MARINE TECHNOLOGY REPORTER

January/February 2017

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Vehicles

All (human & robotic) hands on deck in the historic search for Franklin

Region Focus
Atlantic Canada

Robotics & the Making of the
Unmanned Warrior

Oceanology North America
Technology Preview

Volume 60 Number 1

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(Photo: Thierry Boyer, Parks Canada)

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Editorial

Gregory R. Trauthwein
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Excuse me for stating the obvious, but the age of robotics is here and now. Advances in robotics are quickly removing people from some of the dirtiest and most dangerous jobs, inserting vehicles, sensors and systems where no man has gone, or would like to go. Looking at the beleaguered energy sector alone, according to a recent *Bloomberg* report the energy downturn eliminated nearly 440,000 jobs globally. As energy prices start to rebound it is estimated that nearly one-third to one-half of these jobs will be lost forever, as robotics and automation continues to reduce the needed physical headcount on rigs, for example. This reliance on automation extends to the subsea sector, as vehicles of every shape, size and price point gain capability and confidence among a growing legion of users.

There has been a natural progression of "clusters" of subsea excellence around the globe, and to start 2017 we look at the Atlantic Canada region. I have been privileged to know and work with many individuals and organizations from industry and academia from this world region, and from all that I have seen they work collectively as a cluster as seamlessly as any other in the world.

For insight and overview we visited with **Jim Hanlon**, CEO of the Institute for Ocean Research Enterprise (IORE), starting on page 28. Our sincere thanks to Hanlon not only for his time, but for his candor and unvarnished insights in discussing drivers in the region, as well as discussion on some recent developments designed to bring the Atlantic Canada brand faster, further to the global subsea community.

At the Oceanology International North America expo coming next month in San Diego, *MTR* will have the cameras rolling to debut our new **"MTR TV"** brand. If you are interested in a sit down interview for our cameras, I look forward to your email before or your visit at the show **(*MTR* will be in booth A33)**.

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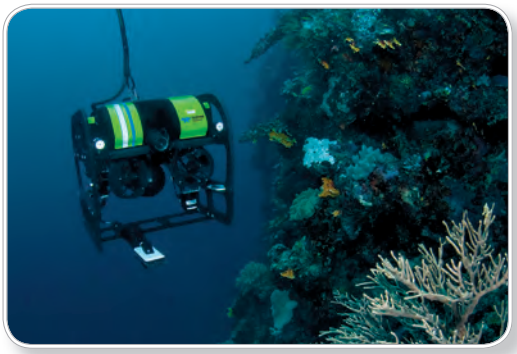

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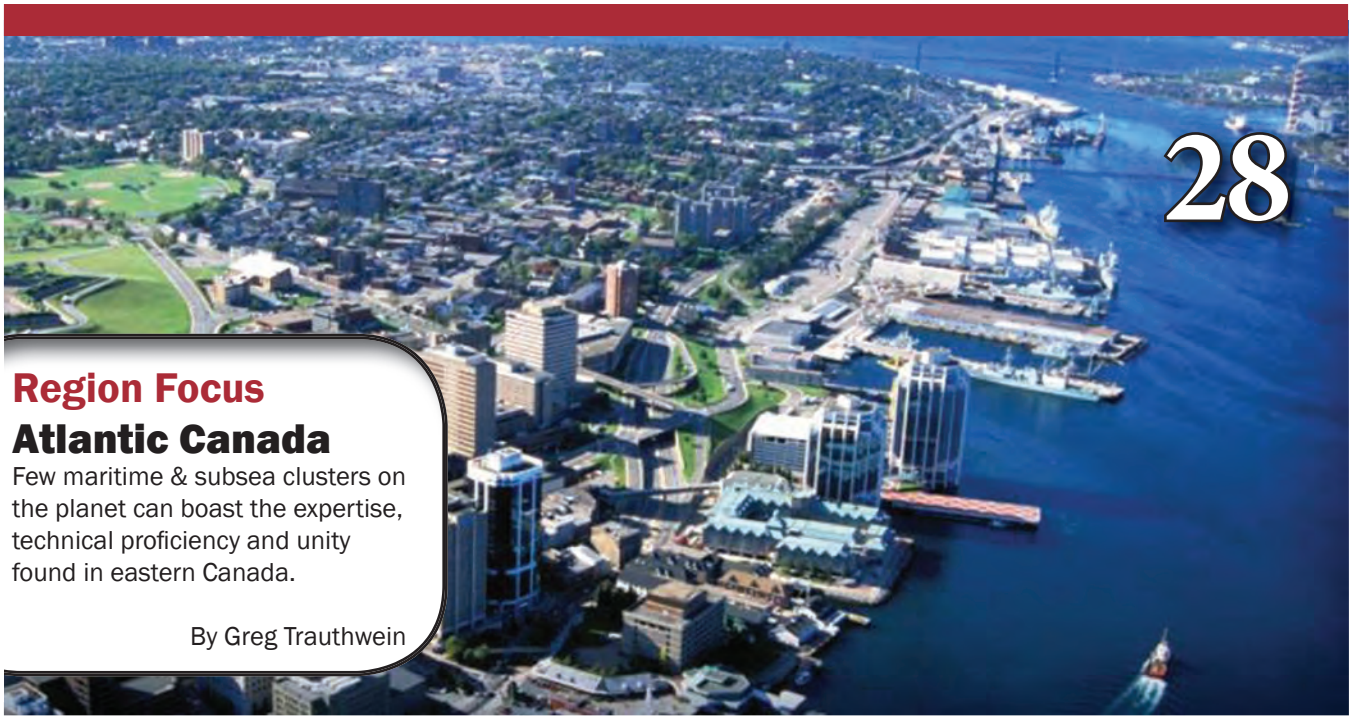
Coley

Mulligan

Coley
Kira Coley is a freelance science writer and regular contributor to *Marine Technology Reporter*. She is a lecturer in science communication and a PhD researcher.

Mulligan
Tom Mulligan was born in London in 1958 and grew up in Manchester, England. His family moved to Arklow, County Wicklow in Ireland in 1972 where he completed his secondary education before entering university at Trinity College Dublin in 1975, graduating in 1979 with a BA Hons Degree in Natural Sciences (Chemistry). He then joined the staff at the National Institute for Higher Education, Limerick (now the University of Limerick) as a Research & Teaching Assistant. Following a period as a production chemist in an electronic circuit board manufacturing company, he returned to the University of Limerick in 1986 where he obtained a Masters Degree in Industrial Chemistry in 1988. He now works as a freelance science and technology writer.



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Region Focus
Atlantic Canada

Few maritime & subsea clusters on the planet can boast the expertise, technical proficiency and unity found in eastern Canada.

By Greg Trauthwein

Best choice ever

for underwater tasks everywhere
the future is electric

WORLD LEADER IN UNDERWATER e-ROBOTIC SYSTEMS

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THE FUTURE IS ELECTRIC

... In case you missed it, highlights from marinetechnologynews.com and the Marine Technology Reporter ENews ...

Photos: Schmidt Ocean Institute

Let There Be Life

With a brand new ROV in tow, a team of leading scientists returned to the largely unexplored Mariana Back-Arc to search for life at depths greater than 13,000 feet. New observations show that the region's recently discovered hydrothermal vent sites have an ecosystem entirely its own, home to some animal species found nowhere else on Earth.

www.marinetechnologynews.com/news/scientists-unexplored-ocean-depths-543758

TechnipFMC: Post-merger

New subsea giant TechnipFMC has begun operating as a unified oil and gas services company following the completed merger of Houston-based FMC Technologies and Paris-based Technip, creating a combined workforce of 44,000.

http://www.marinetechnologynews.com/news/technipfmc-begins-operations-merger-543977

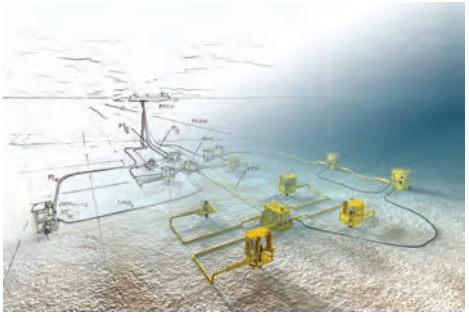


Image: TechnipFMC

(© EDF Courtesy of Ocean Energy Europe)

Let There Be Power

DTOcean, a newly launched open source software package produced through a collaborative project funded by the European Commission, aims to assist project developers to design wave and tidal energy arrays by identifying optimal layouts, components and procedures. "Access to high quality design tools is a prerequisite for reducing costs in complex engineering projects, such as such as wave and tidal arrays," said Henry Jeffrey, coordinator of the DTOcean project. "With the world's first ocean energy arrays now under construction, the launch of DTOcean is very timely."

http://www.marinetechnologynews.com/news/source-software-designing-tidal-543544

NAVIGATOR

A one man navigation and sonar reconnaissance unit

SHARK MARINE TECHNOLOGIES INC.

