the market capable of undertaking long-term residency in difficult to access locations."

Saab Seaeye has also been working on other systems, such as remote operability of its light world class Leopard ROV. It's been working with Boeing doing trials over a satellite link across the US, controlling the ROV to do manipulator work, mating connectors, flying missions and way point control. Even when the latency was pushed to up to three seconds and data rates "messed with", the system still performed, says Siesjö.

Meanwhile, Saab Seaeye is also working on a full work class electrical manipulator. Testing work is ongoing with plans to reveal more to the market next year. The company has also been developing and trialling 3D simultaneous localization and mapping technologies based on an in-stereo camera system developed in Saab some time ago.

OPT: Powering autonomy

In some cases, resident underwater vehicles may not have access to power, so alternative power sources may be needed.

New Jersey-based Ocean Power Technologies (OPT) has been a leading company in this area, working with Italian oil company ENI.

An OPT PB3 PowerBuoy was installed, using a three-point mooring system, in November 2018, near ENI's Amelia B platform in the Adriatic Sea, where it's providing energy to a mock-up of a subsea system. A wave buoy was installed near it, to help monitor performance.

Earlier this year, OPT said the system had demonstrated AUV charging capabilities, successfully sending power and communications to a subsea payload throughout the test period. OPT said that the system was being tested as a standalone charging station and communications platform.

OPT also has other ideas. In fact, another PB3 PowerBouy was recently shipped to the UK ahead of being sent out into the North Sea to work for Premier Oil, providing power for monitoring a safety zone around suspended wells in the Huntington field, as well as providing communications to shore. Its potential for future use, generating power to operate subsea

assets, is also being assessed.

The company is also designing a hybrid PowerBuoy, which uses liquid fuel for power generation and lithium ion batteries, to ensure continuous peak power and communications. This is being designed to provide more than 1 MWhr of energy (scalable) and operate for up to 10 years with minimal maintenance.

The trial in Italy is part of ENI's MaREnergy project, which is targeting the use of wave energy converters to power subsea monitoring and control systems and to support charging AUVs.

Using something like a PowerBuoy, a point absorber technology which captures the energy created when waves send a float up and down a moored spar, motion which is used to generate power, could provide that power and communications link.

OPT's PB3 device would be suitable for lower power requirements and where it would be complicated to provide power other ways, such as remote areas, providing environmental monitoring for engineering and development operations and monitoring and control of low power subsea and topside equipment, Andrea Alessi, Offshore Renewable Energy Program Manager, ENI, told the Offshore Mediterranean Conference (OMC) in Italy earlier this year.

This could even extend to powering electric actuators and AUVs, including those forming ENI's Clean Sea concept, as well as creating security cordons around offshore platforms during decommissioning or other activities to avoid using a manned vessel.

Fred. Olsen: BOLT from the blue

There are always ways to do things differently, however, Fred. Olsen has been working on a wave energy design called BOLT. It's based on a floating platform attached to the seabed via moorings that are in turn attached to a specialized winch line product, which wind in and out of winches (one to three, depending on power requirements) as the sea surges. The winding motion creates energy – up to 10kW of average, exportable power with a standard unit in a high sea state - converted to electricity on board the facility via a custom designed maintenance free gear box and a standard Siemens generator set.

Even Hjetland, engineering manager for BOLT Sea Power, says it's a design that's been worked on for more than 12 years but that now has experience operating offshore Norway, the UK and in the Pacific (at a US Navy site off Hawaii). One of its next jobs is to provide a platform for a temporary 4G base

OPT: Powering autonomy

Image: OPT

station in the North Sea, working with communications firm Tampnet, to support field construction operations.

The lines used to drive the winches are UV (sunlight) and marine growth resistant, and the system still generates power in relatively calm sea states, says Hjetland. A system with one winch would be just 5m-diameter and weight 10-tonne, with up to 500kW of energy storage on-board.

Trials have included operations with the U.S. Naval Facilities Engineering Command, powering external oceanographic subsea sensors – including cameras and sonar systems - that were previously cabled, from a 30m test berth of the Navy's Wave Energy Test Site (WETS), located offshore of Marine Corps Base Hawaii, near Kaneohe, on Oahu.

The system also included an underwater data-logging and non-contact power transfer solution, suitable for charging AUVs, developed by Seattle-based startup, WiBotic. Part of this project also tested the ability to transfer power through the winch/mooring line itself, which would remove the need for an umbilical to subsea power users.

"We're working with Tampnet next year to provide a floating, standalone 4G mast, by pulling a fiber cable from their existing network of subsea fiber cables and then beaming communication service during field construction phase when communication isn't otherwise available," says Hjetland. The floating structure will also house solar panels. The specific construction site has yet to be decided – it could be oil and gas or renewables. "It could also be a platform for flying drones from for wind farm blade inspection," he adds, "or at coastal fish farms. For oil and gas, standalone power and communications can offer charging power and control power. A UiD docking station could be installed wherever you want, instead of where power and communications are available."

Fred. Olsen: BOLT from the blue

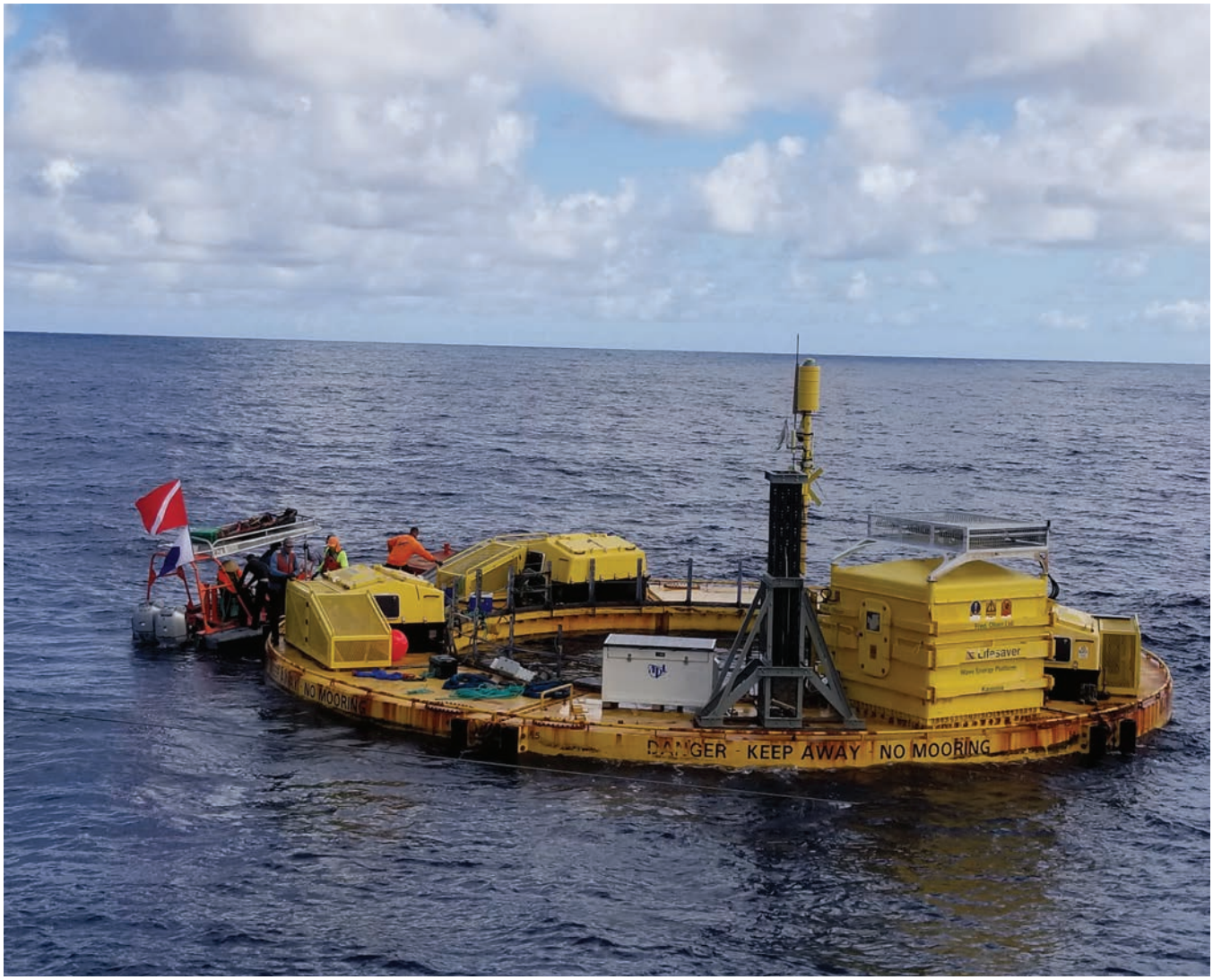


Photo Credit: Pacific Marine Energy Center

Fischer Connectors

Saint-Prex, Switzerland, CEO: Jonathan BROSSARD

No. of Employees: 550 worldwide

www.fischerconnectors.com

Fischer Connectors

Fischer Connector products can be found in multiple applications, from ROVs for deep sea inspection, communications, sensors, sonar and marine radar systems. In June 2018 it launched the Plug & Use Fischer Freedom technology platform, with its first connector, the Fischer LP360, which won in a single year four innovation awards. Thanks to its patent-pending innovations in mating (no key code allowing for 3600 mating freedom), locking and materials (non-magnetic quick-release locking mechanism and IP68-sealed contacts with a membrane), Fischer Freedom facilitates integration, maximizes usability, optimizes cable management and enables versatile innovations for a wide variety of applications in the defense, security, medical, industrial, civil engineering. Notably last June, Fischer Connectors USA became the technological partner in connectivity and official sponsor of the American Magic boat, a challenger for the 36th America's Cup.

The Tech

Technology offering divided into active and custom solutions and 4 product lines and 1 technology platform:

1. Fischer Core Series: Ideally suited to fulfill any need in terms of size, configuration and application, with more than 20,000 references.

2. Fischer UltiMate Series: Best for rugged and compact applications when weight matters.

3. Fischer FiberOptic Series: Easy to use, clean and maintain, pre-cabled solution ideal for indoor, outdoor and extreme applications.

4. Fischer MiniMax Series: High density, signal & power in one rugged miniature connector.

5. Fischer Freedom: Plug & Use connectivity technology maximizing efficiency, usability and performance while facilitating integration and optimizing cable management.

VideoRay's Mission Specialist technology, first available in the Defender, now powers the new Pro 5 system. Mission Specialist systems are used for demanding missions across industries like defense, oil & gas, wind, civil inspection, aquaculture, science and research, and is optimized for performance, size, weight, payload and deployment speed.

VideoRay delivered its first ROV in 2000, and has since become a leader of inspection-class ROVs. VideoRay underwater robots help prevent terrorism, find and retrieve objects, inspect infrastructure both inland and offshore, and keep divers safe from hazardous conditions. As VideoRay innovates with new designs and capabilities, its ROVs assist in increasingly challenging situations and environments; Owners have learned to trust them to perform in their most demanding missions. The hallmarks of VideoRay systems are ruggedness, reliability, portability, ease of use, and integration with a wide range of sensors and tools available for inspection-class vehicles.

A global company, VideoRay specializes in just one niche – one-man portable, reliable underwater systems. VideoRay's first-class customer service has propelled it to dominance in inspection-class (ROVs.) Users from the U.S. Navy to aquaculture farmers in remote areas of the world know that they can depend on VideoRay's durability and reliability – and when something goes wrong – an expert voice on the phone with advice and a solution. While there are less expensive, less powerful systems increasingly available, this continues to set VideoRay apart.

The Tech

Mission Specialist technology is based on modular components providing unrivaled flexibility. The largest and most powerful Mission Specialist configuration, the Defender, is optimized for precise control, heavier payloads, lifting, and specialized operations. The most portable, the Pro 5, has similar advantages but is smaller. Mission Specialist Technology is unique in the ability to add new sensors and accessories from a very wide range of manufacturers, as it supports a wide range of power and communications options.

VideoRay Mission Specialist technology delivers several innovative capabilities – power efficiency, minimal weight, a stable but extremely agile vehicle platform, a small operational footprint, multiple reconfigurable sensor and payload options, and infinite endurance afforded by efficient topside power delivery. Standard VideoRay Mission Specialist ROV modules include cameras with a wide range of resolutions, bright and efficient LED lighting, and powerful thrusters capable of up to one horsepower. There is a very wide range of accessories and instruments, including manipulators, positioning and navigation systems, radiation sensors, water quality, metal thickness, imaging and multibeam sonars. Options include purpose-built frames customized around the payload requirements of the operator's chosen sensor and tooling package.

MIROS

www.miros-group.com

Miros is a technology company that specializes in measuring the ocean surface, providing sensors and systems for environmental monitoring to the global offshore and maritime industry. Its sensors provide real-time data for weather-sensitive operations offshore, as well as offering input to asset integrity systems and coastal monitoring. Primary applications include wave and current monitoring and oil spill detection.

Miros launched Miros Speed Through Water, a dry-mounted, radar-based system used to optimize hull speed with, according to Miros, greater accuracy than is possible with underwater measurement devices. "Access to accurate speed through water data will enable improvements in the application of ship performance optimization protocols. This, in turn, will lead to significant cost efficiencies for ship owners. This is a breakthrough in efficient and data-driven ship performance management and an important contribution to ambitious goals for lowering emissions in the industry," said Andreas Brekke, CEO, Miros.

As a part of a 6-month pilot-project, BW Dry Cargo is testing the new technology on their BW Rye newbuild. The initial results of the pilot are promising, and BW Dry Cargo's Managing Director, Christian Bonfils, believes Miros' technology can contribute to significant (10%) fuel savings for the company.

Andreas Brekke, CEO, Miros.

Photo: Greg Trauthwein

InterMoor

InterMoor

Houston, Texas, President/CEO: Mark Jones, CEO

No. of Employees: 300

www.intermoor.com

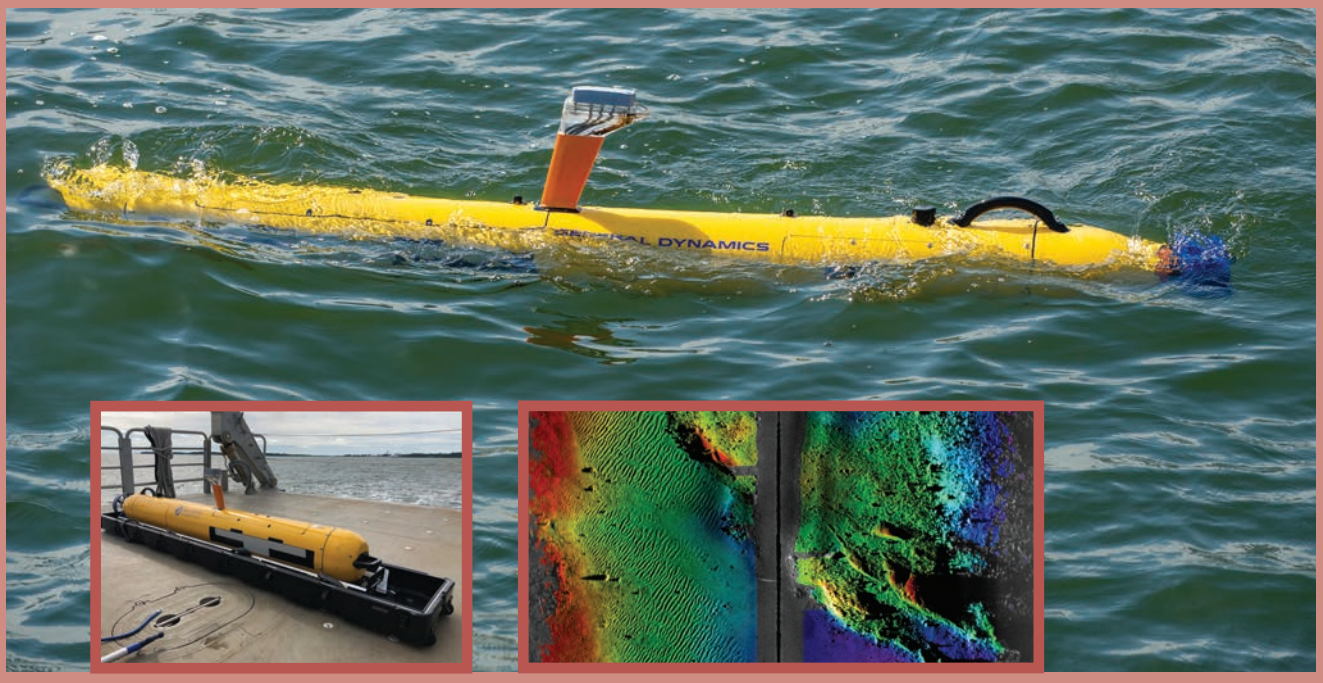
In the past 12 months, InterMoor was chosen by operators and large contractors to secure some of the largest floating assets on the planet. During this time frame, it completed tow and permanent mooring engineering and offshore operations for the Ailsa FPSO in the North Sea, the Benchamas FSO 2 in Asia, and mooring line replacement on two FPSOs in West Africa, amongst others. It has delivered across the lifecycle of operations, from engineering and installation, through to retrieval and decommissioning of their mooring systems. Throughout the years, and even during oil industry downturns, the company has continuously focused on innovation, responding to deepwater mooring challenges with enhanced technology and industry records such as

- The Suction Embedded Plate Anchor, now enjoying a new popularity due to its cost efficiencies,
- H-Links (InterMoor holds the record for the largest/strongest H-Link)
- Pre-commissioning of the Stones Turritella FPSO in ultra-deep water – 9,490 ft. (2,892 m) – the largest foundation pile ever installed in the Gulf of Mexico (32ft. in diameter and 55 ft. long)
- A multi-purpose mooring swivel, allowing for 360° rotational freedom under tension

In 2019, InterMoor continued to expand its product range, by acquiring all intellectual property of the BEL Grapnel & Chaser company, including drawings, designs, and cast patterns for its complete range of anchor and chain handling equipment. Grapnel hooks are traditionally used during the recovery of dropped components offshore; chasers enable steady and controlled lowering and raising during the installation and recovery of mooring system components. BEL products add a new level of intricate anchor recovery in the form of chain pocket, wire roller and detachable and locking mechanisms to InterMoor's existing range of chaser designs. The company also expanded its global reach with more than 17 locations and 10 shore bases around the world, including in the UK, US, Norway, Brazil, Asia Pacific, and Australia. In 2019, InterMoor continued the roll-out of the IM Release and successfully released the first set of the acoustic release connectors offshore Mexico. The IM Release is a new acoustic release mooring connector, that builds on their track record of designing and installing hundreds of mooring systems across the globe.