The Navigator, a second generation Sonar Imaging and Navigation system, designed by Shark Marine primarily for MCM and SAR use.

Proven

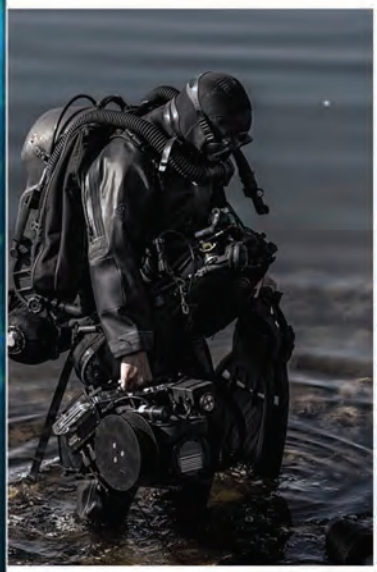
Tested and proven, the Navigator is the trusted choice of 17 Navies, as well as Law Enforcement, Search and Rescue Teams and Scientific Researchers spanning the globe. The Navigator has become a critical part of the Standard Kit and has reshaped SOPs. The modularity of the system and numerous advanced sensors available allow the Navigator be to become a force multiplier, enabling smaller groups to cover more ground efficiently with increased safety.

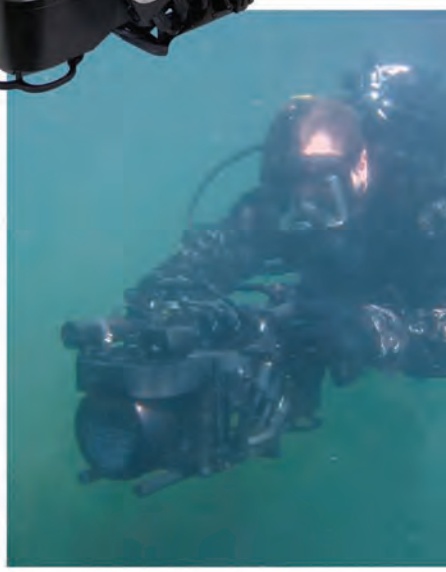
Mission Ready

The Navigator is the most modular system of its kind, enabling it to be quickly configured for any application.

Intuitive

Shark Marine's DiveLog software controls all operations of the navigator and its accessories, operators need only learn one software to master all their equipment.





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Harlan Doliner

Environmental & Maritime Attorney @ Verrill Dana LLP

At Oceanology International North America 2017 in San Diego Harlan Doliner is an organizer and panel member of the "Frontiers of Technology Transfer Panel."

What do you consider to be the key challenges to technology transfer between i.e. naval applications, to marine science and ocean research applications?

From my perspective one of the biggest challenges is the tendency to "silo" or compartmentalize new technologies into existing applications or areas of endeavor. The Naval Undersea Warfare Center has set a wonderful example of getting past this in its commercial application of enhanced sonar processing to digital mammography enhancement. Another major challenge is determining the correct business model between the parties involved in each instance, including protection and/or sharing of IP, intellectual property. A key regulatory challenge in the U.S. is compliance with export controls, including ITAR (International Traffic in Arms Regulations).

Environmental issues are a driver for all in the sector, and collaboration between commercial and scientific entities is growing, but scientific need and commercial realities do not always coexist well. Discuss strategies you have seen that allow science and business to prosper together.

Collaboration, including data sharing, between ocean researchers and industry is undergoing fundamental, structural changes as accelerating technological advancement (think smartphones and smartphone apps, e.g.) facilitate the explosive growth in data and data points via "citizen science," pushing coastal, oceanic and marine tech research further into the realm of "Big Data". Strategies are just beginning to evolve to leverage these changes to augment and leverage the always-vital, traditional models of research vessels equipped with special-

ized technologies operated and maintained by specific experts.

In the case of the offshore energy industry, where markets have been depressed for more than two years now, have you seen a proportionate reduction in scientific activities with oil and gas companies? If so, what are some suggestions to 'bridge the gap'?

While I'm not in position to expertly comment on the downturn on the oil and gas side, it is clear that there is now a sustained, worldwide momentum for research, development and commercial investment in coastal and offshore wind and hydrokinetic (tidal and wave) energy projects for both utility-scale and distributed generation.

Is there enough collaboration between government and business in terms of technology transfer for commercial use and environmental issues? How could this stream be improved?

There is never enough collaboration, as there always can be more. The fundamental key is communication, which makes gatherings like OINA '17 so important, as it crosses the usual divides between government, industry and academia, as well as between commercial and environmental communities.

How can we persuade a greater number of diverse and competing organizations that working together will result in mutual benefits?

Many of the acoustic technologies originally intended to have only military applications are now used for basic ocean data gathering and research. Consider how the free world's globally-deployed network of submarine detection devices evolved into IOOS, the International Ocean Observation System, that now warns of tsunamis, and provides information assisting responses to climate change and the impact of the opening of the Arctic upon marine mammals and other sensitive receptors.

What do you hope to achieve through your involvement in the Frontiers of Technology Transfer Panel at OI NA '17?

I hope that our panel, combined with networking and, most important, listening to attendees' views, concerns and questions will engender new connections that will grow into mutual opportunities going forward. That won't happen if we stay home.

For technology previews from OI NA 2017, turn to page 52.

New Research Vessel

Virginia Institute of Marine Science Orders Research Vessel

Virginia Institute of Marine Science of Gloucester Point, Va. awarded a contract to Meridien Maritime Reparation of Matane, Quebec to build a 93-ft. research vessel. JMS Naval Architects of Mystic, Conn. designed the research vessel to replace VIMS's current vessel, the RV Bay Eagle.

The primary mission of the Institute's fleet is to provide inshore and offshore work platforms for the support of fisheries related oceanographic research projects. The new vessel will be capable of conducting fisheries assessments of greater capacity, in deeper waters and with a larger science complement than the Bay Eagle. In addition, the new vessel will greatly expand VIMS's capability to perform general oceanographic research in the Chesapeake Bay and the mid-Atlantic near coastal waters. The state-of-the-art research vessel offers enormous capability in a small package that is also economic to build and operate.

JMS designed the vessel to operate as an uninspected research vessel with an ABS Loadline. The design offers flexibility in science outfitting allowing for high utilization and affordable operating day rates. The vessel is easily adaptable to evolving scientific research areas such as offshore oil and gas exploration surveys, wind energy development surveys, environmental impact studies, and the servicing of ocean ob-

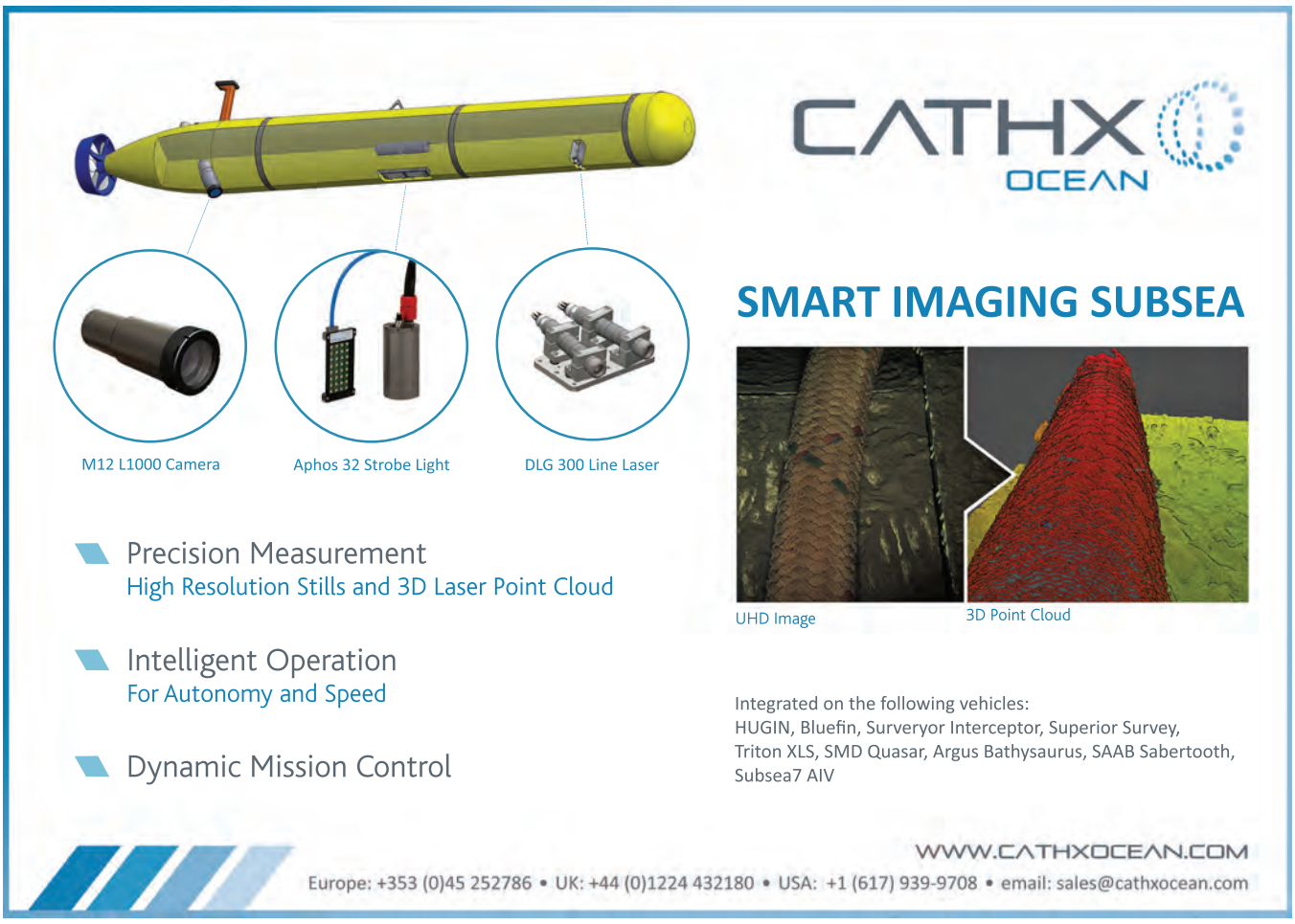
Image: JMS Naval Architects

serving systems.

Main propulsion is provided by a pair of 660 BHP tier III diesel engines coupled to a two-in/one-out marine gear driving a controllable pitch propeller shrouded within a nozzle. This unique arrangement will provide the capability to operate the vessel efficiently on a single propulsion engine when on station or during slow speed transits. This will reduce overall engine hours and thus reduce the cost of operation and improve fuel efficiency, minimizing its environmental footprint. The gearbox also powers a robust hydraulic system required to support the suite of deep water trawl winches and load handling equipment. The electrical system is comprised of a pair of 99 ekW generators which provide redundant capability or can be run in parallel during peak power demands. LED lighting will reduce both power consumption and heat emitted into the accommodation spaces.

Oceanographic outfitting includes large wet and dry labs which have been designed for maximum flexibility to accommodate the many types of science that the vessel is expected to conduct. The 1,000 sq. ft. main working deck allows for a 20 long ton science payload and provides a significant working platform for conducting fishing operations, over-the-side sampling and coring activities. There is also ample room and services to install a 20 ft. science van for specialized science missions. The new research vessel will take advantage of the latest technology through an extensive array of acoustic instrumentation for the gathering and processing of data in support of fisheries research, oceanography and geophysical sciences.

The aft deck is fitted with a stern A-frame with an 8,000 lb safe working load for over the stern lifting operations and a side mounted J-frame with an 4,000 lb safe working load for conducting CTD operations. The principal fishing arrangement consists of a pair of trawl net reels and a pair of trawl winches with 4,000 lb linear pull with 355 fathoms of 3/8-in. wire to support small mesh (200 mm net) bottom trawl surveys inshore and nearshore waters. An electric CTD (conductivity, temperature and depth) winch with 2,000 m of 0.322-in. wire will also be fitted for operation from the side mounted J-frame. There is also a knuckle boom deck crane with a 2,240 lbs capacity at a 33 foot reach to support load handling operations.



Vigor Delivers

New RV Honors Laura King

A new 60-ft. research vessel has been delivered to the California Department of Water Resources (DWR). The rugged and utilitarian catamaran, Sentinel, was designed by Incat Crowther and built at Vigor's specialized aluminum fabrication facility in Seattle.

A replacement for the DWR's 40-year-old vessel San Carlos, Sentinel will be used primarily to monitor water quality, phytoplankton, zooplankton and benthic macro-invertebrates within the San Francisco bay area and close proximity coastline, specifically the Sacramento-San Joaquin Delta and upper San Francisco Estuary.

Sentinel will serve as a floating laboratory whose mission is to protect water quality, according to the DWR. The flagship of DWR's Environmental Monitoring Program (EMP) enables staff to conduct water quality, nutrient and lower trophic monitoring, and plays a critical role in helping to meet water quality objectives and the mandated requirements of biological opinions issued by the courts to guide water quality issues in the Delta.

Sentinel has a large partially-covered aft deck with two deck cranes and two deck winches in addition to stair access to swim platforms port and starboard.

Photo: Vigor

The main deck cabin houses a large laboratory, forward of which are two twin cabins, a bathroom and galley. Forward of this is the wheelhouse with an additional fold-down berth.

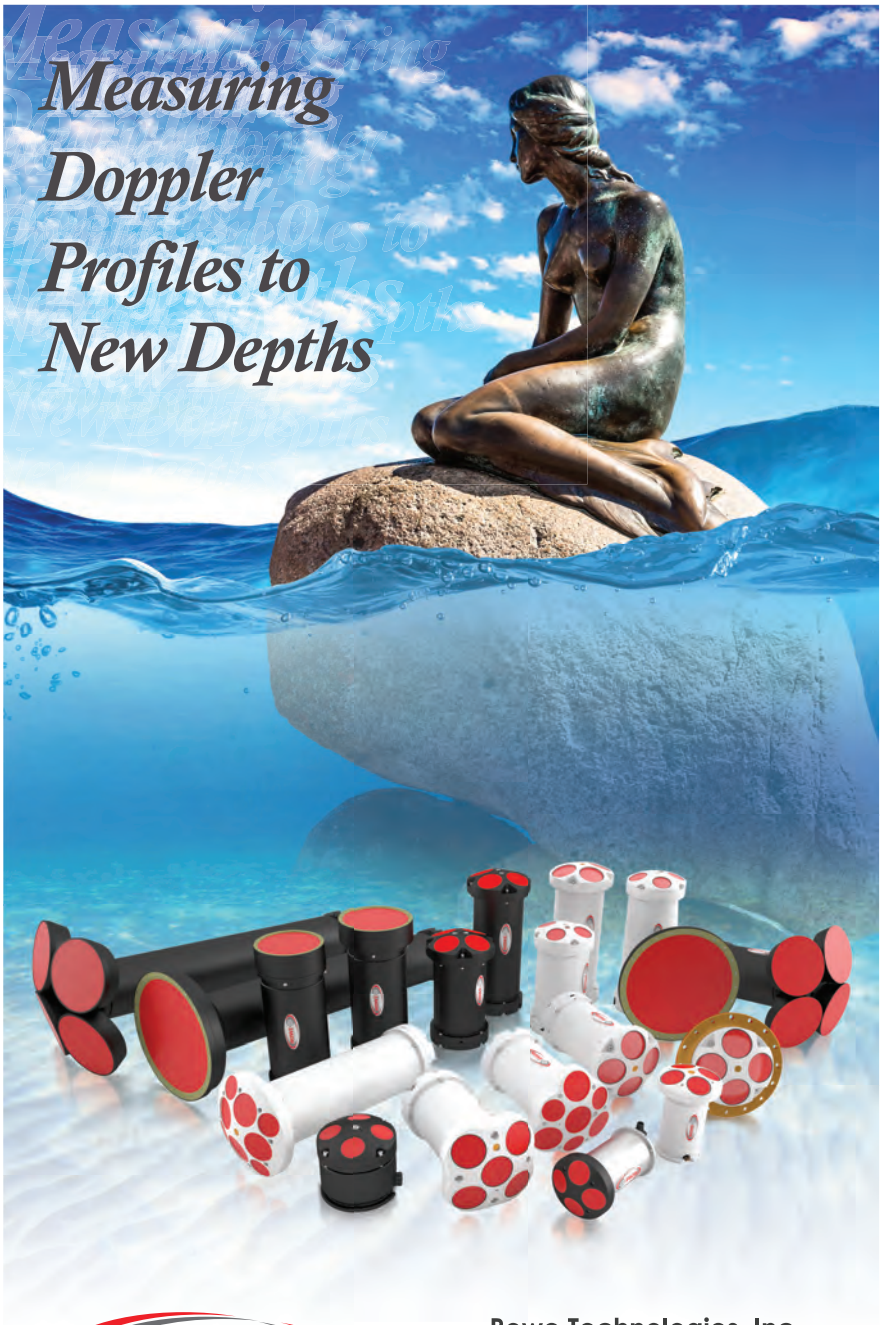
The vessel has a service speed of 18 knots with two Cummins QSB 6.7 main engines producing 260kW each.