The IM Release is a game-changing acoustic release connector that is available to drilling contractors and operators who are looking to save time and money not only in the case of weather or emergency avoidance but also in the context of drilling optimization, allowing for faster rig moves with simplified connect/disconnect operations from pre-laid mooring lines. It was designed using the proven platform of sister company SRP's Rocksteady mooring connector, with a control system developed in conjunction with Teledyne Marine. The advanced control system uses high-fidelity acoustic modems, and implements domain key authorization, unique addressing, network relay and frequency hopping techniques, ensuring the mooring connectors are not affected by obstructions or noise.

These features eliminate the possibility of an inadvertent release and allows for the connector to be actuated individually, in clusters, or even sequenced in any order. These new features have been implemented while improving battery life. More importantly, the new connector weighs a quarter of the weight of other connectors yet can disengage at 100% of its rated break strength, a massive 900t.



General Dynamics Mission Systems

Quincy, Mass., President CEO: Chris Brady

No. of Employees: 13,400

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

General Dynamics Mission Systems is an innovator of open architecture and mission integration to meet the most demanding operational requirements on any platform in the multi-domain operational arenas – from the outer reaches of space to the sea floor. In 2016 General Dynamics acquired the unmanned underwater vehicle (UUV) provider, Bluefin Robotics, to extend the integration of high consequence solutions to the unmanned undersea space. The integration of Bluefin Robotics transitioned more than 20 years of UUV development and sustainment experience into the larger General Dynamics portfolio. General Dynamics has focused continued investment and development of Bluefin Robotics products, developing leading edge UUV platforms across multiple size-classes, sensor and payload integration, and the delivery of next-generation vehicles that explore, inform, and protect our assets and the environment. The General Dynamics family of Bluefin Robotics products consists of autonomous UUVs and related technologies for defense, commercial and scientific customers worldwide. We offer a full range of modular, free-flooded

UUV platforms and products, including more than 70 different sensors on more than 100 vehicles. General Dynamics Bluefin Robotics uses a "system of systems" approach to expand UUV capabilities from task-oriented to mission-based integrations. Its open-architecture approach uses the best available technology to deliver mission-ready products.

The Tech

In October 2018, General Dynamics Mission Systems launched the redesigned Bluefin-9, a two-man portable, small-class UUV to provide leading data quality and area coverage rate (ACR) in an easy to operate, two-man portable solution. Featuring a full carbon fiber body, an integrated suite of sensors, latest generation communications and navigational components, and new onboard processing capabilities, the Bluefin-9 is the professional's tool to know what's below. Bluefin-9's integrated Sonardyne Solstice multi-aperture side scan sonar delivers a 200-meter swath range and ultra-high, along-track resolution of 0.15°. Advanced on-board data processing offers operators access to processed high resolution sonar and camera data that is ready for post-mission analysis, reducing time to action. The Bluefin-9 provides precise navigation (0.3% D.T. CEP 50) and accurate, geo-referenced data by incorporating a high-performance Doppler Velocity Log (DVL) and Inertial Navigation System (INS). The Bluefin-9 allows swapping of the 1.9 kWh battery and 1TB Removable Data Storage Module (RDSM) and redeployment in 30 minutes or less. The modular, free-flooded architecture eases in-field maintenance and minimizes operational down-time. Designed for launch and recovery with Rigid Hull Inflatable Boats (RHIBs) in mind, the Bluefin-9 can be deployed and recovered by operators over the gunnel in a matter of seconds.


Detyens

Detyens Shipyards

North Charleston, SC

CEO/President: D. Loy Stewart. Jr.

Number of Employees: 345

www.detyens.com

As one of the major commercial ship repair yards on the US Southeast Coast, Detyens Shipyards is perfectly positioned to service both blue water and brown water fleets. The firm's location in the deep water port of Charleston, South Carolina offers deep draft repair berths, graving and floating dry docks along with all the services you would come to find at any modern ship repair facility.

Celebrating over 50 years of service to the maritime community, Detyens Shipyards, Inc., located in the historic city of Charleston, South Carolina is busy building a tradition of quality workmanship at a reasonable price. Family owned and operated since its inception, the company has continually emphasized customer service, family values and safety in the workplace. Hard work, dedication and the goal to provide economical ship repair services is the benchmark behind the Detyens Shipyards Creed, "Customer before Company, Employee before Owner, Family before Self, and Safety Above All." Specifically, Detyens Shipyards facility offers three (3) graving docks and with a capacity of up to Panamax. In addition to the docks, the facility also offers modern, enclosed shops for all crafts; eight 56-ton gantry cranes (on a continuous rail system); four tower cranes; rail access and over 8,000 feet of deepwater pier space and a floating dry dock for smaller vessels. Detyens Shipyards continues to increase its capacity with modern equipment and facility upgrades.

Recently completed repair/conversion work includes no less than USNS hulls and projects as well as work for McAlister, Vane Brothers, Bouchard and myriad dredge assignments.

Deep Ocean Engineering

San Jose, Calif.

President/CEO: Mike Takeda - GM

No. of Employees: 15

www.deepocean.com

Deep Ocean Engineering, Inc. is a technology-based engineering and manufacturing company that provides integrated robotic solutions for various underwater applications in harsh and diverse operating environments. Deep Ocean designs, builds and tests its remotely operated vehicles (ROVs) from its plant in California. Deep Ocean has been in operation for over 30 years and has sold more than 600 ROV systems in more than 30 countries. It's ROV systems have been used in a broad range of industry applications - military, security, salvage, long tunnel and pipeline inspection, customs, nuclear and hydroelectric power plants, dams and lakes, offshore oil and gas servicing, scientific research and education, fisheries and broadcast filming. As part of Deep Ocean's efforts to bring the latest technology to the market, the company recently diversified its product line with the introduction of a light work-class ROV for deeper offshore tasks and redesigned our USVs.

In the past year, it advanced its technology through redesigning the Phantom I-1650 and H-1750 USVs for efficient surface surveys, as well as the Phantom S-Series ROV, and introducing a new light work-class ROV called the Phantom X8.

In addition to its own mechanical and electronics fabrication, assembly and machine shop, Deep Ocean continues to work closely with its suppliers and outside fabricators to achieve product delivery on a best value and timely basis. Deep Ocean also designs and manufactures ancillary equipment, including manipulators, cable cutters, cable reels (manual and powered) and various other tools. Deep Ocean works closely with most third-party tooling and electronic equipment manufacturers to ensure that its ROVs and USVs can accommodate the necessary components to get the job done.


Deep Ocean Engineering

MacArtney

www.macartney.com

Designed, developed and manufactured by MacArtney, the latest connectivity series, the TrustLink Metal Shell (MS) series, includes a range of power and signal connectivity solutions for subsea and offshore applications.

MacArtney is a privately owned corporation with group headquarters in Esbjerg on the west coast of Denmark.

It is a global supplier of underwater technology systems, products and integrated solutions specializing in design, manufacture, sales and after-sales service of a wide range of systems to offshore oil & gas operators, surveyors, the renewable energy sector, ocean science institutes and defense and navy industries across the world. The company offers an extensive variety of advanced and product and system solutions which are designed and tested to supply high quality, efficiency and dependable performance in challenging underwater environments. The MacArtney Group supplies and services a wide range of integrated systems and products designed, developed and manufactured by MacArtney, in addition it is a trusted sales representatives of leading manufacturers of underwater products. MacArtney supplies include SubConn, OptoLink, TrustLink and GreenLink connectivity, cable and termination solutions, advanced NEXUS and EMO fiber optic telemetry systems, electric CORMAC and MERMAC winches, handling and LARS systems including active heave compensation (AHC) winches for ROVs. The MacArtney range of fast and precise remotely operated towed vehicles (ROTV) includes the MacArtney FOCUS 2, FOCUS 3 and TRIAXUS vehicles. MacArtney also designs and manufactures CEMAC offshore cable handling equipment intended for pipeline and cable-laying deployment. Moreover, MacArtney supplies a versatile range of LUXUS underwater cameras, lights, media controllers, pan-and-tilt units and accessories as well as a LOTUS data acquisition and telemetry buoy system.

Teledyne Marine

www.teledynemarine.com

With 23 brands, and more than 400 marine products in its portfolio, Teledyne Marine collectively offers the largest breadth of technology in the industry. From tiny connectors to 6000m rated AUVs – and virtually everything in between – Teledyne is well positioned to solve subsea's biggest challenges. Whether customers seek a single product, or a complex turnkey solution, Teledyne Marine has the vision and capability to deliver leading-edge technology to commercial, academic, and defense customers around the globe.

As the organization continues to grow and mature, and customer needs continue to evolve, particular focus has been placed on integrating Teledyne's many sensors, sonars, connectors and vehicles to simplify and streamline customers' technology sourcing, selection and system integration issues.

The following are several examples of how Teledyne's technologies can be combined to solve industry challenges:

Increasing understanding of the ocean

In 2019, Teledyne Marine became a partner to the Nekton Deep Ocean Research Institute in support of First Descent, which was a series of exciting expeditions designed to explore and conserve the Indian Ocean. Teledyne Marine supplied a wide array of sensors and technology to empower Nekton's manned submersible, ROVs, and surface vessel to collect critical data pivotal to this mission.

Equipment supplied by Teledyne Marine included:

- RESON SeaBat T50-P Extended Range multibeam echosounder and RD Instruments new next-gen 6000M rated Pinnacle Acoustic Doppler Current Profiler (ADCP).

These technologies served the dual purpose of supporting the expedition by providing previously unknown information about seabed topology and ocean currents, and assisting in the safe deployment of the two manned submersibles.

- Numerous Bowtech subsea cameras and lights provided critically valuable high quality video of both flora and fauna from remote locations around the Seychelles.
- A BlueView forward looking sonar assisted with safe navigation beyond the range of visibility for the remotely operated vehicles.
- Data collected were processed and visualized using Teledyne PDS and Teledyne CARIS powerful software solutions.

Reaching new depths

In 2019, Teledyne also launched the SEARAPTOR, a survey grade deep water autonomous underwater vehicle (AUV) designed to operate at abyssal depths. A wide range of sensors allow the SeaRaptor to complete several types of missions including: broad area search with side-scan sonar, hydrographic survey with multibeam and sub bottom profiler, and high resolution inspection survey with camera and acoustic sonar. These surveys support applications such as search and recovery, salvage, exploration, construction support, marine archaeology, and oceanography.

The vehicle offers several payload ports that provide serial communication, Ethernet and power.

These ports can be used for field-swappable sensors. In addition, removable batteries and data storage enable rapid turn-around to maximize operating time.

The newly designed SeaRaptor AUV incorporates a broad range of Teledyne content including:

- Benthos acoustic modems, ascent and descent weight releases, a black box pinger locator, sub-bottom profiler;
- RESON multi-beam echosounders, obstacle avoidance multi-beam sonar;
- RD Instruments Doppler Velocity Log (DVL), and Current, Temperature, and Depth sensor (CTD);
- and Teledyne CARIS onboard processing software.

In addition, the first vehicle delivered

All photos: Teledyne Marine

also carried a third party Side Scan Sonar, INS, and camera and strobe system.

The integration of Teledyne Marine's leading vehicle design, instrumentation, imaging, and interconnect solutions from a single supplier, as well as the incorporation of third party sensors into a turnkey package for customers, makes the company unique in the unmanned underwater vehicle market.

Outfitting an ROV

From inspection to work class ROVs, the Teledyne Marine companies have a long history of supplying critical sensors and systems to outfit and empower ROV platforms of all shapes and sizes. Collectively, Teledyne Marine's offerings allow customers and manufacturers the convenience, cost-savings, and interoperability of securing a full suite of leading-edge technology, all from a single entity.

Teledyne Marine's ROV payload options include:

- RDI DVLs and TSS Inertial Navigation Systems (INS) for precision subsea navigation and station keeping;
- BlueView imaging sonars and RESON multibeam sonars for inspection and mapping;
- Bowtech cameras and lights for clear underwater vision and high-res video and images;
- Benthos acoustic modems for communications and USBL for vehicle tracking;
- RDI Conductivity, Temperature and Depth (CTD) sensors for speed of sound calculations;
- TSS compact pipe and cable tracking capabilities;
- A full suite of custom and standard interconnect and cable solutions.

And now, via Teledyne's emerging project UNITY, Teledyne Marine is taking the power of these sensors to the next level by creating a fully integrated, easy to operate, GUI to enhance and simplify ROV operations. With UNITY, operators can quickly and easily manage their vehicle's tracking, positioning, and navigation systems all via a single, powerful interface.

Defining deep-water moorings

Similar to ROVs, Teledyne Marine offers a full suite of sensors and instrumentation to ensure customers collect, transmit, and retrieve high quality data – every time. Scientists now have the ability to acquire the industry's leading ocean observation products all from a single source, allowing for stream-lined logistics and efficient and effective project management.

Teledyne also partners with several experienced mooring engineering firms, all of which specialize in mooring design and installation, for true one stop shopping.

Teledyne's mooring technologies include:

- **RD Instruments Acoustic Doppler Current Profilers (ADCPs)** for shallow to deep water mooring installations, including RDI's new next-gen, deep water Pinnacle ADCP, boasting the longest profiling range in the industry, as well as RDI's short range DVS for boundary measurements, and Citadel CTDs for conductivity, temperature and depth measurements
- **Benthos acoustic modems** for reliable wireless data transmission from the mooring to the surface for data download from ship of opportunity or transmission via a satellite link to shore.
- **Benthos glass-housings** to house instrumentation and/or relieve dangerous mooring strain.
- **Benthos acoustic releases** to ensure mooring/data retrieval. And now, via a GNSS upgrade to the topside unit, users can survey in their moorings, for fast and easy mooring relocation and recovery.
- Webb Research gliders can also be incorporated for mooring data download, or to replace or supplement moorings as a highly effective long-range, long-duration ocean observation tool.

Valeport

Valeport

Totnes, Devon, UK

President/CEO: Matthew Quartley

No. of Employees: 94

www.valeport.co.uk

With a heritage dating back over 50 years, Valeport designs and manufactures oceanographic and hydrographic instruments, providing marine sensing and monitoring solutions. The company, which started by making instruments for measuring the speed of water in London's River Thames, today has a comprehensive portfolio of underwater measuring equipment and supplies a worldwide customer base that includes: environmental, defense, oil and gas, renewable energy, construction, port/harbor, dredging, civil engineering and scientific research sectors. Based in the UK, the privately owned, independent family business has a £8.5m turnover.

It has global sales network and last year the company exported around 80% of its products directly and at least half of the remainder is sold to UK offices of multinational companies, or as OEM to other British exporting companies, so approaching 90% of production ends up overseas.

Valeport launched a new Environmental range of optical sensors at Ocean Business 2019 including: Hyperion Turbidity – the first turbidity sensor combining Nephelometer and OBS readings in such a compact size. Created for inshore, coastal and oceanographic monitoring, this sensor delivers a minimum detection level of 0.03 NTU (nephelometer) and can measure turbidity up to 6,000 NTU (OBS).

The titanium housing, data output up to 16Hz and low power requirements ensures it can be placed in situ for extended periods with easy access to highly accurate data. SWiFTplus Fluorometer – the combined power of SWiFT technology and a fluorometer for the high performance measurement of Chlorophyll a, Fluorescein, Rhodamine or Phycocyanin. Compact and robust, the suite of instruments are ideal for shallow water bathymetric and environmental survey, where observations can be monitored and recorded for surveys for up to three days continuous operation. These sensors combine all you need to carry out survey grade Sound Velocity, Salinity, Density, CTD and optical profiles up to 200 meters, in a single instrument. Valeport will also expand its premises on the River Dart (UK) to 40,000 sq. ft.