The Sentinel was named by DWR Director Mark W. Cowin, who is retiring at month's end after a 36-year career at the Department. Cowin named the vessel to honor the late Laura King Moon, DWR's former Chief Deputy Director who passed away in 2015. "Laura King Moon worked tirelessly as a guardian of California's water supply and its environment," Cowin said. "This new research vessel is dedicated in her memory." Moon was an environmental champion who dedicated her 38-year career to resource and water policy.

The Sentinel replaces the San Carlos, which provided valuable service for the past 40 years gathering information that informed water quality analysis, biological opinions and State Water Project (SWP) decisions. Cowin said it was time for a "new guardian of the Delta waters to greet new challenges." Design and construction of the Sentinel was accomplished with funding from the SWP's 29 contractors. The construction project began in February 2015, and the vessel was launched in October 2016, with sea trials occurring since the launch.

Principal Dimensions

Length, o.a.	18.3m
Length, w.l.	17.1m
Beam, o.a.	7.3m
Draft (hull)	0.9m
Draft (prop or max)	1.1m
Depth	2.35m
Capacities	
Fuel Oil	1,700 liters
Fresh Water	470 liters
Sullage	190 liters
Passengers	20
Crew	5
Propulsion and Performance	
Speed (Service)	18 knots
Speed (Max)	21 knots
Main Engines	2 x Cummins QSB6.7
Power	2 x 350hp / 260kW @ 2,800rpm
Propulsion	2 x Propellers
Generators	2 x Northern Lights M864W3
Flag	United States of America
Class /Survey	USCG Subchapter T



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Forum ROV Supports Renewables Projects

Forum Energy Technologies, Inc. won an order to supply the University of Limerick with an ROV to support its subsea inspection and intervention work on renewable energy infrastructure. The University's Mobile and Marine Robotics Research Centre (MMRRC) purchased the Sub-Atlantic Comanche 2,000m Observation Class ROV and associated launch and recovery system for delivery in March 2017 under a MaREI Science Foundation Ireland infrastructure grant (15/RI/3232). "To aid research, development and roll out marine renewable energy, it is vital that we can operate in the high energy wave, wind and tidal regimes of target sites and understand the environment from an operational capability," said Dan Toal, Director MMRRC, University of Limerick. "Wind, waves and currents can make it an extremely difficult environment for humans to operate in, so it is necessary for us to use advanced subsea robotic systems and vehicles which are capable of operating in the harshest of underwater conditions."

The vehicle will be housed at Limerick Docks where experimentation, testing and demonstration will be carried out. It will also be mobilized on vessels at other ports in Ireland, for offshore work at wind, tidal and wave energy test sites and farms.

(Photo: Forum Energy Technologies)

The University of Limerick has purchased a Sub-Atlantic Comanche ROV from Forum for renewable energy project work.

Bluefin SandShark AUV

Small enough to fit in a backpack, Bluefin SandShark dives to 200 meters and multiple vehicles can work in parallel for large area, underwater missions.

General Dynamics Mission Systems announced its new Bluefin SandShark autonomous underwater vehicle (AUV) can now be ordered on the company's website by defense, commercial and scientific customers worldwide. Weighing less than 11 pounds before adding a mission payload, the 'micro' AUV fits in a backpack, can swim up to five knots and dive down to 200 meters (656 feet). The tail section of the Bluefin SandShark houses the battery and system electronics and is designed to leave most of the vehicle open for the user to customize with sensors and other mission critical payloads. The Bluefin SandShark joins the company's Bluefin Robotics family of autonomous underwater products.

(Credit: General Dynamics Mission Systems)

The Bluefin SandShark is a one-person-portable, low-cost autonomous underwater vehicle (AUV) designed to leverage today's miniaturized sensors and small enough to be carried in a backpack.

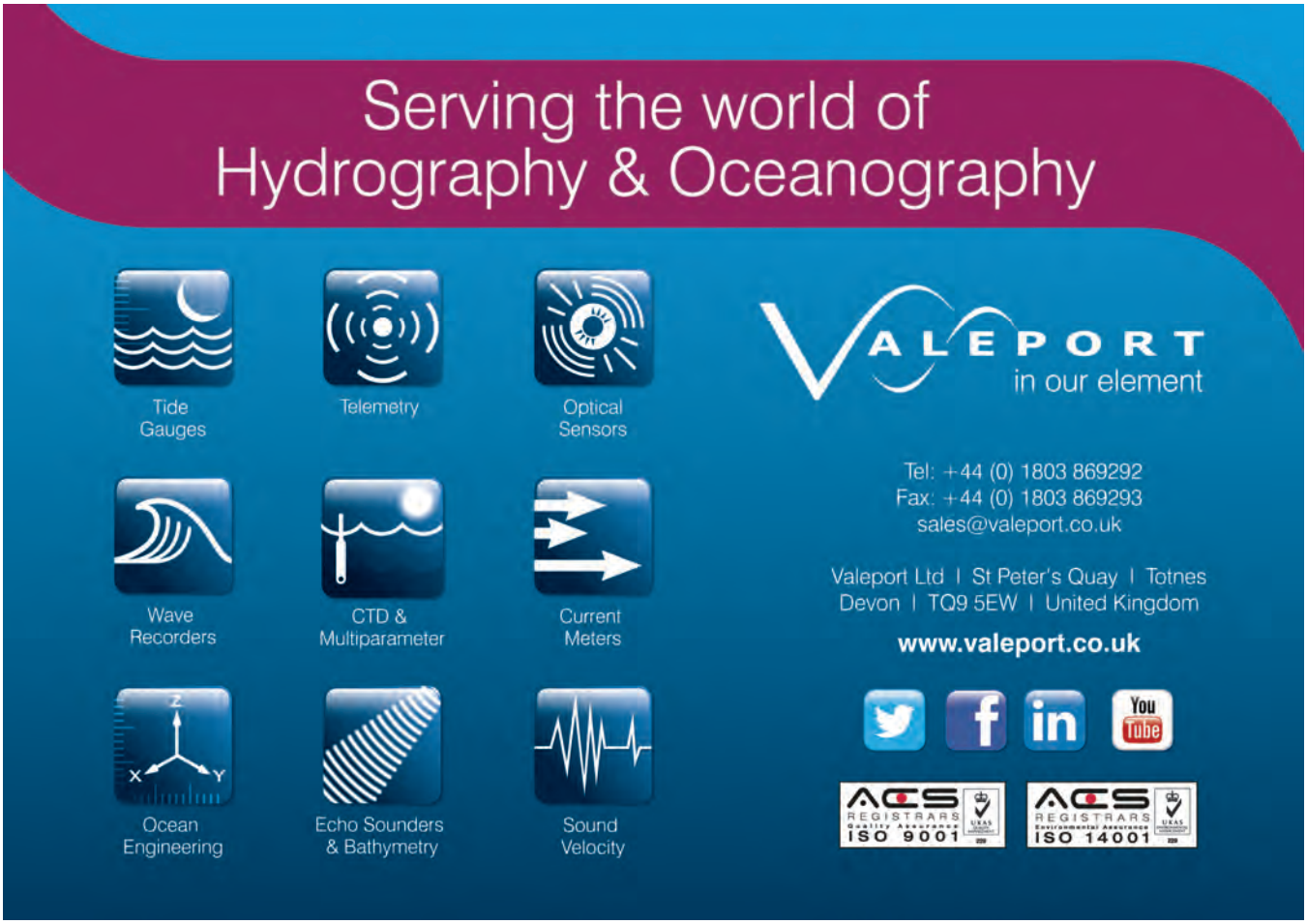
The Bluefin SandShark's operating software is compatible with most underwater vehicle autonomy suites, the software languages AUV operators use to talk to the vehicle and program its mission instructions. This operating flexibility makes integration with existing underwater vehicle components and systems faster and more cost-effective.

Changing, adding and reconfiguring the payload section can be performed quickly, without specialized tools. This capability allows Bluefin SandShark customers to efficiently and cost-effectively create and test small, low-power sensors and other capabilities needed for underwater tasks. The Bluefin SandShark payload section can be dry or free-flooded, based on the customer's needs.