The Tech:

More than 50 years of engineering and production excellence is built in to every Valeport product. Valeport's Research & Development is renowned for developing ground breaking technologies.

Valeport developed the Digital Time of Flight Sound Velocity measurement – which made Valeport a leader in Sound Velocity technology. This position has been achieved by both innovative development and meticulous attention to detail throughout the design, manufacture and especially the calibration processes. Having been at the forefront of this field for more than a decade with their Digital Time of Flight technology, Valeport continues to evolve the technology to reinforce that position, ensuring that Valeport SV sensors offer levels of performance that are demonstrably far in excess of competitors, including:

- Genuine Accuracy of ±0.02m/s (Total Error Budget)
- Precision (peak to peak noise) of ±0.002m/s
- Operating range of 1375m/s to 1900m/s (covering all environments from fresh water to the Dead Sea and the Marianas Trench)
- Data rates up to 60Hz (instrument dependent)

This year Valeport introduced Environmental range of optical sensors, the Hyperion Turbidity and SWiFTplusFluorometer.

Southwest Electronic Energy Corp.,

an Ultralife Company

Houston, Texas, Michael D. Popielec, CEO

No. of Employees : 70, www.swe.com

SWE

SWE has pioneered underwater lithium-ion battery solutions that power subsea vehicles, control systems and oceanographic equipment more safely and longer than sealed lead acid batteries. SWE's battery solutions also deliver up to four times the energy, and its batteries have a built-in patented battery management system so operators can monitor the system's health. Because of the reliability, efficiency and inherently safe design of the SeaSafe suite of solutions, OEMs routinely specify and install SeaSafe, SeaSafe II and SeaSafe-Direct batteries. When SWE sets its sights on improving battery technology, it focus eson increasing safety, reducing the equipment's total cost of power, reducing the time needed to swap out battery packs, and increasing the amount of runtime the equipment achieves from a battery pack. That mindset has served the oil and gas, oceanographic and military industries well since SWE entered business in 1964. SWE has built lithium battery packs for 25 years and lithium-ion batteries for 16 years. SWE holds 10 patents on lithium-ion batteries.

Earlier this year, SWE validated its SeaSafe II battery module in a 629 volt battery system to meet the intense power needs of a customer's next-generation subsea infrastructure. This subsea validation lays the foundation to meet the projected needs for subsea infrastructure electrification. SWE recently joined the Ultralife Corporation family, which provides long-lasting, rugged and reliable batteries for the defense, medical, robotics and security sectors. SWE will continue to offer its existing product range to support OEMs for the oil & gas, remote field applications and subsea sectors.

As it stands, SWE's line of SeaSafe battery packs can deliver four times longer mission run time and six times longer battery life time than compared to traditional sealed-lead batteries. Because of the purchase, SWE will be able to devote additional resources to R&D efforts, including those aimed at delivering superior performance, safety and reliability in subsea battery solutions for increasingly demanding applications.

The Tech

SeaSafe subsea batteries are one-quarter the weight of traditional sealed lead acid batteries and offer a longer service lifetime.

SeaSafe units are powered by large lithium-ion polymer cells specially engineered into modules to provide 30V at 28Ah or other size options. They can operate in water depths to 6,000 meters, and multiple SeaSafe batteries can be hooked together to meet the voltage and power needs of various applications. The batteries have been used in short-duration, high-power demand applications and long-duration, low-power demand situations.

Applications include AUVs for propulsion, control, and instrumentation; in remotely located infrastructure equipment for valve control and pipe shearing; and in oceanography sensing set-ups such as for monitoring the salinity and temperature of ocean water over time.

These smart batteries can track and report the status of the batteries via SWE's patented Battery Management System. The SeaSafe Direct can be placed directly into the water without requiring a pressure vessel, and the direct-in-the-water use is fast-growing in popularity. Both SeaSafe II and SeaSafe Direct are ABS certified in various voltage size configurations.

Credit: Rebecca Marshall

GEBCO-Nippon Foundation Alumni Team

The GEBCO-Nippon Foundation Alumni Team won the Shell Ocean Discovery XPRIZE. The GEBCO-NF Alumni Team includes 16 alumni of The Nippon Foundation-GEBCO Postgraduate Training Program at the University of New Hampshire (UNH), US. They are Dr. Evgenia Bazhenova (Russia), Aileen Bohan (Ireland), Dr. Mohamed Elsaied (Egypt), Andres Fitzcarrald (Peru), Tomer Ketter (Israel), Christina Lacerda (Brazil), Jaya Roperez (Philippines), Azmi Rosedee (Malaysia), Ivan Ryzhov (Russia), Hadar Sade (Israel), Sattiabaruth Seeboruth (Mauritius), Masano Sumiyoshi (Japan), Neil Tinmouth (South Africa), Dr Rochelle Anne Wigley (US), Dr Yulia Zarayskaya (Russia), and Dr Karolina Zwolak (Poland). The team's entry into the competition was funded by The Nippon Foundation, and used the SEA-KIT Uncrewed Surface Vessel (USV) Maxlimer, alongside the Kongsberg Maritime HUGIN Autonomous Underwater Vehicle (AUV) System. The team's concept for efficient, safe and cost-effective seafloor mapping was based around the Kongsberg Maritime HUGIN AUV, rated to operate at depths of up to 4,500 m, supported by the SEA-KIT USV, which has the ability to autonomously launch and recover the AUV and acts as a communication link during subsea survey operations. The team venture was based at the Center for Coastal and Ocean Mapping/Joint Hydrographic Center at UNH. The Alumni worked with partners including the Sasakawa Peace Foundation, Hushcraft, Ocean Floor Geophysics, Earth Analytic, Teledyne CARIS, Raitt Orr and Associates, ShipOwners, and OmniAccess, as well as equipment supplier Kongsberg Maritime AS, to develop and advance the team concept created especially for the Shell Ocean Discovery XPRIZE. The team mapped 278 sq. km. and produced 10 high-resolution images which were selected using the Kongsberg REFLECTION software package from standard HISAS imagery. Additionally, eight 3D surfaces of the seafloor were produced using Fledermaus software. Kongsberg EM304 multibeam data was uploaded online and team members at UNH cleaned and produced nine point cloud images using Qimera.

McLane Research Labs

E. Falmouth, Mass.

President/CEO: Susumu Honjo

No. of Employees: 20

https://mclanelabs.com

McLane Research Laboratories, founded in 1983, is a leader in time-series in-situ oceanographic profilers, samplers, and flotation. In 2019, McLane launched the commercial model of the revolutionary Prawler, which is a low-cost, wave-actuated vehicle that moves along the mooring wire, collecting data from the surface to 500m of the water column. A leader in technology transfers in the field of oceanographic instrumentation, the company maintains significant development, innovation, and commercialization capabilities.

McLane instruments are all designed to withstand the rigors of long-term open ocean and freshwater deployments. The company produces three main product lines: Profilers, Samplers and Flotation. In 2019, McLane expanded its profiler line with the Prawler which collects and transmits sensor data from the surface to 500 m of the water column. The instrument travels the mooring wire using wave actuated motion. The Prawler is a field-proven instrument originally developed by NOAA's Pacific Marine Environmental Lab with support primarily from NOAA's Office of Oceanic and Atmospheric Research Climate Program Office. In addition to the Prawler, the McLane Profiler line includes the Ice Tethered Profiler (ITP) and the McLane Moored Profiler (MMP). Samplers include flagship Sediment Traps, as well as the Remote Access Sampler (RAS), Phtoplankton Sampler (PPS), and Large Volume Pumps. 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.

McLane Resear ch Laboratorie

ABB

www.abb.com

Autonomous installations have the potential to save operators money by enhancing operational stability for more uptime and increased safety. Achieving those benefits requires confidence from companies and regulators. Companies like ABB are part of the drive toward autonomy for topsides and subsea installations.

Some of the biggest cost savings in the oil industry have come in the facilities design and engineering phase with the move from manned facilities to remotely operated facilities to unmanned, said Håvard Devold, group vice president, Digital, ABB Oil, Gas & Chemicals lead. Even so, these installations still require someone at a central facility keeping track of operations. On a scale of one being not at all autonomous and five being highly autonomous, Devold estimates the oil and gas industry's capability for autonomy is reaching stage four. Moving the industry to stage five is no one-size-fits-all task, says Susan Peterson Sturm, digital lead for ABB's overall Energy Industries business. The risk associated with the specific operations and the variables in the processes are major factors. Barrier management is crucial, she said, with management performance operations such as dashboards of safety systems an enabling technology for actionable data historically "stuck in the realm of spreadsheets."

© Equinor. Photographer: Roar Lindefjeld and Bo B. Randulff

ABB implemented a condition monitoring system at Equinor's Aasta Hansteen project in 1,300 meters of water in the Norwegian Sea (pictured). The system monitors more than 100,000 maintenance conditions from more than 4,000 pieces of equipment, with tools for alarm management and alarm rationalization, delivery of several safety critical applications, data storage solution to store all alarms and events easily, and third-party system integration of essential data traffic. "There is a tremendous amount of value of taking that risk, and those indicators from the field, to give real-time visibility, and in coupling it with maintenance-related risk," she says. Devold says autonomous operations will reduce operational expenditure and the carbon footprint of a project, and any re-engineering carried out in the name of autonomy will likely improve processes and help reduce shutdowns.

For the industry to buy into fully autonomous operations, there must be confidence that the operations are safe and that the equipment can deal with problems, he says.

Jennifer Pallanich

Cellula

Vancouver, BC, Canada; President/CEO: Eric Jackson

No. of Employees: 35; www.cellula.com

Cellula Robotics has developed a fuel cell powered long range unmanned underwater vehicle (UUV) called Solus-LR for Defense Research Development Canada. Solus-LR has a range of more than 2000km submerged and is fitted with a patented suction anchor. The project has been executed on a tight schedule, with the vehicle design starting in June 2018 and sea trials planned for later this summer. A month-long demonstration mission will be completed in Spring 2020, which will also include underwater acoustic and bluelight communications. Cellula Robotics is an engineering solutions company based in Vancouver, Canada, that specializes in the turnkey design and production of seafloor intervention and subsea autonomous vehicle systems. Through its team, Cellula has developed extensive experience in projects that require integrated mechanical, electrical, hydraulic, and software elements in a subsea environment.

Cellula's Solus-LR, a 3000msw rated long range Unmanned Underwater Vehicle (UUV). This UUV is fuel cell powered with 250kWh usable energy, enabling the aforementioned 2000km mission ranges. The UUV includes a suction anchor module which allows the Solus-LR to hold station in a low-powered state, in currents of up to 4kts. Cellula's Imotus Hovering Autonomous Underwater Vehicles are built on a modular, scalable architecture enabling a highly functional and affordable solution. The two primary applications are confined spaces, such as aboveground storage tanks and concrete legs of oil platforms, and open-water, including ship hull and infrastructure inspections. The CRD100 seafloor drill is 3000msw rated, with up to 70m core depth capabilities. The solution is highly autonomous to speed up operations and reduce human errors. Cellula has significant experience in the design, build, and operation of the CRD100. Cellula is also able to design, build, and deliver custom subsea robotic systems or subsystems. Previous designs have included an ROV suction sampler, seafloor drill subsystems, and control system design.

Unmanned Survey Solutions

Hayle, U.K.
President/CEO: James Williams
No. of Employees: 4
www.unmannedsurveysolutions.com

Unmanned Survey Solutions (USS) designs, builds and operates USVs. In the last 12 months, it has modified its Inception Class MKII USV and launched the Accession Class USV. The Inception USV is designed to be a modular, versatile and a robust USV composed of aluminum hulls, weed cutting propellers and a modular payload pod system for fitting a variety of sonar and environmental sensing equipment. The Inception USV has a payload pod that can be fitted with single or multi-beam sonar systems, phase measuring bathymetric sonars, side scan sonars or a variety of other sensors. Used on inland waterways, reservoirs, lakes, marinas and harbor for hydrographic surveying (bathymetry mapping). The Accession Class USV launched in April 2019, sporting a unique modular design which was modelled and tested in numerous environmental conditions. Built by surveyors for surveyors, this USV is designed to be simple to operate, reliable and robust. The Accession USV starts at 3.5m hull and offers 12 hours endurance for hydrographic surveying at typical survey speeds. Then, with either the addition of a 0.75m or 1.50m section of hull and various payload and/or fuel combinations, the vessel can operate in excess of eight days at sea. It can operate as a lone survey vessel or as a force multiplier from a mother ship increasing productivity and lowering costs.

Unmanned Survey Solutions

Applied Acoustics

Applied Acoustics

Great Yarmouth, Norfolk, UK
President/CEO: Adam Darling
No. of Employees: 44
www.appliedacoustics.com

Applied Acoustics reached its 30 year milestone this year. Back in the 80's it manufactured subsea equipment for the offshore hydrocarbon industry, but now it supplies the commercial offshore sector as well as oceanographic institutions and defense markets. Increasingly sales are exported across the world's oceans, served by strategically placed service centers and a network of competent overseas agents.

All the design and manufacturing of the acoustic products is carried out from the single site in Great Yarmouth, UK where more than 80% of the staff are skilled engineers. The company constantly invests heavily in R&D so that its products are always of cutting- edge design and suitable for the challenging subsea environment.

This year alone the company has launched a further Ultra High Definition sparker for sub-bottom profiling using a double-decker design and further enhancements to its market-leading Easytrak range of USBL systems suitable for the novice user right up to the sophisticated geophysical engineer.

SBG Systems

www.sbg-systems.com

SBG Systems has continued its development in the marine Industry by completing our product line dedicated to Hydrographers with a FOG IMU, the Horizon. This new IMU brings the Navsight technology to the most demanding environments such as surveying highly dense areas (bridges, buildings, etc) or where only a single antenna can be used. This technology allows robust and consistent performance even in low dynamics survey. SBG Systems is a fast growing supplier of miniature, high performance and innovative motion sensing solutions. SBG Systems headquarters are based in Carrières-sur-Seine, France. SBG Systems offers a complete line of inertial sensors based on the state-of-the-art MEMS technology such as Motion Reference Uni (MRU), Inertial Measurement Unit (IMU), Inertial Navigation Systems with embedded GNSS (INS/GNSS), etc. Our sensors are ideal for marine applications such as hydrography, ship motion monitoring; SONAR, LiDAR, and Buoy orientation & position ; ROV & AUV control, etc.

Offering both MEMS and FOG technology, SBG inertial navigation systems combines robust sensors with advanced calibration techniques to offer miniature and affordable solutions.

Blueprint Lab

St Peters, NSW, Australia
President/CEO: Paul Phillips
No. of Employees: 9
www.blueprintlab.com

Blueprint Lab is focused on making the smallest, all-electric subsea-rated actuators available in the world. According to the company, this filled a capability gap for users of portable Remotely Operated Vehicles (ROVs) at an affordable price

Blueprint Lab

point. The launch of its Reach 5 Mini robotic arm represents a game changer for scientists, militaries and the oil and gas industry.

The last 12 months have seen significant change and growth for Blueprint Lab. First, it commercially launched its flagship product, the Reach 5 Mini, a five-function robotic arm in September 2018. This unit has since achieved close to 20 sales in five countries. In addition, it achieved recognition by the Australian government as a promising new technology company through the award of a $240,000 grant to accelerate commercialization of its product line.

The company's Reach 5 Mini builds on patented modular design to create a highly durable, tough, and incredibly small five-function manipulator, capable of performing dexterous subsea tasks including: precise placement of probes for crack and corrosion monitoring; placement and recovery of objects with minimized workload; sonar and camera scanning; and, underwater IED countermeasures.

RJE International

Irvine, CA
President/CEO: Robert Jechart
No. of Employees: 14
www.rjeint.com

Since 1991 RJE International Inc has been a leader in the underwater product world. Most recently, this ISO 9001:2015 certified company has developed a groundbreaking ROV and associated ROV Navigation solution. Also specializing in acoustic marking and relocation systems, diver navigation and more. As a leader in acoustic marking and relocation systems, diver navigation, sonar underwater communications and small boat navigation, RJE International Inc continues to provide a wide range of excellent products for the commercial and military markets, as well as for divers, worldwide. As a manufacturer of sonar beacons, diver navigation, diver sonar and underwater relocation products, RJE International Inc also has the design and engineering capabilities to develop custom solutions. Its new Oceanbotics division has developed a cutting edge ROV System: the most agile and maneuverable in the market; as well as an associated ROV Navigation Solution. Its public safety division supplies pool safety products for children and pets. Operating on a global scale, RJE International Inc has established distribution points in more than 45 countries.

Copenhagen Subsea

Hellerup, Denmark
CEO: Allan Nygård Bertelsen
No. of Employees: 3
www.copenhagensubsea.com

The unique thruster technology of Copenhagen Subsea A/S helps to reduce downtime and improve the success rate of subsea operations in several ways. Ten years ago, the conventional hydraulic thruster was the only option for underwater propulsion. Copenhagen Subsea A/S saw that the market for underwater propulsion was ripe for a substantial rethinking of technology. In order to meet the industry's new and higher demands for reliable thrusters and decreased operating costs, the solution was to construct a new product line of electrical rim-driven thrusters. Building on the innovative ring thruster technology, Copenhagen Subsea A/S has been able to develop and manufacture four thruster sizes – from VS as the smallest to VXL as the largest – that show a significant increase in reliability.

Copenhagen Subsea A/S was founded in 2014 and develops and manufactures electrical rim-driven thrusters for the most commonly used subsea vehicles in the marine industry. In a 10.000-liter test-tank located on the premises in Hellerup just north of Copenhagen, Copenhagen Subsea A/S performs continuous testing of its thrusters. 1,000 hours of operating time, in fact, comprise 42 days during which the thruster operates 24/7 at maximum power. During this period, the thruster is constantly monitored for performance and energy consumption, and any aberration is registered. When reaching the milestone of 1,000 operating hours, the thruster is examined and, showing no signs of exhaustion or corrosion, allowed to continue operation in the test tank. The operational limit has yet to be explored since the thrusters at all times during and after the test have shown that they maintain full functionality and unaffected performance.


Copenhagen Subsea

The rim-driven thruster is a tight integration of motor parts within a housing. The electrical motor takes the form of a thin ring that has permanent magnets fixed to its rotor. This rotates within the stator arrangement of magnetic flux. The housing remains fixed to its platform on the subsea vehicle. The propeller – the only moving part in the rim-driven thruster rotates within the nozzle, eliminating the need for a drive shaft and hub. The technology of the electrical rim-driven thruster not only improves reliability it also makes the rim-driven thruster the right green choice eg. due to the acoustic profile. Our innovative electrical design has no gears, only one moving part and bearings that make use of the surrounding seawater for lubrication.

Schmidt Marine Technology Partners

Mark Schrope, Director
No. of Employees: 3
www.schmidtmarine.org

Schmidt Marine Technology Partners (SMTP) is a relatively new program of the Schmidt Family Foundation established in 2015. SMTP helps to grow early stage marine technologies that can transform the way society uses ocean resources and protect them for the future. SMTP focuses on technologies working toward sustaining fisheries, enabling ocean research, habitat health, and preventing marine plastic pollution, using scaled funding and related business assistance to support their development. SMTP has funded more than 30 groups in accomplishing the development, dissemination, and possible commercialization of ocean technologies. By tailoring assistance to the needs of individual groups, they have helped these groups move ideas and ready themselves for economic viability. This "venture philanthropy" model was created to fill an often-fatal gap in support available for the development of ocean technologies, which typically require something beyond traditional grants in order to achieve full potential and availability.

SMTP has aided a wide range of ocean technology and conservation companies to reach their potential. Pelagic data systems is a great example of a supported technology platform that is working to bring transparency to the fishing industry by monitoring illegal fishing activity in protected areas and managing boat activity in fisheries for their sustainable future.

Schmidt Marine Technology Partners

Schmidt Ocean Institute

Schmidt Ocean Institute

Palo Alto, Calif.
President/CEO:
Eric & Wendy Schmidt
No. of Employees: 61
www.schmidtocean.org

Established nearly a decade ago to advance the frontiers of global marine research, Schmidt Ocean Institute (SOI), a 501(c)(3) private non-profit operating foundation, completed its most productive year in 2018 with 11 at-sea ocean science and technology development projects. One example of this transformational work was the White Shark expedition conducted aboard the research vessel Falkor in the Pacific aimed at studying why this remote area attracts white sharks and establishing justification for a World Heritage Site nomination. Traversing thousands of miles, two Saildrones, unmanned wind and solar powered vehicles, were launched from San Francisco ahead of Falkor's arrival. Their early entrance informed sampling plans, gathering sensor data that showed how eddies draw nutrients closer to the surface; one reason why the sharks maybe drawn to this area.

This was one of many expeditions focused on implementing multiple robotic vehicles to enhance operational flexibility and observational data, while reducing costs and risks. Additionally, SOI shares all of its data with the public including live-video streaming of its ROV SuBastian dives.

In the past 12 months, SOI has made it a priority to support the development of technology that will redefine the way we conduct ocean research. Science and engineering teams on Falkor tested AI-based multi-vehicle ocean survey software using SOI's shipboard high-performance computer.

Falkor's innovative computing system has a Graphics Processing Unit installed to support scientists' emerging technologies. Another expedition completed centimeter-scale resolution seafloor maps resulting in the discovery of a new vent field in the Pescadero Basin. The list of species occurrences for the area provided important insight into understanding how vent fauna colonize and evolve. With these unique journeys of discovery, SOI continues to bring the ocean to people in the communities in which we work, as exemplified by the 2,700 people reached in 2018 through in-person public presentations.

D-2 Inc.

Falmouth, Mass.
President/CEO: Alan Fougere
No. of Employees: >5
www.D-2.com

D-2 provides instrumentation solutions across are variety of markets. Its re-entry into oceanographic markets is the direct result of direct invitation by leading groups such as ONR and WHOI to fill the need for high performance full ocean depth CTD systems. **D-2 has developed and patented a novel "Hybrid" Conductivity sensor.** The Hybrid sensor incorporates the best physical measurement aspects of electrode and inductive sensors to form the foundation of a new full ocean depth precision conductivity sensor. This new sensor can be used aspirated by a pump, as the measurement field is 100% enclosed within the sensor. However, it's short length and large internal diameter also allow its use freely aspirated applications where pump is impractical, such as slow moving AUV's, UUV's gliders, for example.

Impact Subsea

Aberdeenshire, UK
President/CEO: Ben Grant
No. of Employees: 5
www.impactsubsea.co.uk

Impact Subsea was created in 2015 by Ben Grant and Alistair Mclennan-Murray, and the company specializes in underwater sensors. Its range includes underwater altimeters, depth sensors, AHRS and sonars. Each sensor is designed to emulate any device in order to assist with integration into pre-established systems. Most recently the company has been focusing on the development of its newest sensor, the ISS-360which it dubs ***'The World's Smallest Imaging Sonar.'*** Due for its release later this year the ISS360 will feature a 90-meter range, and a maximum depth rating of 4000 meters in a titanium housing.

Impact Subsea

OceanAlpha Group

Hong Kong, China
President/CEO: Ran Zhang
No. of Employees: 329
www.oceanalpha.com

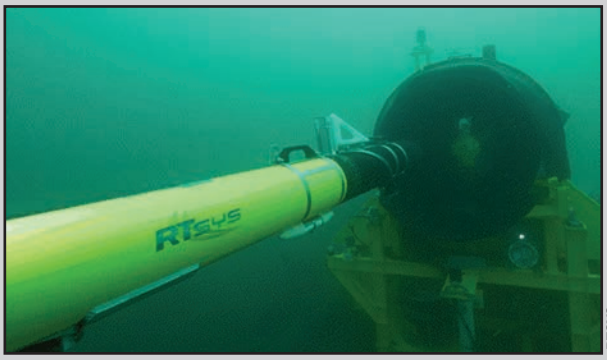
Founded in 2010, OceanAlpha Group Ltd. is an Unmanned Surface Vehicle (USV) manufacturer. In nearly a decade, the company has developed 92 USV related patents hatching more than 25 models of USVs from 1m to 50m in length basing on a 100+ person engineering team out of 298 total employees. The company is applying its USV technology to serve a number of customers including rescue, water environment sampling & monitoring, hydrographic survey, oceanographic survey, nuclear radiation monitoring, and water surface cleaning. The company is now operating in 18 countries around the world and has delivered more than 400 USVs.

OceanAlpha Group

Dong Fang Hong 3

World's Largest Silent RV

The world's largest silent research vessel built by China was officially put into use, designed to pave the way for the cultivation of innovative deep-sea talent and ocean science study. Built by Shanghai-based Jiangnan Shipyard (Group) Co., Ltd, the Dong Fang Hong 3 is the first Chinese research vessel and the world's fourth to have obtained a Silent-R certificate, the highest standard for underwater noise control issued by, DNV GL, according to Xie Jun, chief builder of the vessel. The 5,000-ton ship can hold 110 people and is capable of sailing for 15,000 nautical miles continuously. With a total length of about 103 meters and a width of about 18 meters, the ship has the ability to navigate the infinite navigation area of the world. "When the boat is sailing, it is so quiet that fish beyond 20 meters under the water are not disturbed," Wu Gang, chief designer of the ship from the No. 708 Research Institute under China State Shipbuilding Corp, said. "We will use the vessel for comprehensive and inter-disciplinary marine science research," said Yan Ju, vice president of the Qingdao-based Ocean University of China.



RTSYS

RTSYS

Caudan, Brittany, France

President/CEO: Mr Vidal dos Santos Teixeira

No. of Employees: 40

www.rtsys.eu

Created in 2010, RTsys is a fast-growing company with more than 40 employees serving both civil (scientific studies, offshore works, ect.) and defense clients. For the defense market RTsys has on staff several ex-marine officers that today serve as project managers, answering naval needs worldwide. Its core technology SDA (Synchronous Data Acquisition) motherboard is embarked on each of its products to make them long-lasting and reliable, be it recorders and buoys, sonar systems or AUVs.

Amongst other products, RTsys developed a new micro-AUV which is less than 1 meter long called NemoSens. Light and cost-effective NemoSens is easy to carry and deploy thanks to an open Linux architecture allowing any payload to be embarked on it. It can last up to 8 hours at 4 knots and speed up to 8 knots to achieve various missions such as seabed mapping, offshore structures diagnosis or environmental monitoring (up to 300 meters depth). NemoSens can navigate in swarm for bigger missions (up to 7 in a row) using acoustics.

The Tech

Thanks to its core SDA technology, RTsys products all have very neat acoustic and data rendering and can be divided into three categories :

- **AUV** (micro-AUV NemoSens; COMET AUV used for Mine countermeasures and seabed mapping; SEMA Target AUV used for Antisubmarine Warfare training);
- **Sonar Systems** (handheld sonar for divers SonaDive; sonar retrofit system AS3I; sonar calibration system SIERA);
- **Underwater recorders** (Passive acoustic monitoring; subsea stations with sensors) and buoys (real-time acoustic monitoring).

TE Connectivity

El Cajon, CA

President/CEO: Terrence Curtin

www.te.com/MOG

TE's SEACON portfolio includes more than 2500 underwater and fiber-optic connectors, and complete connectivity systems to give a wide range of advanced connectivity options. The portfolio includes not only SEACON products, but DEUTSCH connectors, Rochester engineered cables and TE sensors. TE's electronic components have helped keep commercial vessels, offshore platforms and marine applications productive, safe and dependable for more than half a century.

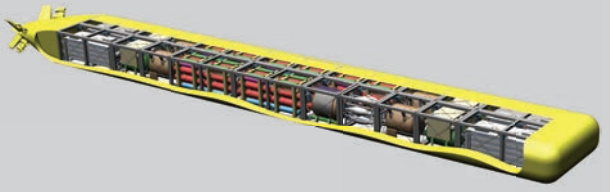
SEACON was welcomed into the TE Connectivity family in 2014. TE's range of SEACON products include electrical dry-mate, wet-mate, and fiber-optic hybrid connectors suitable for many subsea applications including oil and gas, alternate energies, military, remotely operated vehicles (ROV) / autonomous underwater vehicles (AUV), environmental, and oceanographic, including exploration and survey. TE's DEUTSCH high density optical in-line dry-mate connector is a multichannel fiber optic connector developed from reliable high pressure/high temperature (HP/HT) technology backed by more than 30 years of performance in the field. This connector was designed with size and bulk restrictions in mind, making it suitable for harsh marine applications that need maximum weight and space savings. The high density in-line connectors offer a cost-effective solution for multichannel fiber optic management, packing 12 to 24 fiber optic channels (FO) in stand versions and up to 48 FO upon request. With operating temperatures between minus 30 and 121 degrees Celsius using the HT fiber, and bulkhead receptacles that are rated to withstand 450 bar (6,536 psi) of differential pressure, this connector maintains stable performance during strain and temperature monitoring. Low insertion loss and back reflection (≤ negative 45dB) are achieved using angled physical contacts. In addition, the system maintains integrity in the face of flooding due to a dual sealing bulkhead receptacle.

Thyssenkrup Marine Systems

Thyssenkrupp Marine Systems (MS) is is designing a very large (up to 50m-long) unmanned underwater vehicle (UUV) called a modifiable underwater mothership (MUM), based on a modular design, comprising basic and mission modules. The thinking behind it is that today's subsea underwater vehicle market is dominated by specialized products, with no one vehicle able to be used for multiple tasks. So, Thyssenkrupp set about designing a modular system.

Basic modules would be trim and diving systems, battery, propulsion and a hydrogen fuel cell. Then, mission focused modules could range from ocean bottom seismic node (OBN) deployment (>1000 OBNs) to core drilling systems, or from subsea control module change out to hosting remotely operated vehicles, which would use the large UUV as a mother ship.A MUM modular kit would consist of modules that have the size of standard 20ft or 10ft containers. They can be combined according to the mission specifications resulting in quite different vehicles, from 80 metric tons to above 300 metric tons, or from 20m-long, 4m-wide and 3m-high to about 50m-long, 7m-wide and 3m-high, with power consumption dependent on the payload and propulsion speed.

The MUM vehicle will be designed to be able to travel hundreds of miles, depending on the vehicle configuration, with its 80-160kW hydrogen fuel cell power, and down to thousands of meters water depth. Hydrogen fuel cells are a proven air-independent technology for Thyssenkrupp submarines; the company has profound experience with hydrogen fuel cells in the German HDW Class 212A submarine as well as other submarines. Batteries might be necessary for peak loads of some payloads, but most of the current MUM vehicle designs only have a small sized backup/emergency battery, says Thyssenkrupp.



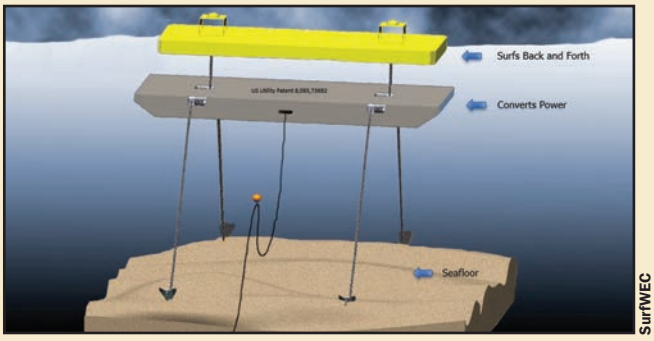
Thyssenkrup Marine

SurfWEC LLC

SurfWEC is a new name in wave-generated power, but the technology behind the system has been in development for more than a decade, a patented "surf-making" Wave Energy Converter which has been in development since 2007. SurfWEC LLC, which is aiming to become the 'go to' in the wave energy category, both as a stand-alone system and as added power source, energy storage, and wave damping units co-located with existing or future offshore wind farms.

A driving force behind the new performance projections for Wave Energy Converters (WECs) is Martin & Ottaway, a New Jersey-based marine engineering firm that has been in continuous operation since 1875 which incubated SurfWEC LLC in December of 2018. SurfWEC, with university and industry partners – Stevens Institute of Technology, ABB, Airline Hydraulics, Bosch-Rexroth, Deeptek, HYDAC, ISCO Pipe, Wire Co./Lankhorst Ropes, and others – is working to develop WECs using patented features that are expected to increase energy recovery rates by an order of magnitude as stand-alone units or integrated with legacy WEC systems.

The SurfWEC system is also designed to avoid wave damage associated with hurricanes, equipment located in surf zones, and stationary mooring systems offshore via technology that conquers the challenge of highly variable wave sizes. To put it simply, it does this with a patented variable-depth shoaling feature, invented by Michael Raftery, SurfWEC Chief Technology Officer (CTO) while performing



SurfWEC

research at Stevens Institute of Technology from 2004 to 2012. The technology essentially allows offshore waves to be converted to surging surf waves, allowing much more effective wave energy recovery.

Stevens Institute of Technology paid for and owns the patent rights to the system, while SurfWEC has an exclusive license option agreement in place to use this technology.

The system under development now is designed to be a 'smart', a system able to adjust itself continually to maximize and efficiently convert the ocean's motion into power, was central to success. For this, the SurfWEC team relies on a neural network. The system is designed to be flexible too, and in principle the SurfWEC system can be placed anywhere where there are ocean waves and water depths are from 135 to 1000 ft. It is, in fact, a major design feather in SurfWEC's cap that the system need not be placed directly in the surf zone to work.

Turner Design

San Jose, Calif.