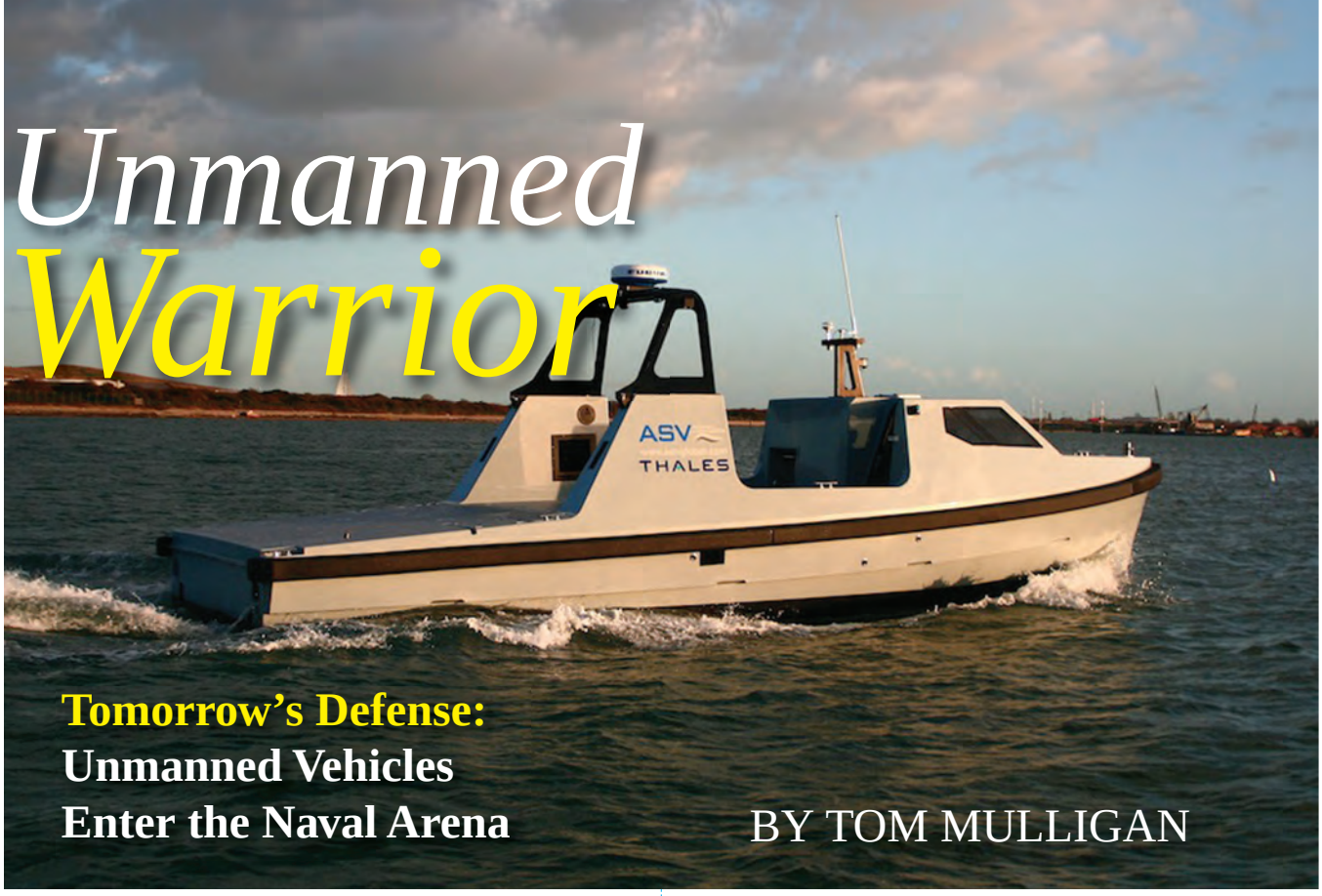
US DoD Orders 60 ROVs

Manufacturer of underwater observation class remotely operated vehicles (ROVs) Teledyne SeaBotix said it was recently awarded a multimillion dollar operational capability upgrade contract with the U.S. Department of Defense through distributor, Atlantic Diving Supply (ADS). Explosive Ordnance Disposal (EOD) Mobile Units have a long operational history with Teledyne SeaBotix ROVs and have utilized the capabilities of both the LBV and vLBV systems for several years. The upgrade program will result in delivery of 60 new Teledyne SeaBotix vLBV300 ROV systems for EOD Mobile Units around the globe. The new SeaBotix vLBV 300 systems will be fitted with a range of commercial off the shelf (COTS) equipment, including SeaBotix's unique tracked crawler attachment skid, imaging sonar, tooling options, altimeter and USBL/GPS navigation capability plus the Teledyne Marine autonomous ROV navigation package, SMARTFLIGHT.

Photo: Blake Midnight / DOD



Unmanned Warrior



(Photo: Thales Group)

Tomorrow's Defense: Unmanned Vehicles Enter the Naval Arena

BY TOM MULLIGAN

Autonomous vessels provide the key to the future safe conduct of naval operations in hostile and hazardous environments.

A little more than a year ago, 40 global research and defense companies met to discuss how unmanned systems could be used by the world's armies, air forces and navies in the defense systems of the future. This led to the British Royal Navy staging its first 'robot wars' last fall to give companies the chance to demonstrate their latest technology in a realistic workout. In the largest exercise of its kind ever staged, 'Unmanned Warrior', held off the coasts of Scotland and Wales, provided an international showcase for industry to demonstrate what autonomous systems can do for naval warfare, including the use of unmanned vessels (AUVs, ROVs, USVs) in surveys, antisubmarine warfare, ISTAR (information, surveillance, target acquisition and reconnaissance) and mine hunting.

Royal Navy Fleet Robotics Officer, Commander Peter Pipkin, stated that Unmanned Warrior, the brainchild of First Sea Lord Admiral Sir George Zambellas, was "a unique and innovative challenge to deliver the Royal Navy's vision for autonomous systems."

Sir Philip Jones, Fleet Commander and Vice-Admiral at the time, added that as an instinctive innovator and exploiter of modern technology, the Royal Navy was enthusiastic about new ideas, new concepts and new technology: "In our view the unique selling point of Unmanned Warrior is its ability to provide a playground, if you like, in which we can simultaneously demonstrate unmanned systems and do so across a range of warfare disciplines. We see a clear opportunity to shape the future of not just the Royal Navy but a raft of our partners."

Challenging Test Environment

The main planning conference for the exercise took place last October and Unmanned Warrior saw representatives from defense, industry and academia discuss how to deliver such a large unmanned systems event and decided that the demonstration of unmanned systems would be overlaid onto the twice-yearly multinational 'Joint Warrior' exercise to set a more challenging environment for the participants and allow the Royal Navy to see first-hand how some of the systems and sensors could integrate into current and future operations.

Unmanned Warrior saw more than 50 vehicles, sensors and systems operating in a number of themed activities in the U.K. Ministry of Defense exercise areas based around Scotland and Wales, the organizers deliberately trying to keep the scope of activity as broad as possible with few, if any, constraints on what participants were allowed to demonstrate.

"Unmanned Warrior was about seeking innovative ways to operate on the leading edge of technology; it wasn't about removing humans from the decision chain or replacing every bit of our current capabilities with unmanned systems. If a system was unmanned and could operate in the maritime environment then we worked hard to find a way of incorporating it into the program," said Commander Pipkin.

Admiral Sir Philip Jones, First Sea Lord and Chief of Naval Staff, added, "Unmanned Warrior clearly demonstrated the Royal Navy's ambition to lead and win through technological innovation. Unmanned maritime systems will change how we operate, but they're just the start. Our pursuit of new technologies and ideas – from big data to 3D-printing – will ensure we remain one of the most capable and successful navies in the world."