President/CEO: James Crawford

www.turnerdesigns.com

Turner Designs recently introduced C-FLUOR, a family of sensors designed with customer requirements for extended deployments in mind. Power is one of the defining determinations for how long sensors can be deployed in the field. Long-term deployments often get their power from limited sources such as batteries, the sun, or wind. Reducing power requirements of sensors can greatly increase their usability. The C-FLUOR family of single-wavelength in situ fluorescence and turbidity sensors have ultra-low power requirements of a maximum of 12mA current at 12VDC input. Fast response times of T99 < 0.6 seconds further reduce the sensors' power requirements. Coupling low power with anti-corrosion measures such as titanium construction enables the sensors to be deployed for extended periods of time. Providing multiple fluorescence & turbidity sensors for long term deployments enables studies of HABs, Dye Tracing, Wastewater monitoring, Oil Detection, and general environmental research. Pin-compatible with our Cyclops Sensors, C-FLUOR can be easily integrated into many of the same third-party systems.

Turner Design

The Tech

Turner Designs specializes in fluorometers and turbidimeters as it has for more than 47 years. The company offers multiple configurations using its modular optics: in-situ sensors such as C3, C6P, Cyclops Integrator, Cyclops-7F, Cyclops-6k, Turbidity Plus, PhytoFind, and C-FLUOR; handheld and portable instruments such as AquaFluor, CyanoFluor, AquaFlash, and Ballast-Check 2; inline sensors such as Enviro-T2; and laboratory instruments such as Trilogy. It has standard optical configurations for in vivo and extracted chlorophyll; blue-green algal pigments such as phycocyanin and phycoerythrin; active fluorescence for determining photosynthetic efficiency; dissolved organic matter; optical brighteners and tryptophan for wastewater monitoring; dye tracers; crude and refined oils as well as infrared wavelengths used to detect turbidity. The company's modularity also makes it relatively easy for us to provide custom optical configurations.

AXSUB

www.axsub.com

AXSUB Inc. is a supplier for the commercial diving, hyperbaric, S&R and military, with its systems used for video recording and continuous real time depth monitoring system (DMS) for commercial divers.

Its flagship product is the AxVIEW 2V-RM, designed for commercial diving operations. When used with a computer, it is designed to enable video recording and numeric depth meter connectivity which will transform the AxVIEW into a Diver Control platform. This is the second generation of its Diving Data Management System (AxDDM) that is design for a typical rackmount installation available as a 1, 2, 3 or 4-diver system.

Deep Trekker

www.deeptrekker.com

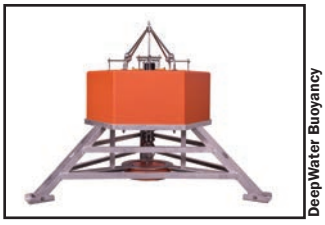
The Deep Trekker Revolution ROV is engineered with carbon fiber and stainless steel, a more powerful and better equipped ROV with auto-stabilization, wireless connectivity, augmented recording capabilities and 4K Ultra HD video resolution. Deep Trekker Revolution is based on an automated station holding, allowing the camera, sonar and manipulator arm to rotate a full 260 degrees for advanced situational awareness and flexibility. It can be remotely controlled to depths of 305 meters underwater. The vehicle's manipulator arm has a close strength of 70 lbs and the ROV tether can pull up to 300 lbs to the surface. Deep Trekker Revolution is designed to detect and locate objects hidden beneath the water, assist divers and safely conduct underwater inspections in harsh environments. Coupled with the driving force of BRIDGE, Deep Trekker Revolution provides advanced stability in underwater environments.

Deep Trekker

DeepWater Buoyancy

https://deepwaterbuoyancy.com

DeepWater Buoyancy supplies subsea buoyancy to the ocean science community and provides products to all offshore, subsea markets. In the last 12 months the company has been working to a strategic plan to grow its capabilities, including QSHE, products and processes. Quality and Health and Safety have always been in important to DeepWater Buoyancy and the state-of-the-art practices of these disciplines are ingrained in its culture. In the past year, the company has validated those practices by third parties. In addition to continued product development in the existing line, new products added to the product line include solutions for



DeepWater Buoyancy

deep water oil and gas such as Jumper Buoyancy, Umbilical Buoyancy and Buckle Mitigation Buoyancy. Finally, to coincide with the offering of new products, new capabilities have been added to the facility in the form of manufacturing equipment, computer-aided engineering tools, and product and material test equipment.

Digital Edge Subsea

www.digitaledgesubsea.com

Digital Edge Subsea

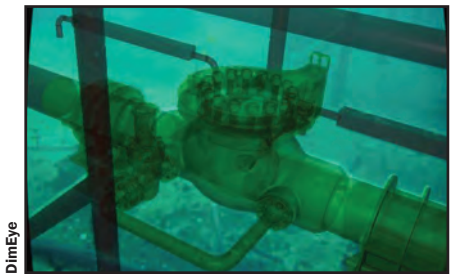
Digital Edge Subsea supplies the oil and gas industry with digital video recording inspection system, the EdgeDVR. During 2019 the company has been developing the next-gen of digital recording equipment, which are due for release Q3 2019. The software will now have three levels: EdgeLite, Edge and EdgePro. With regards to the hardware, the company will also have three main types, Standard Definition, High Definition and our first 4K system. The addition of a 4K(UHD) model is a reflection of the latest technology that is now being used on some of the latest ROV and diving systems.

Later in 2019 the company plans to launch EdgeLive, a subscription-based live remote monitoring service.

DimEye Corp.

www.dimeye.com

DimEye has developed a unique 3D Subsea Survey Technology called Video Laser Scan (VLS) and combining Advanced Photogrammetry & Laser Techniques. The company was founded in January 2009, and has been carried out more than 500 3D projects since then. During the last 12 months, besides the Integrity Management applications (3D mapping of defects) the company has been developing the 3D As-Built CAD modeling activity subsea and topside, using operators, mini ROV(s) and drones, literally "from seabed to space".



DimEye

Hydromea

www.hydromea.com

Hydromea developed an ultra-slim (15 mm thickness) rim-driven brushless thruster with integrated motor control. The hubless propeller prevents it from getting tangled. The patented design is pressure-proof without seals, hydro-lubricated and oil free. Its thin size makes it ideal for low-drag vertical stabilization thrusters, as well as small vehicles where space is limited. The integrated motor controller uses advanced sinusoidal drive algorithms to improve efficiency and smooth operation. Precise and fast speed control enables accurate attitude control of the submarine. The patented design allows it to use hub-less propellers that are not affected by floating debris such as pieces of water plants or ropes. Propellers can be exchanged quickly without special tools.

Hydromea

Hydromea also offers wireless optical nodes for through-water high-speed wireless communication with extremely good power efficiency. Finally, its portable swarm-capable drones can carry a multitude of environmental sensors through the water column and produce a 3D mapping of an area with unmatched detail in a fraction of the time it takes today with traditional technologies.

Lindorm, Inc.

https://lindorm.com

Lindorm, Inc. is a private Florida corporation that in 2006 took over the activities of Erlingsson Sub-Aquatic Surveys. In 2018 it delivered the 4th-gen SediMeter, and on May 15, 2019, it released a new instrument, SediTrans for sediment transport, which is a unique combination of sensors and hardware that creates a versatile instrument that measures turbidity, currents, waves, and depth, but can also be used for acceleration, vibration, magnetic field, fluorescence, light, and temperature.

LYYN AB

www.lyyn.com

LYYN AB has a unique tech for video enhancement in real time. In the subsea segment LYYN helps provide a clearer visibility in turbid waters and principally being used in ROV's or by divers. LYYN technology is also used in marine applications above water in order to improve visibility during fog, rain, haze and smoke. LYYN's analogue technology has this year been complemented with products for digital video. It now also offers products which are compatible with full HD video. The new digital Integration Kit is small, the size of a business card, in order to facilitate integration in camera housings.

NOVACAVI

www.novacavi.it

Novacavi, is a specialist in cable design and manufacturing since 1975 with a sound experience in ROV tethers and umbilical custom cables feasible on any conceivable configuration. Novacavi offers prototyping development, low volume & high mix production of fit for purpose cables for underwater or water-based environments. Its technical team can deal with increased workload, strength and lift capacity or higher flexibility and size and weight reduction, torque balance construction, positive or negative or neutral buoyancy, water tightness, deeper depth, enhanced environmental risks, longer deployable single length.

Sonardyne

Hampshire, UK

John Ramsden, Managing Director

Staff: 290

www.sonardyne.com

Sonardyne

From the day it was founded close to 50 years ago, Sonardyne's focus has been customer-driven innovation in our oceans for energy, science and security. Today, it operates on a global scale, providing underwater acoustic, inertial, sonar and optical technologies that are enabling users to position, monitor, measure, detect, image, log, analyze and communicate data, when and where they want in the ocean space.

The company is at the forefront of the drive towards safe, efficient and cost effective marine operations including: the latest in over-the-horizon, unmanned and remote autonomous navigation and data harvesting systems; centimeter-level seabed monitoring for hydrocarbon and geoscience applications; intruder detection systems able to detect and track next generation asymmetric threats in the defense space; and supporting emergent subsea resident robotics systems with hybrid navigation capabilities and super-fast, free space optical communications for live control.

This UK, privately-owned enterprise also has an eye on the future, and 2018 and 2019 has seen it make a number of acquisitions as part of a long-term diversification strategy. This includes environmental monitoring specialists Chelsea Technologies, and Danish maritime survey software and construction firm EIVA. Both organizations are to remain independently run and with their own brands.

Sonardyne's recent focus includes collaborations with manufacturers of marine autonomous systems (MAS). This spring, its acoustic communications technology has been used onboard an unmanned surface vessel (USV) operating in the North Sea to harvest data from seabed sensor nodes in what is believed to be the first over-the-horizon operation by a UK-based oil major.

Around the same time, the company's BlueComm optical modems were used to support the world's first television broadcast from an untethered manned submersible, as part of the Nekton First Descent mission in the Seychelles.

Meanwhile, the company's leading subsea hybrid navigation instrument, SPRINT-Nav, is helping to push the boundaries of long-range autonomous subsea navigation in partnership with the National Oceanographic Center (NOC). It's already the instrument of choice for subsea resident vehicles and is supporting the most demanding autonomous underwater vehicle (AUV) applications, from the NOC's ALR 2KUI to Cellula Robotics' Solus LR.

Sonardyne's recently launched Fusion 2 all-in-one Long BaseLine (LBL) and inertial navigation system (INS) technology is also bringing new capabilities and far easier ways of working to subsea survey and construction staff. Its remote access capability also unites with the company's increasing involvement in MAS.

The Tech

Sonardyne's heritage is in acoustic underwater technologies. Today, its breadth of expertise embraces high-grade inertial, free space optics (FSO), optical communications and high resolution sonar imaging.

Integrating all the technologies helps the company achieve its goal of making equipment not only more capable, but also simpler to use and, ultimately, to help make survey operations, ocean observation projects more efficient.

Examples include Fusion 2, which supports both LBL and INS operations and reduces hardware requirements. SPRINT-Nav combines inertial, Doppler and depth instrumentation and capability into one compact, low power unit, increases navigational precision and frees up valuable payload for additional mission sensors.

The company's sixth generation hardware remains a highly regarded choice for positioning, tracking and autonomous monitoring applications. New 'plus' hardware, supported by Wideband 3 digital signal architecture, further strengthens the investment case.

Increasingly, Sonardyne is helping ocean space users to monitor and protect their assets. With Sentinel, underwater intruder detection is provided, while Sentry is helping operators to detect oil or gas seeps from subsea assets and reservoirs. Sentry can also spot leaks from emergent CO2 storage sites. Meanwhile, Sonardyne's Solstice multi-aperture sonar also offers high definition imaging mission from low-logistic AUV platforms.

Norbit Subsea

www.norbit.com

NORBIT Subsea is part of NORBIT Oceans that provides Technology, products, solutions and services in the full "Ocean Space" domain. Together, the business unit NORBIT Oceans, comprises four Ocean related specialists market fields under a single identifiable brand. Operating in Defence & Security; Maritime Surveillance & Environmental Monitoring; Oil & Gas; Renewables; Transportation; Research and Engineering. NORBIT Subsea is well known for high resolution, ultra-compact wideband multibeam sonar systems for permanent or temporary installation on vessels, USV, ROVs; AUVs and the seabed. As well as leading bathymetric and forward-looking visualisation sonars, NORBIT also produce tightly integrated survey solutions and real time steered multibeam visualisation systems. Clients including military; governmental; leading research institutions as well as respected public and private international companies, rely on NORBIT to delivering capability every day. With a strong value to be safe under pressure and refine talents, NORBIT allows clients to Explore More with a high value and high-performance product and service deliverable

The Tech

NORBIT technology is based on the latest in analogue and digital signal processing enabling products to provide wide coverage monitoring combined with high sensitivity and accuracy.

Peter Eriksen

Blue Robotics Inc.

Torrance, Calif.

President/CEO: Rustom Jehangir

No. of Employees: 34

www.bluerobotics.com

Blue Robotics

Since its founding in 2014, Blue Robotics has existed to propel marine robotics. Starting with the T100 Thruster, launched through a Kickstarter campaign, its product line has now grown to more than 250 components designed to advance the field of marine robotics. Its focus on cost consciousness, its open source philosophy and its extensive product documentation has made Blue Robotics' products popular in a wide range of applications and industries. Since 2014, it has shipped hundreds of thousands of components, including more than 35,000 thrusters, to customers globally.

Blue Robotics' customers are tackling some of the biggest challenges facing the planet, creating solutions for the present and future. The Blue Robotics staff is driven to enable this work with its components and systems.

In the last 12 months, Blue Robotics has grown to support and enable that mission and community. It has added staff to support a growing list of distributors and component integrators, it hosted its first ever Blue Robotics Open House to bring together marine robotics enthusiasts from around the world, and it expanded its support of marine robotics competitions. It also introduced of a number of new products including a tether spool and gripper for the BlueROV2, an affordable potting compound for subsea applications, and its first sonar product, the Ping Echosounder. To support the mission, the Blue Robotics team has grown to 34 people and it recently moved into a new 25,000 sq. ft. design and manufacturing facility in Torrance, CA. Blue Robotics' product line spans a wide range of technology areas with a common theme of cost-consciousness, innovative design drawing inspiration from proven technologies, and extensive documentation and information. Its core technology is its patented thruster design, which is compact, inherently pressure tolerant and affordable. In addition to thrusters, the company offers actuators, watertight enclosures, buoyancy foam, sensors, lights, cables, control system electronics, sonars, and its flagship product, the BlueROV2 subsea vehicle. The has several expansion options including additional thrusters for six-degree-of-freedom maneuvering capability, an acoustic positioning system, a tether spool, and a low-cost single-function manipulator. In the last year, Blue Robotics have added new products including the Ping Echosounder, a low-cost, depth rated echosounder. It has also developed a special geared version of its thruster that is now in use on the WHOI Mesobot project.

BIRNS, Inc.

Oxnard, Calif.

President & CEO: Eric Birns

Chief Marketing Officer: Amy Brown

http://birns.com


BIRNS

Established in 1954, BIRNS, Inc. is a leader in the design and manufacturing of connectors, custom cable assemblies and lighting systems. BIRNS began serving the subsea industry in developing early lighting solutions for the U.S. Navy, and went on to contribute advanced lighting systems for key defense, offshore, and scientific applications. BIRNS provided lights for major archeological and scientific projects from SEALAB to the Titanic, and more recently in creating custom lighting with the BIRNS Titan for the Costa Concordia salvage project. In 1979, BIRNS developed the first self-contained underwater BIRNS Blackbirn Magnetic Particle Inspection (MPI) system, which enabled a single diver to detect oil leaks and cracks or weld defects in underwater steel structures. In 1990, BIRNS launched its connector division, which today is one of the most successful divisions of the organization. As the company is a connector user for its lighting systems, as well as a connector manufacturer, its team has special insight into the changing needs of its customers. BIRNS used that acumen to develop an elegant solution in 1997, the popular BIRNS Millennium connector series, a 6km-rated high density dry-mate connector range, to add to its suite of connector lines that included the BIRNS Primum, a robust electrical 6km-rated series, and the BIRNS Polymeric series. Configurations of the BIRNS Millennium series include high and low voltage, coax, fiber-optic, and hybrids of electro-coax, electro-optical and electro-opto-mechanical formats. The company launched revolutionary coax contacts for the BIRNS Millennium series in 2015 that are open face pressure rated to 1433m. In 1997, BIRNS started developing its line of penetrators—which has since evolved to become ABS Product Design Assessment (PDA) certified, and include optical fiber configurations.

The Tech

BIRNS' molding facility has been NAVSEA S9320-AM-PRO-020 certified since 2012, and thus is one of the few facilities approved to develop outboard cables for US Navy submarines. BIRNS has continued its history of serving U.S. and international naval defense customers, with lighting systems for illuminating military ports, lighting and connectivity solutions for naval submarines, diving bells and decompression chambers to ROVs, AUVs and UUVs. From massive manned systems to masts and intricate towed arrays, BIRNS products offer illumination at great depths, and faster, more robust communication options for severely demanding environments.

BIRNS has invested in the development of it world-class testing capabilities, for its own lighting and connectivity systems, but also serving as an independent testing resource for many subsea companies. The company has a custom electrical test system which permits the simultaneous testing of 16 circuits with up to 99 programmable test sequences at voltages up to 10kV, in addition to a high voltage test system that allows simultaneous testing of 64 circuits at voltages up to 2100 VDC and 1200 VAC. In 2019, BIRNS developed new custom titanium cable assemblies for an extreme cold, extreme depth rated AUV, and along with them a new extreme cold/hydrostatic test system that successfully allowed 48 hour+ continuous testing of connectors and cable assemblies at 6km in a highly controlled 2°C (±1°C) environment.

Norwegian start-up uSEA is proposing a hybrid system to disrupt existing manned vessel supported subsea operations via a subsea and surface drone combination. uSEA was founded in 2017 and since then it has been developing a USV to support underwater drones so that manned vessels are no longer needed and battery recharging can be done in the water, avoiding launch and recovery operations.

uSEA's system is called uLARS for underwater drones, says uSEA CEO Felipe Lima

The system includes a submersible towing head, with an inductive connector for charging and data transfer, which acts a little like an in-air refueling of fighter jets.

The system will support subsea survey in shallow waters as well as in deep and ultra-deep waters, operating a wide variety of payloads ranging from more conventional types such as side-scan sonar and multibeam echosounders to more advanced such as synthetic aperture sonar.

uSEA is looking for partners to complete the qualification program, which is expected by the end of 2020. After that, the company is targeting operations in the sea and it's looking for pilot projects to perform in 2021.

Moog Focal

www.moog.com

Focal Technologies, a Moog Inc. company, specializes in providing electrical slip rings, fiber optic rotary joints, hydraulic utility swivels and fiber optic multiplexer solutions for the worldwide marine industry including ROV, seismic, FPSO turret and oceanographic applications. This year Moog Focal has developed new technology and recently launched products in a number of new markets. One of these product lines includes the release of the 914-X Series modular multiplexer product line. The Model 914-X series represents a technical leap forward for the Moog Focal multiplexer product line. The 914-HDE is a single universal motherboard with 3 optical speed options, 20+ optical wavelength options, and an ever expanding array of expansion cards allow users to configure a modular multiplexing system.

PELI Products

www.peli.com

Since 1976, Peli has designed and manufactured both high-performance case solutions and advanced portable lighting systems, with great experience in the research, development and manufacturing of a wide range of premium products. In January 2019, Peli products introduced the 9600 LED Modular Light with powerful wide beam coverage. With 3,000 lumen value per light head, the 9600 offers continuous lighting that complies with the HSE requirement for illumination. In June 2019, Peli Products Unveiled the PELI Air 1745 Long Case. Now pro-users can protect their long equipment in a case line that is up to 40% lighter than other polymer cases, minimizing additional travel costs. The 1745 PELI Air Case boasts more than 3.8 sq. m., making it the deepest PELI long case. It was especially designed to protect all manner of long equipment, like surveying equipment, camera tripods, weapons and archery bows, in the harshest environments.

Seafloor Systems

Seafloor Systems

www.seafloorsystems.com

Seafloor Systems was founded in 1999 has 20 years' experience delivering high-performance hydrographic survey solutions to the marine industry. In addition to providing proven solutions, Seafloor is the leading manufacturer of Unmanned Surface Vehicles (USV's) for hydrographic applications in the world. Seafloor Systems is a customer-driven manufacturer of unmanned hydrographic solutions to the marine industry. With the introduction of the HydroCat range of USV's in 2018, Seafloor now offers a complete range of vehicles from inshore to the Surf zone, to offshore environments. Seafloor designs, develops, and manufacturers hydrographic survey solutions and platforms for the hydrographer and non-hydrographer alike.

Sensor Technology

www.sensortechcanada.com

SensorTech has embarked on a significant growth phase. In the past year, it has added close to $500,000 of new equipment to increase its capacity as well as capability in both the manufacture of piezoelectric ceramic and acoustic transducers. It has also expanded with a new facility in Atlantic Canada where all final assembly of sensors is now done. It launched a new product line that allows the system integrator a rapid way to get sensors into their system for real-world testing. First Gen Acoustics was created to fill a gap in the marketplace reducing lead-times by four times helping our clients get its Next Generation acoustic system into validation phase faster.

SubC Imaging

www.subcimaging.com

SubC Imaging continues to grow in designs and employees, moving from a 5000 sq. ft. to a 6500 sq. ft. facility in 2018. In this location, it has developed an extensive quantitative optical test setup. Testing includes 3D prototyping, 10m x 1m in-house test tank, image calibration, and nearby port facilities for field testing to ensure the highest quality products. SubC's latest product developments include the Rayfin UltraOptics, Aquorea LED Mk3, MantaRay Parallel lasers, and streaming with the DVRO. UltraOptics offers a 120 degree ultra-wide angle rectilinear lens and 21MP digital sensor PTZ. With the pan-tilt-zoom function inside the camera, the task of physically moving the camera is not necessary. MantaRay Lasers project two parallel beams that appear as green dots in images, used to get distance and scale of underwater objects. SubC Streaming is a cloud-based service that sends streaming of video and audio to your browser. Rayfin camera (available in UltraOptics and LiquidOptics) 21 megapixel digital stills with embedded metadata Live Ethernet transfer of video and stills continuous 21MP photos up to 4Hz 4K and HD recording to internal storage simultaneous video recording and digital stills scripting with acquisition API 5x sensor crop zoom + 5x digital zoom (10x total) 21MP digital sensor PTZ (UltraOptics) Situational awareness with 120-degree ultra-wide angle rectilinear lens (UltraOptics) Aquorea LED Mk3 Aquorea Hybrid - a strobe/light hybrid that synchronizes the camera exposure time with its activation time while strobing, freezing the stills taken so that objects photographed can be captured in highest detail.

SubC Imaging

National Oceanography Centre

National Oceanography Centre (UK)

Southampton, UK

President/CEO: Ed Hill OBE

No. of Employees: 620

ww.noc.ac.uk

The National Oceanography Center (NOC) is the UK's leading institution for integrated coastal and deep ocean research. NOC undertakes and facilitates world-class, agenda-setting scientific research to understand the global ocean by solving challenging multidisciplinary, large scale, long-term marine science problems to underpin international and UK public policy, business and wider societal outcomes. At the Marine Robotics Innovation Center in Southampton, the NOC hosts a community of 28 innovative partner companies, working in collaboration to develop next generation technology for platforms, components and sub-systems in order to advance oceanographic research for the benefit of both science and industry. The last 12 months has seen the NOC expand its reach and influence around the globe, with a number of overseas projects aimed at advancing marine science, capacity building and knowledge transfer under the SOLSTICE project focusing on the West Indian Ocean region, and the Commonwealth Marine Economies Program (CMEP) which is helping Commonwealth Small Island Developing States (SIDS) make the most of their natural maritime advantages. 2019's STEMM-CCS expedition saw one of the largest deployments of bespoke oceanographic equipment aimed at furthering our understanding and capabilities within the field of subsea carbon capture and storage. Technology development with industry has seen innovative, low cost EcoSUB vehicles expand their networking capabilities, in partnership with Planet Ocean and the University of Newcastle. The NOC's Autosub Long Range (ALR) successfully completed its first under ice mission in Antarctica. Another ALR project – P3NAV collaborating with Sonardyne and L3 ASV – has delivered advanced positioning capabilities without the need for surface vehicles.

The NOC is at the forefront of global marine technology development, with a focus on cutting-edge marine autonomous systems (MAS) and sensors. The Center is responsible for the development of the world-famous Autosub family of autonomous vehicles, including the pioneering Autosub Long Range vehicle, depth-rated to 6000 meters with extreme endurance capabilities and sophisticated payloads. Under the Oceanids program, further platforms are under development that will deliver more advanced AI and navigation, greater endurance and range, and world-leading under-ice exploration capabilities. The program has also delivered a unified Command and Control (C2) infrastructure for operating a range of MAS, and related collaborative developments with industry are introducing improved networking capabilities, power consumption and endurance.

Sercel Underwater Acoustics

www.sercel.com

Sercel Underwater Acoustics develops and markets underwater data transmission systems and marine instrumentation for oceanographic engineering, scientific community, military and oil & gas applications. Its products include underwater acoustic communication and positioning systems, passive acoustic monitoring and marine mammal detection systems, ocean bottom seismometers, mooring monitoring beacons, acoustic transducers and hydrophones. Products designed by Sercel include:

• **MATS 3G:** MATS 3G is an underwater acoustic modem that offers a single solution for all underwater communication needs. Its DSP technology ensures long-range and reliable communication. MATS 3G's use can range from oceanographic applications to real-time monitoring by networked stations across vast instrumented fields.

• **GeoTag:** GeoTag is an acoustic positioning system that has been designed to work with any ocean bottom or transition zone seismic equipment down to 500 meters deep.

• **QuietSea:** QuietSea's passive acoustic monitoring (PAM) system is designed to detect the presence of marine mammals during offshore operations. QuietSea provides high marine mammal detection capabilities in a wide frequency listening range that covers a large variety of vocalizing cetacean species.

• **BASM/BABS:** Designed to retrieve a buoy in case of mooring line break, BABS warns owners of line breakage by transmitting a signal to ARGOS satellites while BASM alerts of underwater equipment that may surface by transmitting through the same ARGOS satellite system.

Sea Machines Robotics

Boston, MA 02128

CEO/President: Michael G. Johnson

Number of Employees: 30

https://sea-machines.com

Sea Machines is developing autonomous control and advanced perception systems for workboats and other commercial vessels. Available for installation now, its autonomous-command and remote-control products are designed to increase the safety, efficiency and performance of marine operations. Sea Machines also enables minimally manned and unmanned autonomous operations, ideal when crews are unavailable or restricted.

Founded in 2015, the company builds autonomous vessel software and systems, which increases the safety, efficiency and performance of ships, workboats and commercial surface vessels.

Sea Machines' SM series of products includes the SM200 (available now), an Industrial-grade, remote control navigation capable of interfacing with pumps, winches and other equipment. This is ideal for workboats, tugboats, fireboats and utility craft. The SM300 (available now), provides autonomous and remote control operability for pre-planned, routine or predictable workboat tasks. This is ideal for workboats, patrol and daughter craft. The SM400 (in development) is an A.I.-powered situational awareness, using computer vision, LiDAR and perception software; ideal for commercial and naval ships.

It has been a busy year for Sea Machines. They partnered with Hike Metal to Demonstrate Capabilities of Marine Autonomy during Search-and-Rescue Missions. Separately, Sea Machines opened a new Technology Center in Boston. In another important development, Sea Machines established a Global Dealer Program and, just as importantly, raised $10 Million in Series A Funding to the ensure the growth and success of the firm's already impressive array of technology and hardware.

Canada to the Fore

Tom Mulligan reports on how the Canadian government, industry and academia are advancing the boundaries of ocean and marine technologies.

Canada has the longest coastline and the fourth-largest ocean territory in the world, and Canadian companies are established as world leaders in ocean technologies. Canada's Innovation Superclusters Initiative is an industry-led consortium uniting businesses, government and academia and pulls together technology clusters across the country into large collectives focusing on technology innovation in specific areas, aiming to drive economic growth, develop and attract top talent, solve complex challenges, and advance world-leading research and innovation in each main sector. The three superclusters that are most pertinent to the ocean technology sector are Canada's Ocean Supercluster, Digital Technology Supercluster and Advanced Manufacturing Supercluster.

The Ocean Supercluster addresses global challenges related to sustainability, reducing carbon footprints and improving energy efficiency, and strengthens links between ocean-based value chains and providers of enabling technologies with partnerships between academic institutions, government, indigenous groups and global investors, resulting in the development, deployment and exportation of innovative technology platforms applicable to multiple ocean industries. The Ocean Supercluster includes companies from eight Canadian provinces and one territory and, over the next ten years, is expected to have an impact of more than C$14 billion on the country's GDP and create more than 3,000 jobs, thereby ensuring that native and foreign investors have readily-available talent for their innovative R&D efforts in Canada over the next decade and beyond.

https://oceancluster.ca

World's largest towing tank

The National Research Council of Canada's Ocean, Coastal and River Engineering Center located in St. John's, Newfoundland offers specialized consulting and applied research services in ocean engineering, coastal engineering, solutions for water resources management, and marine safety standards and technologies, as well as marine renewable energy assessments and technology. Its work supports industries that operate in harsh environments characterized by ice, wave, wind and cold temperature, the Center serving the needs of clients in a variety of sectors, including offshore oil & gas, marine transportation, marine and waterfront infrastructure, hydropower production, water resource management, standards and regulation, engineering design and construction.

Key technologies cover a broad range of applications, including marine vehicles design and operation, and ice forecasting and measurement, as well as methods to predict structural loading in ice, improved coastal defenses against erosion and storm damage, better marine safety and risk management systems, and more reliable flood forecasting and modeling through facilities that include cold-test laboratories (refrigerated material test laboratory), a 200-meter x 12-meter towing tank, a 75-meter x 32-meter offshore engineering basin, the longest ice tank in the world (90 meters x 12 meters). Core technology competencies include vessel and platform engineering; autonomous systems, intelligent systems and robotics; risk management and loss control; remote power systems; convertible energy systems; information systems; and sensors and communications.

www.nrc.canada.ca

World's largest towing tank

Photo: National Research Council of Canada

The Marine Institute's ROV Simulator

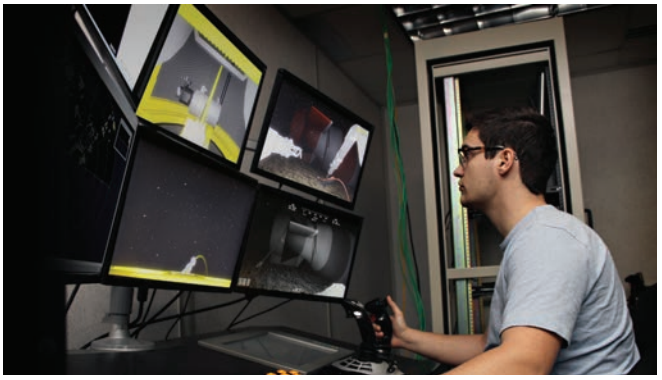


Photo: Marine Institute of MUN

Applied research and new marine tech

The Fisheries and Marine Institute of Memorial University of Newfoundland, (the Marine Institute) in St John's, Newfoundland is dedicated to education, training, applied research and industrial support for the ocean industries and provides more than 20 industry-driven programs with awards ranging from technical certificates to master's degrees. In addition, the Institute also offers advanced diplomas, diplomas of technology, and technical certificates, and runs a number of short courses and industrial response programs that are designed to provide students with the knowledge and skills they require for success in the marine industry workforce. Its School of Maritime Studies provides training and certification programs that qualify mariners in the design, operation and management of ships for the transportation of materials and products including education and training in the design of ships and associated systems, preparing individuals for entry-level operational positions as deck officers, engineering officers and ratings.

One of the centers the School operates within its facilities is the Centre For Marine Simulation (CMS) where its ROV Simulator, which was commissioned in 2006, is used to replicate the operations of offshore and military workclass vehicles. Control consoles mounted in cubicles replicate conditions on board the vehicle of interest through a number of features including GRI Simulations VROV simulation software; Schilling Robotics rate hand manipulator controllers; a Titan Master 7 axis manipulator controller; four onboard remotely operated vehicle (ROV) cameras; a Digital Edge DVR dive recording and logging system; and full integration of simulator components and features with both KPOS dynamic positioning and full-mission ship's bridge simulators.

www.mi.mun.ca

Supporting business, tech collaborations

COVE, the Center for Ocean Ventures & Enterpreneurship, is an Canadian government-owned ocean technology business park that houses start-ups, small and medium enterprises (SMEs), and large businesses, and works with a range of organizations to develop programs that encourage collaboration across sectors to connect local and international companies in the ocean industry, its five main areas of operation being marine transportation, energy, fisheries & aquaculture, marine tourism, and marine defense & security. COVE is managed by a small team that develops and administers the programs, services, and initiatives companies that operate in the Canadian national and global ocean economy. The facility is owned and managed by the province of Nova Scotia, giving its tenants access to equipment, marine infrastructure, resources and partnerships. Housed in a former Canadian Coastguard facility, COVE is located on an eight-acre site with a 12-acre water-lot on Halifax Harbour and includes 2,850 feet of docks with two finger piers, up to 49 feet of water depth, and 50,000 square feet of office and workshop space. Currently, COVE has about 50 tenants, including 13 start-ups and 35 fully commercial companies.

https://coveocean.ca

New multiplexer systems

Subsea sensor specialist MacArtney, a COVE tenant, was recently commissioned by UK-headquartered Subsea Technology & Rentals (STR) to design and custom-build a new NEXUS MK C to compliment the NEXUS MK IV and MK VI systems purchased by STR last year. The multiplexer systems include full real-time diagnostics such as link status, temperature, optical power and voltages, a seven-inch touchscreen for configuration and operation, an advanced diagnostics graphical user interface, software-configurable multi-protocol ports, micro-second latency data and full bandwidth real-time video with no compression. The MacArtney Group has been developing NEXUS multiplexers for two decades, designing and manufacturing multiplexers and telemetry solutions in-house for interfacing underwater technology systems and applications, providing a safe and efficient fiber-optic link between the surface and seabed.

www.macartney.com

Smart hydrophones for ocean research

In a related technology area, Nova Scotia-based Ocean Sonics has introduced the first in a new generation of smart

Supporting business, tech collaborations

Photo: COVE

New multiplexer systems

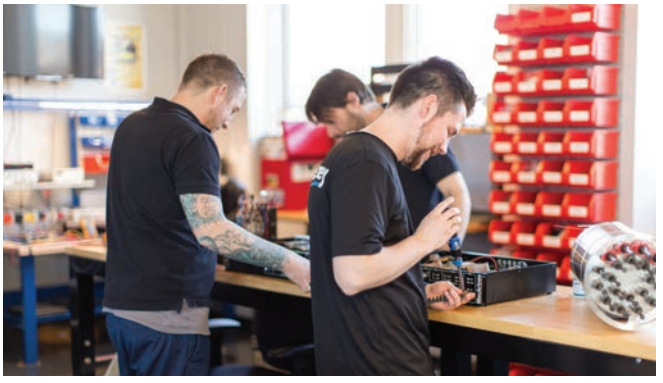


Photo: MacArtney

hydrophones, the Kayak, which provides the features of the company's established range of icListen Smart Hydrophones in a smaller, low-power, and scalable way with a bandwidth covering 10 Hz to 200 kHz in 24-bit resolution, thus offering very high sensitivity based on built-in processing. The versatile, modular 0.2 W, 23 mm diameter icListen Kayak can be connected via USB, serial or Ethernet connectors and can be custom-integrated or mounted on users' vehicles or platforms, as well as used to create large arrays with simplified cabling and an uncomplicated user interface for recording data or real-time listening.