Delivering Maritime Capability

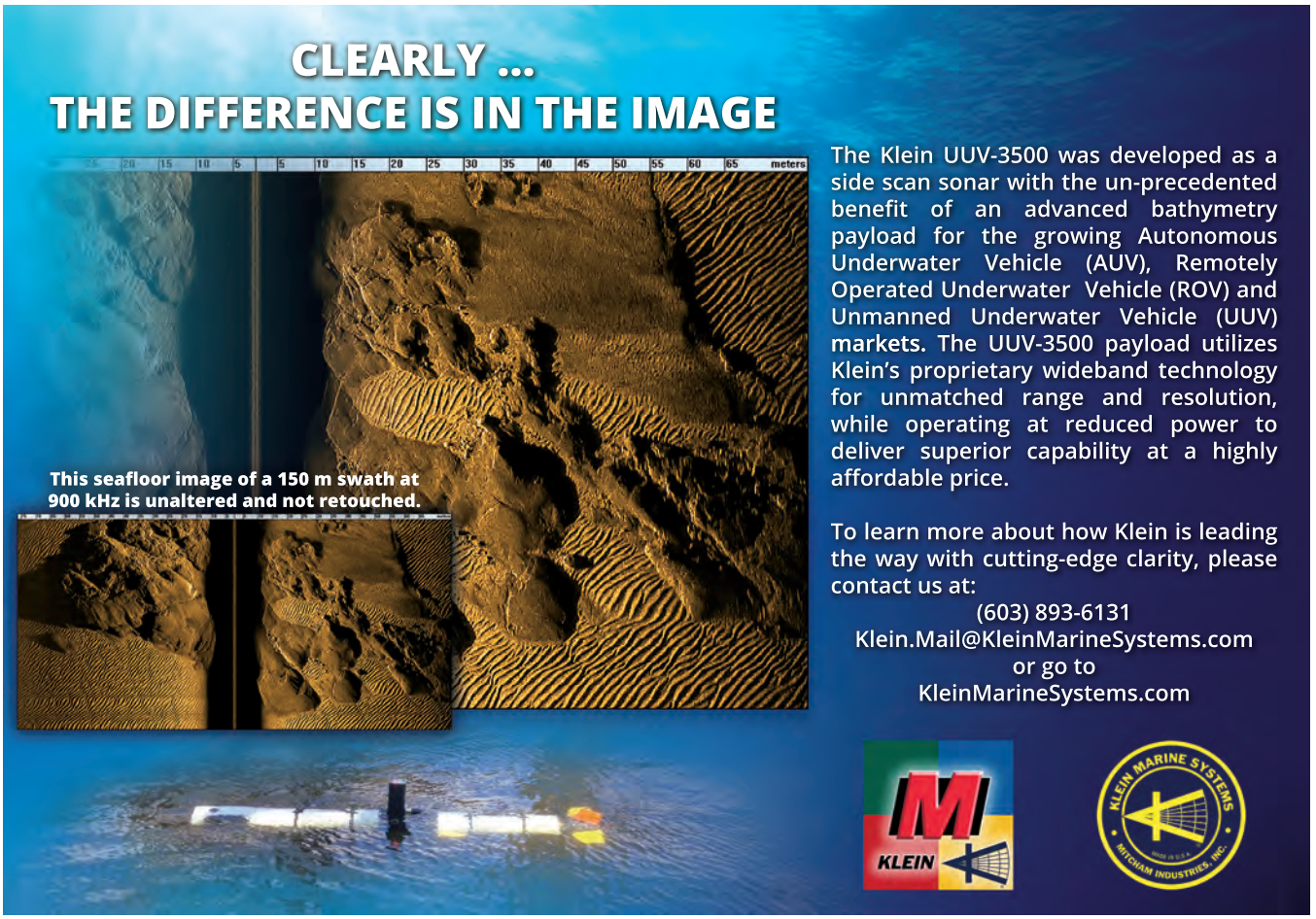
When the Unmanned Warrior program was completed in line with the U.K. government's Strategic Defense and Security Review direction on innovation and defense exports, the Royal Navy invited industry, academia and other defense partners, including the U.S. Navy and NATO's Center for Maritime Research and Experimentation, to safely experiment and demonstrate the potential offered by maritime autonomous systems within the Joint Warrior operational environment, exploring the feasibility of increasing the use of unmanned and autonomous systems in delivering maritime capability, featuring the latest unmanned system technologies for air, surface and sub-surface use.

Joint Warrior provides a complex environment in which U.K., NATO and allied units can go through training together in tactics and skills for use in a combined joint task force. The exercise runs through a range of scenarios, including crisis and conflict situations, that could be realistically encountered in operations taking place over disputed territory, or against terrorist activity, piracy and more. Unmanned Warrior was explicitly designed to fit into this framework while also demonstrating British innovation and highlighting the strengths of British industry.

Taking place in the fall of 2016, Unmanned Warrior saw 40 participants from industry, academia and defense, including the U.S. Navy and NATO's Center for Maritime Research and Experimentation, operating unmanned and autonomous vehicles, sensors and software in the air, on the surface and underwater in an exercise predominantly funded by the participants that provided a showcase for the demonstration of products in a tactically relevant environment. Commander Pipkin commented, "The overall value [of Unmanned Warrior] is in transforming the market as a whole by creating increased demand for these technologies, not seeking specific business opportunities within the event."

Technology Themes

The demonstrations in Unmanned Warrior were based around the follow-



(Photo: Thales Group)

ing five themes that were selected by participants:

- *Antisubmarine Warfare (ASW)*
- *Information, Surveillance, Target Acquisition, and Reconnaissance (ISTAR)*
- *Command and Control*
- *Hydrographic and Geointelligence*
- *Mine Countermeasures (MCM)*

"We deliberately adopted a different approach to capability demonstration in that the MOD invited participants to offer their thoughts on what future capability might look like and where technology could be exploited without any preconceptions," stated Commander Pipkin. "This recognizes that we do not always have a crystal ball but are willing to look at the full breadth of possible technology exploitation paths."

The mine hunting activities of Thales Group's Halcyon Unmanned Surface Vehicle are planned and controlled through Thales mission management software.

The 40 industry partners and international allies showcasing the latest in remote technology presented more than 50 aerial, surface and underwater maritime autonomous systems (MAS) in a range of demonstrations on the themes of surveillance, intelligence-gathering and mine countermeasures. The collaborative approach of Unmanned Warrior is at the heart of the U.K.'s new Defense Innovation Initiative and the £800 million ($985 million) fund that supports the generation of ideas to benefit both the country's defense and British business. U.K. Defense Secretary, Michael Fallon MP, commented, "The sheer scale of this exercise demonstrates how our armed forces are leading in developing futuristic technologies to keep us safe at sea or in the air. This is part of our new approach to harnessing innovation, backed by a rising defense budget, to ensure we keep ahead of our adversaries."

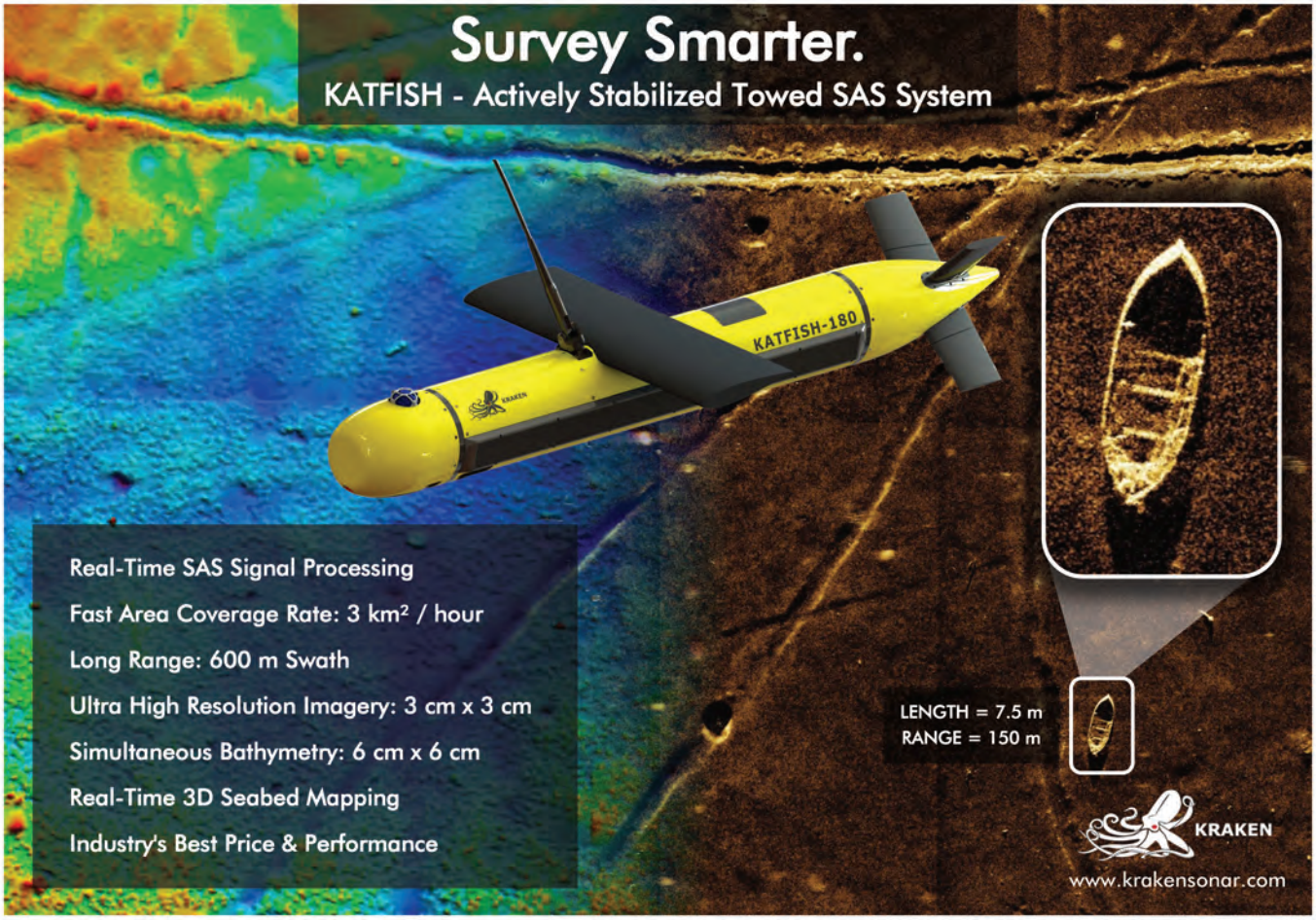
Commander Pipkin added, "The technologies demonstrated in Unmanned Warrior have the potential to fundamentally change the future of Royal Navy operations just as the advent of steam propulsion or submarines did. This is a chance to take a great leap forward in maritime systems – not to take people out of the loop, but to enhance everything they do, extending our reach and efficiency using intelligent robotics at sea."