Ocean Sonics hydrophones operate based on the company's Lucy software, the newest version of which, Lucy II, being designed to simplify processing and make understanding real-time, waterfall and time-series data easier. Acoustic events can be detected using epoch triggers and advanced

SEL settings and impulse detection ensure regulatory compliance. In addition, multiple hydrophones can be viewed on a single screen, as Lucy II is optimized for handling arrays, the system also being compatible with Windows, Linux, or Mac OSX devices for simplifed acoustic data processing.

Ocean Sonics Smart Hydrophones can be turned into wifi devices quickly and easily with the company's Launch Box which makes projects portable as there is no need for a cable to directly connect to the device and data can be streamed in real time directly to a PC, tablet or smartphone. Also available is the PAMGuard Plug-in for marine mammal monitoring. By downloading the new plug-in and adding an Ocean Sonics' icListen hydrophone as a sound source, researchers can listen to marine mammals in real time. The PAMGuard plug-in also enables simultaneous control of multiple hydrophones.

www.oceansonics.com

Specialist acoustic equipment

Dartmouth, Nova Scotia-based acoustics specialist company GeoSpectrum Technologies Inc, a producer of underwater acoustic transducers and systems, has been in operation for more than 20 years, supplying hydrophones and sound projectors to a range of customers in the marine and oceanography sectors, as well as providing consultancy services on acoustic systems integration and test procedures. End-user sectors include defense and homeland security, oil & gas, and environmental services. As well as standard products, GeoSpectrum can also provide customized products and is particularly recognized as a leading provider of systems for the marine mammal monitoring and ocean observation sectors. Components designed and manufactured by the company are tested with a range of on-site equipment to ensure these meet customer requirements: this equipment includes pressure and environmental chambers and NIST-traceable calibration equipment, and the company has a production facility capable of manufacturing more than 1,000 hydrophones a day. GeoSpectrum's wide-band omnidirectional hydrophones include an integral, low-noise voltage- or current-signaling preamplifier and can be configured to operate over customer-defined bandwidths with required sensitivity and also allow for customizable gain. In addition, the depth rating for each hydrophone can be tailored to meet specific requirements to meet shallow- to deep-water requirements.

In addition to hydrophones, the company designs and manufactures electrodynamic sound projectors and has recently introduced its C-BASS family of very-low-frequency projectors. These are less expensive and smaller, lighter and designed to be more efficient than standard products. With their broad bandwidth, they can be used in a variety of applications where sound projectors could not previously be employed. The C-BASS systems may be used omnidirectionally or in arrays to produce high-power sources with or without directivity and applications include their use as diver deterrents to protect marine assets; as VLF ASW systems; as a VLF calibration source; in AUV-based target emulation; for underwater navigation/GPS applications by providing a network of beacons; for acoustic and health monitoring purposes; and in VLF communication systems with a range exceeding 1,000 kilometers.

www.geospectrum.ca

Smart hydrophones for ocean research

Photo: Ocean Sonics

Specialist acoustic equipment

Photo: GeoSpectrum Technologies

New subsea survey and installation tech

PanGeo Subsea's SBI SeaKite ROTV (remotely operated towed vehicle) enables low-cost subsea survey operations to be performed by acting as a multi-sensor platform that supports the company's SBI high-resolution sub-bottom imager payload in addition to other sensors such as multi-beam, magnetometer and SSS (side scan sonar) instrumentation with 3D automated control of altitude and run-line via EIVA flight software. PanGeo Subsea said that its SeaKite ROTV technology provides significant benefits in carrying out subsea survey operations including providing a more cost-effective platform in comparison to an ROV by requiring a smaller vessel and fewer crew; having the capacity for multiple co-located sensors to eliminate positional error across survey campaigns; providing survey flexibility with operational speeds ranging from 0.5 to 4 knots, depending on the target; and enabling the acquisition of multi-sensor data sets in a single pass, thereby reducing survey time and overall campaign cost.

One of the latest subsea survey technologies developed by PanGeo Subsea is the company's Acoustic Corer, which is designed to investigate the sub-seabed and optimize offshore installation programs by filling the gap between current geophysical and geotechnical site investigation methods by using an acoustic core 12 meters in diameter penetrating up to 30 meters sub-seabed to provide images of geohazards such as boulders, gassy soils and unexploded ordnance (UXO), and delineate subsea stratigraphy including bedrock (chalk), permafrost, gravel and cobble layers, and dipping slippage planes and beds, while providing full soil characterization.

Typical projects in which the Acoustic Corer finds application are in offshore wind farm foundation, subsea oil & gas installation, rig relocation, ie. borehole replacement, and in profiling excavated drilling centers. The technology can also be used in marine and mining archaeology projects for deposit delineation, nodule detection and locating marine artifacts. The operational support required when working with the Acoustic Corer include a 20-ton crane that is heave-compensated in waters deeper than 100 meters used for its deployment; IMCA class 2 ROV support; and an operations team comprised of five or six PanGeo Subsea technical operatives, an ROV support team and a survey team. Launch and recovery methods are, however, vessel-dependent but are generally carried out via the vessel crane or A-Frame used in conjunction with semi-customized launch and recovery aids supplied by PanGeo Subsea.

www.pangeosubsea.com

Underwater data acquisition and analysis

Kraken Robotics Inc. subsidiary, Kraken Robotic Systems, has been conditionally approved by Canada's Ocean Supercluster to progress OceanVision, a three-year, $20 million project focused on the development of new marine technologies and products to build an underwater robotics data acquisition and data analytics service business, a turnkey service solution for ultra-high definition seafloor imaging, mapping and analytics, including simultaneous acquisition of ocean environmental and marine habitat data based on unmanned maritime vehicles, advanced sensors, robotics, autonomous systems, big data machine learning and predictive analytics and allowing end-users to make more informed operational decisions in real time.

www.krakenrobotics.com

Lightweight ROVs for marine inspections

Marine-grade navigation products, ROV and marine software solutions specialist MarineNav recently showcased its latest technologies and equipment serving defense, aquaculture, law enforcement and first responder needs in marine operations. The company's offerings include marine-grade navigation components such as computers and displays; advanced vessel monitoring (AVM) and fleet management systems; and customizable industrial underwater remotely operated vehicles (ROVs). For its ROVs, MarineNav has developed units that are designed to enable quick and easy exchange of interchangeable modular components. The company said that with a range of optional plug-in accessories available, its ROV design is rugged and versatile and that

New subsea survey and installation tech

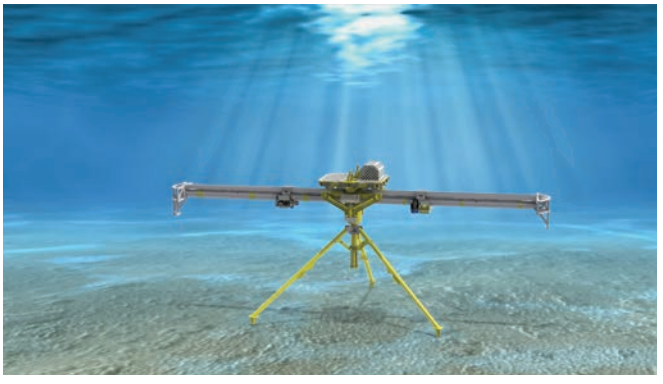


Photo: Pangeo Subsea Inc.

Underwater data acquisition and analysis

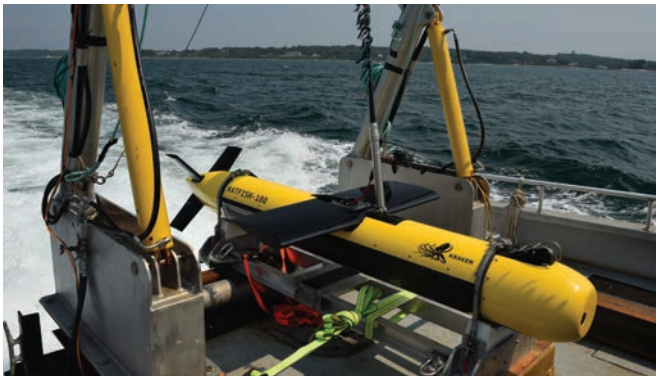


Photo: Kraken Robotic Systems Inc.

units can be operated by a single person, while interchangeable modules minimize ROV downtime, thereby reducing repair costs. The majority of the company's ROV components are manufactured in-house at its Montague, Prince Edward Island premises.

MarineNav manufactures a number of ROV product types, including its Oceanus Hybrid ROV System, the Oceanus Hybrid Plus ROV System, the Oceanus Pro ROV System, and the Oceanus Pro Plus ROV System, each with its own particular features and operational advantages, plus a range of Oceanus ROV accessories. The Oceanus Ultimate ROV System will debut in the fall of this year.

MarineNav's latest ROV product introductions are its Oceanus Pro and Oceanus Pro Plus ROV systems. These units are rugged inspection-class ROVs capable of operating to a maximum depth of 1,000 feet (305 meters) at a maximum speed of six knots, making them highly suited for performing not only propeller, hull and wharf inspections but also for carrying out underwater search and recovery missions. The low weight of the Oceanus Pro and Oceanus Pro Plus submersibles of 38.1 lbs (17.3 kg) means that the units can be easily deployed by one person, while the standard features of these units include an ROV housing made of anodized aluminium and an ROV power tether. Optional upgrades include wireless broadcasting in which the operator can enable screen-sharing with other operatives and the MarineNav Fleet Management Suite – this reports the status and health of ROVs remotely to give full tracking of single or multiple units.

The Oceanus Pro Plus includes all the features of the Oceanus Pro as well as the flexibility to customize the system with a range of extra features and attachments, for example the upgrade of the Topside Control Case to an 18.5-inch (47 cm) widescreen version or a 24-inch (60 cm) TFT-active matrix LCD display. The Oceanus Pro Plus is equipped with Full HD 1080P front and back cameras to enalble simultaneous viewing and an optional 4K external camera provides even greater functionality.

www.marinenav.ca

High-fidelity maritime safety simulation

Virtual Marine develops high-fidelity maritime safety simulation systems for a number of sectors, including offshore oil & gas, maritime training, the military and naval sectors, and coast guards. The company's products include lifeboat, navigation and ice management simulators, as well as fast-response craft (FRC) simulators in desktop format with virtual reality training scenarios. Customized simulators using vessel-specific equipment for lifeboats and fast-rescue boats (FRBs) are also available. The company's range of simulation scenario software is designed to test operator proficiency in a realistic manner while delivering safe and repeatable training to quicken competency development. Its FRB simulators are custom-designed to match client boat controls, while simulation scenarios incorporate time of day and a range of weather conditions in order to test operators' navigation and pilotage skills, with graduated levels of complexity across a range of SAR, security and interdiction missions on offer, providing a realistic and verifiable medium to execute safe and repeatable training on a virtual fast and potentially dangerous craft to enable operators to develop positive boat handling and navigation skills before engaging in on-the water operations.

Virtual Marine's lifeboat simulators can be customized to represent any model of lifeboat and include emergency evacuation scenarios specific to any offshore facility or training organization, Virtual Marine having simulated davit-launch and freefall/skid lifeboats from manufacturers such as Harding Safety, Norsafe, Survival Systems International and Fassmer. The systems can be autonomous or instructor-based depending on the user's training objectives and are certified by DNV-GL and recognized by the International Maritime Organization's STCW and MODU Codes.

The company's Freefall Lifeboat Simulator on a motion bed is designed to generate the "gut-wrenching" experience of a freefall launch for either a lifeboat coxswain or passenger and offers an innovative medium in which to practice pre-launch safety inspection checks, the proper sequence to safely execute a freefall launch procedure, and a variety of

Lightweight ROVs for marine inspections

Photo: Tom Mulligan

High-fidelity maritime safety simulation

Photo Virtual Marine

on-the-water boat handling maneuvers. The Closed Configuration Lifeboat Simulator places coxswains in a cabin modeled after the lifeboat that they would use in a real evacuation. The full-motion bed replicates the sensation and force of being launched off an oil platform or off a cargo vessel, and subsequent movements replicate a lifeboat's navigation in varied sea states and extreme weather conditions. Virtual Marine also provides its Full Mission Lifeboat Simulator which, like its Freefall Lifeboat Simulator, comes in both Open Configuration and Closed Configuration version, as well as a Motion Configuration Lifeboat Simulator version which brings together the realism of being in the lifeboat cabin and the sensation of movement directly replicating a lifeboat in sea states matching the emergency scenario the coxswain is experiencing.

www.virtualmarine.ca

Advanced ice analysis for safer navigation

Rutter Inc. has made significant additions to its sigma S6 Ice Navigator marine radar advanced ice analysis system to enhance both image quality and navigational ability for safer navigation around and through sea ice or for use in scenarios where enhanced situational awareness is required. The new additions to the sigma S6 Ice Navigator make it possible to identify ice ridges within ice floes and fields, and also to detect and identify icebergs embedded in pack ice, aiding navigators to identify the safest, most efficient route through ice fields. The system can also outline open water leads, providing real-time radar imagery to assist in route planning through dynamic ice environments.

Complementing these new features are further enhancements to Rutter's high resolution imaging system to improve target tracking for small, faint ice targets amongst sea clutter. In addition, Rutter has introduced its next-generation ice radar, sigma S6 Ice Defence, making it possible to obtain additional tactical information for ice management systems. sigma S6 Ice Defence includes all the features of the sigma S6 Ice Navigator, as well as unique new features targeted towards ice management operations that enable ice to be seen before a collision can occur. Floe detection takes place in a user-configurable area, providing drift vectors based on historical movement. The system is also capable of ice drift prediction in open water using radar-based current analysis and wind sensors. Also available from Rutter are two new capabilities for all of the company's systems, Coastline Masks and sigma S6 Connect. The automatic Coastline Masks feature incorporates a world coastline map, eliminating false-positive targets when operating near land, while sigma S6 Connect makes all sigma S6 data available through a web interface using open standards to allow easy integration into external systems such as Google Earth Pro, GIS, and ice management systems that use industry-standard formats.

www.rutter.ca

Running Drillship thrusters on Batteries

Engineering and power systems solutions firm Aspin Kemp & Associates Inc (AKA) recently installed and tested energy storage systems (ESSs) for the transfer of power to thrusters on board Transocean's drilling vessel Spitsbergen, marking the first time that thrusters have been run directly from batteries on this type of vessel. AKA stated that the installation demonstrated the safe use of lithium-ion batteries on an offshore drilling rig and that it enables safer operation and increased reliability for station keeping, while also providing additional benefits in optimizing how the diesels are run, thus saving fuel and reducing environmental impact.

AKA's full scope of supply for the Spitsbergen Hybrid System includes the conversion to DP3 closed-bus operation and the addition of 5.6 MW of hybrid power. The thrusters can operate completely independently of the main generators and distribution system, thereby allowing the main generators to be fully optimized to the load and simultaneously reducing DP station-keeping risk. The drilling rig is currently in full operation while the retrofit is being carried out in Norway. AKA has already demonstrated its Hybrid concept on the first thrusters, the ESS transferring energy to a thruster for a short period of time and the on-site team is continuing its work with the commissioning of the remaining seven thrusters.

www.aka-group.com

Advanced ice analysis for safer navigation

Photo: Rutter Inc.