Thales Group: Benefits of taking part in Unmanned Warrior

Thales Group played a key role in the U.K. Royal Navy's Unmanned Warrior exercise held in the fall of 2016. Thales demonstrated its capability through the Watchkeeper Unmanned Aircraft System, the Halcyon Unmanned Surface Vehicle and its collaborative work in the field of unmanned command and control research. Watchkeeper, currently in service with the British Army, flew for the first time in a littoral naval environment operating alongside a Type 23 warship and a merchant vessel and was integrated into a series of exercises varying from persistent wide-area surveillance support up to 150 km offshore to landing forces and naval gunfire support. Data collected by Watchkeeper were streamed down remotely to the vessels and analyzed by operators to make better-informed command decisions in support of the trials.

Also participating was Thales's Halcyon Unmanned Surface Vehicle (USV) equipped with a Thales Towed Synthetic Aperture Sonar. The USV took part in a number of minehunting challenges aimed at demonstrating the significant benefits of autonomous technology when operating in hostile environments, including the reduction of risk to life. Missions using Halcyon were planned and coordinated using Thales mission management software, providing comprehensive command and control of the USV operation. Thales is a key sensor provider to the Royal Navy's existing minehunting fleet through the operationally proven Sonar 2093 and Sonar 2193.

Thales is also involved, with industry partners, in the U.K.'s Defense Science Technology Laboratory (DSTL) innovative research program MAPLE (Maritime Autonomous Platform Exploitation), which is developing the future architecture for Unmanned Systems Command and Control by enabling multiple unmanned platforms, such as unmanned air vehicles (UAVs), unmanned surface vehicles (USVs) and unmanned underwater vehicles (UUVs), and their payloads, to be commanded and controlled from a single control station. The company has been instrumental in the design of this multi-domain architecture and has brought experience of operating unmanned vehicles into this design activity.



Search for Franklin

Marine & Subsea Vehicle Technology in Underwater Archaeology

BY KIRA COLEY

Propeller aperture of the HMS Erebus, from the port side, ROV Deep Trekker going in the aperture.

(Photo: Thierry Boyer, Parks Canada)

For centuries, the ever-changing sea ice of the Northwest Passage made the route through the Arctic Ocean unpredictable and, on occasions, virtually impassable. Yet, since the 1500s the promise of connecting the Atlantic and Pacific Oceans, and the economic benefits which would follow, were enough to entice many expeditions into this treacherous pass. One such explorer, Sir John Franklin, set sail in 1845 from England with his crew on board HMS Erebus and HMS Terror, vanishing almost without a trace. In September 2014, more than 170 years on, search expeditions led by Parks Canada discovered the wreck of HMS Erebus and two years later, HMS Terror was found. While advancements in technology have proven useful to underwater archaeologists in the search for Franklin's ill-fated crossing, in a remote, harsh environment, even the most advanced underwater vehicles have limits.

In Canada, much of modern history in the Arctic comes back to Franklin and his lost ships. As a result, many of the search expeditions that were launched with the intent to locate them ultimately charted much of the Arctic Archipelago, geopolitically underpinning Canada's sovereignty Arctic territory.

Parks Canada has the world's oldest dedicated underwater archaeology team in which Ryan Harris serves as one of the senior underwater archaeologists. In the Arctic, Harris is the lead archaeologist for Parks Canada's ongoing work in studying the wrecks of HMS Erebus and HMS Terror, "It's an enthralling story of human fortitude, deprivation and sacrifice. Even the initial reports of men desperately resorting to cannibalism add a chilling element to it. The Franklin Expedition was well equipped with state-of-the-art equipment for that time and departed with much optimism with the objective of finally charting a Northwest Passage which had been an elusive goal since Elizabethan times. Finally, it would be realized. But, with all of these men to have disappeared nearly without a trace, it has held captive the public's imagination since the Victorian age."

In comparison to traditional archaeology conducted on land, underwater archaeology is inherently reliant on technology to a much greater extent. The difficulties that are represented by searching for and locating sites within a marine environment, working on and under the water offers an array of challenges to the archaeologists involved. This includes the caprice of weather, often limited underwater visibility, cold water and its chilling effect on dexterity and ability to concentrate, as well as having a limited supply of air to conduct underwater tasks.

Harris explains, "When investigating a location, simple things that you

might take for granted on land, like determining what is level, and where is north, and generally orienting yourself to determine how a site lies within the world coordinate system, are significantly more challenging underwater. Those challenges only increase with sites that are in deeper water and in remote contexts such as the sites we find in the Arctic. So, we've always had a very open mind in terms of exploring emergent technologies to determine what has application in underwater archaeology. That said, we are also quite cautious concerning evaluating the technologies quantitatively and taking the time to validate which technologies hold genuine promise."

In 2012, Parks Canada engaged the University of Victoria Ocean Technology Lab (OTL). OTL contributed a Bluefin 12 autonomous underwater vehicle (AUV), a 12-inch diameter unit equipped with Klein UUV 3500 side-scan sonar transducers. An AUV has the advantage of diving beneath the surface of the waves where it can render very stable sonar imagery in sea states that would otherwise stymie traditional towed side-scan instrumentation. In 2014, Defense Research Development Canada (DRDC), the R&D branch of the Canadian Armed Forces, joined the project. DRDC provided a 7.5 meter Arctic Explorer AUV equipped with a Kraken second generation interferometric synthetic aperture sonar system (INSAS) developed for mine countermeasures.

"This incredible Arctic Explorer AUV, although rather large and ungainly to mobilize where you need it, had the benefit of being able to survey for up to 72 hours underwater at a time without surfacing with complete autonomy. It has a state-of-the-art sonar system which can image targets on the seafloor the size of your thumb at ranges of 315 meters to either side. So, we were hoping that this formidable technology would blaze large swaths of this uncharted stretch of the Victoria Strait where we hoped one of the wrecks lay hidden."