Running Drillship thrusters on Batteries

Photo: Aspin Kemp & Associates

Oceanology International

Oceanology International

This ubiquitous gathering of subsea pioneers and tech turns 50

The Oceanology International exhibition held every second year in London is arguably the world's largest and best gathering point for the subsea industry, a conduit for the exchange of ideas, the launch pad for next-generation technologies and the meeting point for the "Who's Who" in the global subsea sector. But when the exhibition and conference started in 1969 in the seaside resort of Brighton, ocean exploration was a wide-open frontier of possibilities in the world's deepest seas. Today, there are moves to search the oceans other worlds inside our galaxy, but the deep ocean still remains a frontier. To the emergent underwater oceanographic and hydronautical world, the excitement that had been building over the past decade about what exploration of the deep could offer, through the likes of Jacques Cousteau, was starting to be applied in a new industry, North Sea oil and gas exploration. The possibilities of new industries such as deepsea mining and seafloor habitation were also being discussed.

Looking ahead to 2020, the subsea industry will once again gather in the U.K. for Oceanology International, but like the industry it serves, the exhibition and conference has undergone many changeovers and transitions. For one, it has been bought and sold, today owned and operated by Reed Exhibitions, a global behemoth in the exhibition space. It also outgrew its original home of Brighton, moving to the much larger, but decidedly 'less homey' confines of London. In fact the move to London spurred the creation of a competing exhibition, Ocean Business, held every two years in Southampton, England. It has grown its international footprint, with spin-off events in North America and China. But through all of the years and changes, Oi has retained the mantle of 'biggest' and 'best'. Oceanology International 2020, due to be staged (as is now customary) in the ExCel London, March 17-19, 2020.

To celebrate Oi's 50th Anniversary, the publishers of *Marine Technology Reporter* have been commissioned to publish a commemorative "Oi @ 50" anniversary magazine, filled with insightful subsea industry developments through the last five decades. This edition will publish with the March 2020 edition of *Marine Technology Reporter*, and distribute at the Oceanology International 2020 event in March 2020.

Remote Ocean Systems

San Diego, California

President/CEO: Bob Acks

No. of Employees: 30+

www.rosys.com

Remote Ocean Systems is an ISO 9001-2015 certified company with a 28,000 sq. ft. research and manufacturing facility dedicated to producing products that are reliable in extreme environments and applications. Its 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 55 lean manufacturing environment.

The Tech

ROS design and manufacturing credentials are the result of 40 years experience, state-of-the-art manufacturing facilities and a team of highly qualified engineering specialists in video technology, lighting design and mechanical design reliability. Its 28,000 sq. ft. headquarters and manufacturing facility houses hydrostatic pressure test tanks, electronic labs, advanced computer modeling, prototyping systems and environmental test chambers. Its custom product development partnerships with leading ROV manufacturers foster new product designs in deep water camera technology, new LED lighting ideas and revolutionary sonar positioners that are lightweight and accurate.

ROS

QPS Inc.

Zeist, The Netherlands

MDs: Jonathan Beaudoin & Almar Hollaar

No. of Employees: 70

https://qps.nl/

For more than 25 years, Quality Positioning Services (QPS) have been experts in maritime geomatics software and services.

The company's solutions are designed to encompass the entire workflow, from the surveyor all the way to the pilot, and are used across a variety of industries, including hydrographic surveying, offshore construction, oil and gas, chart production, and piloting. QPS is headquartered in Zeist, The Netherlands, and has subsidiary offices located in Portsmouth, USA; Fredericton, Canada; and Banbury, UK. QPS is a SAAB Group Company since 2012.

The Tech

QPS marine construction solutions are highly focused in oil and gas, offshore wind farms, and the dredging industry. Services include on-site and on-board training, setup, and support. QPS' mission is to keep even the most complex jobs running smoothly.

- Qinsy: systems integration, navigation, and survey planning, acquisition, and real-time processing.
- Qimera: multibeam data processing made simple and intuitive, while still offering advanced tools.
- Fledermaus: 4D geo-spatial analysis, with movie making tools and integrated video.
- Qarto: rapid, automated ENC production from high resolution source bathymetry.
- Qastor: precise piloting with under-keel clearance capability and real-time inform.

Silicon Sensing Systems

Plymouth, Devon, UK

President/CEO: Kevin Pindard

www.siliconsensing.com

Silicon Sensing Systems is a provider of silicon MEMS-based gyroscopes, accelerometers and inertial measurement units. The latest solutions offer robust non-magnetic north finding technology – a cost-effective alternative to FOG-based products – as well as systems suitable for a wide range of navigation and stabilisation requirements. With a heritage dating back more than 100 years, Silicon Sensing Systems and its predecessor companies have a unique record in delivering gyroscope systems to the marine industry. Formed in 1910, Sperry Marine was set up to provide practical navigation and stabilization systems based on the newly emerging gyroscope technology, delivering the first north-finding gyrocompass system aboard the Dominion Line's 'Princess Anne' in 1910. With Sperry Marine being subsumed into British Aerospace, Silicon Sensing Systems was formed in 1998 as a result of BAE Systems and Sumitomo cooperating to develop and produce the next generation of solid-state gyroscopes, based on a silicon MEMS construction.

Silicon Sensing Systems

Silicon Sensing Systems flourished, to enjoy a strong reputation for the production of low-cost reliable gyros. It led the entry into the consumer car market, producing up to 4M devices per year – and more than 30M to date.

The patented construction of its silicon MEMS gyros – based on a vibrating ring – makes the Silicon Sensing Systems gyros highly resistant to shock and vibration, increasing the reliability and quality of its inertial portfolio. An in-house MEMS foundry has manufactured all of the core gyro technology since the birth of the joint venture. Amongst its unique fabrication equipment is a deep reactive-ion etching capability, developed in-house in Japan. In recent years, Silicon Sensing has also chosen to develop and produce a range of sophisticated accelerometers to augment its total inertial capability.

Most recently, Silicon Sensing Systems has leveraged the inherent capability of its MEMS devices to create a new range of high-performance gyros and inertial systems. Specific new products now on offer include, CRS39 and CRH02 gyros (with performance better than 0.1deg/hr bias instability), plus DMU11 and DMU30 inertial measurement units.

JW Fishers

East Taunton, Mass.

President/CEO: Karen Fisher

No. of Employees: 13

Website: www.jwfishers.com

JW Fishers

JW Fishers Mfg has specialized in the design and manufacture of high-tech, reasonably priced underwater search equipment for more than 51 years. Its sonar systems, underwater metal detectors, ROVs, and magnetometers are in use by commercial diving companies, public safety dive teams, government agencies, police and military units worldwide.

JW Fishers was founded in the mid-60s by Jack Fisher. Mr. Fisher, an avid diver, needed an underwater metal detector to use on a salvage project. Over the next several years he developed and built his own underwater metal detector. The company continually expanded its line to include boat-towed metal detectors and magnetometers. Underwater cameras were a natural follow-on to the product line. Next came a family of sonar systems including scanning sonars and side scan sonars. Acoustic pingers were added as a way to mark the location of underwater sites and oceanographic instruments. Cable and pipe trackers followed resulting from customer demand for easy to use instruments that could find deeply buried pipelines, electrical lines, and fiber optic cables.

JW Fishers designs/manufactures all of its underwater search systems at its factory in the U.S. The extensive line includes hand-held and boat-towed metal detectors, the Proton 5 magnetometer (5th generation), numerous underwater video systems, two ROVs, side scan sonar, sector scan sonar, acoustic pingers & receivers, pipe & cable trackers, a sub bottom profiler system and the Pulse 8X underwater metal detector recognized #1 by US Homeland Security.The SAR-1 metal detector was specifically designed for projects that need to locate metal objects in poor visibility, underwater environments. The unit alerts the user to the presence of metal by vibration which is transmitted through the handle and a bright red LED display. It's "snareless" design with no external wires or cables, rugged construction, streamlined configuration, and bright yellow search coil help the end user find any target in ZERO visibility waters.

Hemisphere GNSS Inc.

President/CEO: Farlin Halsey

No. of Employees: 110+

www.hgnss.com

Hamlsphere GNSS Inc.

Hemisphere GNSS designs and manufactures heading and positioning products, services, and technology for use in multiple markets, and any application that requires high-precision heading and positioning. Hemisphere holds numerous patents and other intellectual property and sells globally with several brands including Athena, Atlas, Crescent, Eclipse, Outback Guidance, and Vector for high-precision applications. Hemisphere is headquartered in Scottsdale, AZ, , with offices located around the globe and is part of Beijing UniStrong Science & Technology Co., Ltd.

Powered by Hemisphere's Crescent Vector technology, the V200 is a multi-GNSS compass system that uses GPS, GLONASS, BeiDou, Galileo, and QZSS for simultaneous satellite tracking to offer heading, position, heave, pitch, and roll output. The all-in-one V200 GNSS compass combines Hemisphere's Crescent Vector H220 OEM board, two superior multipath and noise-rejecting antennas (spaced 20 cm apart), a multi-axis gyro, and tilt sensors in a single easy-to-install and use enclosure. The V200 delivers 1.5 degree (or optional 0.75 degree) heading accuracy and Atlas L-band accuracies of 30 cm to 60 cm and offers instantaneous sub-meter accuracy and DGPS-level accuracy. Measuring only 35 cm in length, the V200 can be either pole or surface mounted and comes in 5- or 12-pin options that require only a single power/data cable connection for fast and reliable installations, even in the presence of strong radio transmissions.

Hemisphere's Vector GNSS compass solutions provide precise heading and positioning for IMO-wheel marked applications, hydrographic surveying vessels, fishing vessels, leisure boats, work boats, and other general marine navigation applications. The Vector compasses bring a collection of robust features including heave, pitch, and roll output as well as NMEA 0183 and NMEA 2000 support. Hemisphere's Atlas is an innovative service that delivers correction signals via L-band satellites at scalable accuracies ranging from sub-meter to sub-decimeter levels.

L3Harris

Portchester, Hampshire, UK
Broussard, Louisiana
Fall River, Massachusetts
President/CEO: William M. Brown
No. of Employees: 50,000
www.l3harris.com

WATCH the 'ROV from ASV' concept in action @ www.marinetechnologynews.com/videos/video/l3-technologies-debuts-rov-from-asv-technology-100112

L3Harris

L3Harris Unmanned Maritime Systems division is helping to redefine the way the world works at sea with unmanned and autonomous technology. L3Harris produces Autonomous Surface Vehicle (ASV) and Unmanned Underwater Vehicle (UUV) solutions from the ASV and Iver product ranges. L3Harris vehicles have been deployed in the field since the early 2000s in the service of military and commercial organizations. To date L3Harris has produced more than 400 unmanned and autonomous vehicles for worldwide operations and remains at the forefront of latest de-velopments with ongoing R&D.

The company provides defense and commercial technologies to the maritime domain. L3Harris grew its portfolio of autonomous and unmanned technology with the acquisition of OceanServer in 2017 and ASV Global in 2018. The company's newly formed Unmanned Maritime Systems division now houses the ASV and Iver product ranges of sur-face and subsurface autonomy. L3Harris achieved an industry first earlier this year with the demonstration of an ASV deploying, operating and recovering a Remotely Operated Vehicle (ROV). The C-Worker 7 ASV deployed an inspection-class ROV for vertical and horizontal subsea inspection off the south coast of the UK. In May 2019, the Iver4 UUV completed a long-endurance mission of over 14 hours in San Diego Bay. The route of over 35nm saw the Iver4 UUV collect high-quality side scan and bathymetry data.

The Tech

L3Harris' Iver and ASV product ranges are developed specifically for hydrographic survey, offshore energy, re-search, environmental monitoring, Mine Counter Measures (MCM), Intelligence, Surveillance, and Reconnaissance (ISR) and Anti-Submarine Warfare (ASW). The Iver vehicles are fully autonomous, capable of operating for up to 20 hours on NiMH and 300m deep while carrying a variety of sensors. The Iver4 can cover more than 40nm of survey lines on a single charge. The C-Worker range of ASVs ranging from 4m-8m, are custom designed for inland, coastal and offshore tasks including survey and inspection. L3Harris' ASVs are controlled using the ASView autonomous control system for operations spanning remote control and full autonomy. L3Harris is undertaking research and development in the areas of advanced autonomy and operating over the horizon safely. L3Harris employs techniques such as machine vision and deep learning to develop its autonomous navigation and situational awareness capability.

SubCtech

SubCtech

Kiel, Germany

President/CEO: Stefan Marx

No. of Employees: 30

www.subctech.com

SubCtech provides ocean technology in two domains: rechargeable Li-Ion subsea batteries and environmental monitoring systems. With 30 years of experience, SubCtech – a privately owned SME from Germany – has established its position among leading manufacturers of ocean and subsea technologies for industry and science, while still keeping its original company philosophy: "innovative, flexible and tailored solutions are the key to success in the field of ocean technology."

The Tech

SubCtech's portfolio comprises innovative products designed for marine and climate research, offshore oil & gas, environmental monitoring, aquaculture and energy extraction. Together with customers, the SubCtech team is tasked to develop optimal solutions in all project phases. Our products are made according to the highest industry level, up to IPC-A-600/610 class 3 and hold multiple industrial certificates such as ISO 13628-6 or API17f and MIL-STD 810G. SubCtech cooperates with international universities and institutes to keep up with the current state of scientific knowledge and research. In addition, it has an internal R&D department to be able to offer state-of-the-art customized solutions.

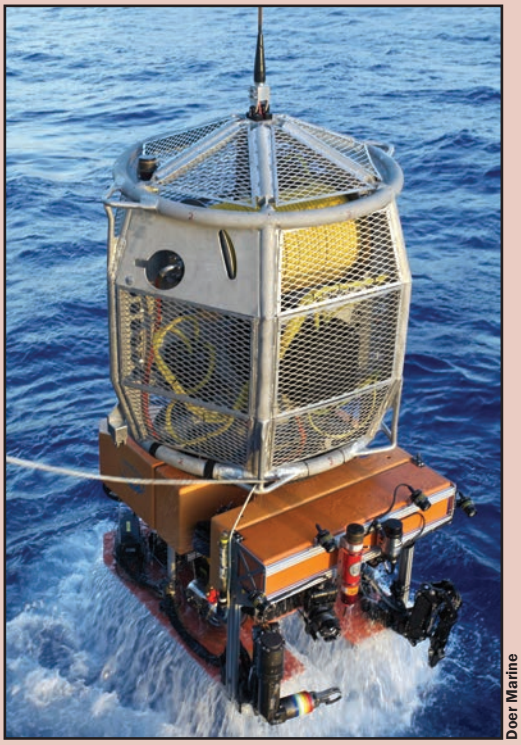
DOER Marine

Alameda, Calif.

President/CEO: Liz Taylor

No. of Employees: Less than 25

www.doermarine.com



Doer Marine

In the past 12 months, DOER has increasingly been engaged in discussions around deep sea mining. While many millions have been spent in development and build of very large ROVs for breaking up and lifting nodules and mineral deposits on the sea bed, very little has been done by way of documenting and discretely sampling these remote environments prior to mining. Working with the University of Hawaii, and the Lu'lukai ROV that DOER built to their specifications, DOER supported a seven-week expedition to the deep CCZ to gather baseline information about habitats, distribution of nodules and biodiversity. In addition, DOER built specialized cameras for use on multiple sampling platforms to characterize sea bed types prior to sampling activities. Plume monitoring studies were also undertaken to gauge duration in the water column. Return trips are planned for 2019 and 2020.

The Tech

The science class ROVs built by DOER are compact yet can carry out a variety of work tasks from geological/biological sampling to moving/positioning instruments around ocean observing systems. Typical depth rating is 6500m but shallower systems have been produced as well per client specification. Deep water accessories include manipulators, pan/tilt, compensators, lasers, thrusters, valve packs, camera housings, suction tools, and other ancillary devices that can be used both on our ROVs and other platforms. A novel sampling "drawer" allows collection and transport of multiple specimens. Because DOER systems can operate from standard UNOLS oceanographic cable, these systems can be used across different research vessels bringing added value at a time when science budgets continue to be limited.

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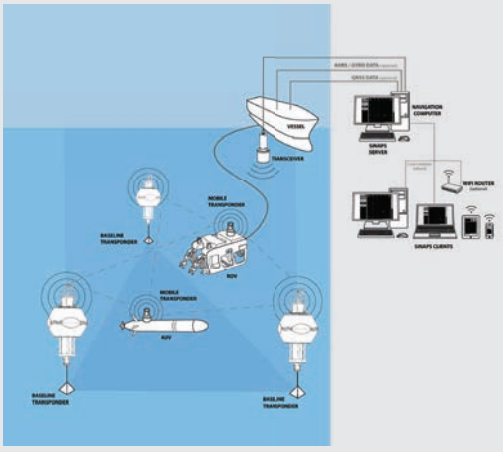

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