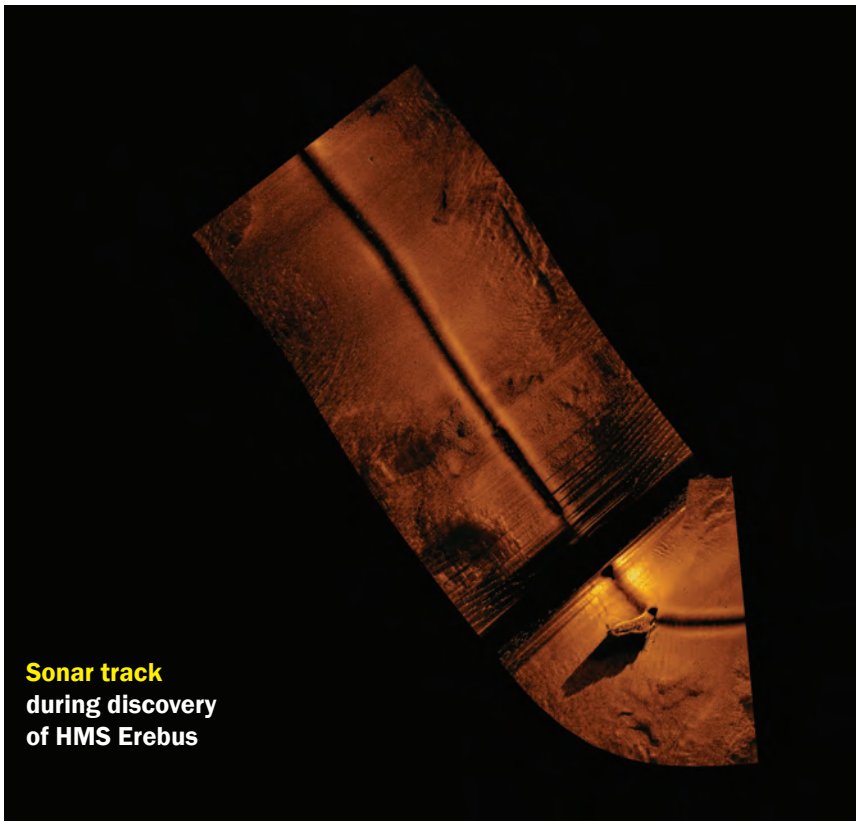
Harris and his team applied AUV technology to the search for Franklin's

Deployement of Iver 3 - 312 AUV by Marc-André Bernier and Ryan Harris

Thierry Boyer (selfie) and Deep Trekker ROV above the HMS Erebus wreck.

(© Parks Canada)

(Photo: Thierry Boyer, Parks Canada)



Sonar track during discovery of HMS Erebus

(Photo: Underwater Archaeology Team, Parks Canada)

The screen shows the sonar image of a wreck lying on the Arctic seabed in this Nunavut bay. These images, combined with archaeological dives, will contribute to the identification of the wreck.

(© Parks Canada)

Ryan Harris operating the multibeam echo sounder on RV Investigator, Chriss Ludin at the helm.

(Photo: Thierry Boyer, Parks Canada)

ships. While the team had somewhat mixed results, this reflects not on the technology itself but on the challenging environment in the North. As such, the discovery of the shipwrecks came about through the marriage of marine survey technologies and painstaking research into Inuit accounts since the 19th century as to what they saw befall the Franklin Expedition all those years ago.

"While the capabilities of the technology were successfully trialed, the environmental conditions severely restricted its deployment ultimately. The ice cover in the Victoria Strait that year was almost complete, so there were just tiny little pockets where we could safely deploy the vehicle. You can prepare all the technology you want but you're still in many ways at the mercy of the elements, and that's certainly our experience up north since 2008," said Harris.

Inuit's traditional knowledge directed the team to the Queen Maud Gulf, a body of water farther south of King William Island in Nunavut, where HMS Erebus was eventually discovered. While the Erebus discovery validated Inuit accounts in terms of there being a wreck somewhere in Wilmot and Crampton Bay, this still prescribed an enormous area, in excess of 800 square kilometers, to be systematically scanned over five years. Supported by much historical research, marine technology, and guided by a dedicated and disciplined systematic approach, and a lot of patience, the team successfully discovered HMS Erebus in 2014.

"When the Erebus finally appeared on the side-scan sonar screen it was a moment of absolute jubilation… but also relief that we hadn't wasted our time for five years scanning the seafloor in vain. In the back of your head is the anxiety that maybe on a day when the weather was marginal, and sea state all riled up, that maybe we missed something on the edge of the sonar swath and have been searching pointlessly ever since. So, when the wreck finally appeared, unmistakable and clearly a wreck, it was a moment of pure elation and relief," recalls Harris.

"The discovery of Terror was quite different as it happened rather unexpectedly. It was found in an entirely different body of water than we were presently searching and was detected by another vessel, not by a high tech towed side-scan sonar or multibeam system but rather by a bottom sounder."

Due to the complexity of the sites, the Parks Canada underwater archaeology team expects many years will be spent studying both shipwrecks. Both sites have maintained considerable structural integrity and three-dimensionality. While this presents many archaeological opportunities, in terms of preserving diagnostic artifacts within, not without a share of technical challenges behind delving into the bowels of the ships so the team can learn what happened.

Parks Canada contacted Deep Trekker to provide a purpose-built remotely operated vehicle (ROV) for its mission to investigate the inside of HMS Erebus. Parks Canada had planned a dive mission during the summer but needed a way to also view deep inside the vessel which would have been too dangerous for divers at that time, until mobile elements of the upper deck are eventually shored-up and stabilized. Deep Trekker's ROV was selected for its maneuverability into small areas and ease of deployability from small open boats.

"We had to be very surgical in our examinations of these ships and that's where we started to look at different technology approaches to document the ships, both externally and internally. This last September we used Deep Trekker ROV to penetrate deep down into the main hold of the Erebus to visualize a compartment that we hadn't seen yet, taking advantage of this extremely agile vehicle to inventory visible artifacts and head into unseen parts of the site. The vehicle was also used to image inside Franklin's cabin, navigating under the collapsed upper deck overhead."

In addition to the 270-degree camera view and 180-degree pitching system, a full HD camera system will be added to Deep Trekker's ROV for future surveys. When combined with the purpose-built inertial motion unit and finely-tuned thrusters this allowed underwater archaeologists to remotely access and document previously hidden recesses of HMS Erebus.

"Externally we are using a cluster of 3D imaging technologies that really stand to revolutionize underwater archaeology, digital stereo photogrammetry being one of the most obvious. So, photogrammetric documentation and underwater laser scanning techniques were and will be used, where we worked closely with a company called 2G Robotics. They developed, to our specifications, an underwater tripod-mounted laser scanner that can image large underwater sites and structures, even if they are quite complex, to a very high resolution and precision."

Parks Canada's underwater archaeology department has historically been eager to embrace technologies that they

believe can help document these complex structures in a very remote and challenging work environment to get the most out of short windows of survey opportunities. As part of this quest, they have recently procured a very high-resolution R2Sonic 2024 multi-beam echo sounder system (MBES) with a 200-400 kHz and 700 kHz ultra-high resolution imaging capacity. Also, as part of this MBES, are an Applanix POS MV 320 inertial navigation system and AML Micro and Minos sound velocity sensors.

In addition to the MBES, the team have also procured an Iver3 AUV equipped with ring laser gyroscopic INS, for operating at high latitudes which render traditional fluxgate compasses useless, Klein UUV 3500 SSS, and Marine Magnetics Explorer Overhauser magnetometer. They hope to use this unit to systematically survey the extended debris fields of both wrecks.

"Our overall approach is indeed evolving, we are in the midst of exciting planning returning to the sites next year. We're continually looking out for newly developed technologies that might help us study archaeological sites, learn about the past with the ROV, AUV, MBES along with all the documentation tools we have. But, what is for sure is that no one tool will work in all environments and in all circumstances. The more tools you have in your tool kit regarding different tech and experience in deploying them, the better off you certainly are."

"To my mind, there will always be an important role for hands-on underwater archaeology. Certainly, I'm able to get much more information from a site when I can get up close and have a tactile experience. Then again, often you can glean hidden details within video footage gained from ROVs that escaped you on the site, so it gives you the capacity to review the footage to ferret out all the information. While AUVs and ROVs are amazing tools, there are some things that machines do well and certainly do better than human beings, but definitely not everything. It's the appropriate marriage of human and technology that will get the job done."

In the field of underwater archaeology, forensic tools are also becoming increasingly important. Harris hopes that DNA analysis will figure prominently in their ability to tease out information about the Franklin expedition, to try to identify from DNA evidence who the final survivors were on board.

Marine technology which can work alongside underwater archaeologists through high-resolution imaging of complex sites, improved capacity to be used in challenging conditions and aid in the forensic analysis will be highly valued in future expeditions. In the end, advancements in the field of underwater archaeology aided by marine technology comes down to cost and accessibility of these tools, and the mercy of the elements.

Acknowledgements

- Ryan Harris, Senior Underwater Archaeologist, Parks Canada
- Deep Trekker

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Atlantic Canada

Where the World's Subsea Technology Grows

Atlantic Canada is a 'Silicon Valley' of sorts for the global ocean community, a comparatively small but highly intelligent and energized cluster of academia, government and industry laser focused on growing its connection to everything ocean. *MTR* spoke with **Jim Hanlon, Chief Executive Officer, Institute for Ocean Research Enterprise**, for his take on the current speed and future direction of this innovative cluster.

By Greg Trauthwein

Institute for Ocean Research Enterprise

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Halifax Waterfront

For our readers not familiar, can you give a brief overview of Institute for Ocean Research Enterprise and its role in ocean related activities on Canada's East Coast?

IORE is a federally incorporated not-for-profit corporation. We have one and only one purpose, and that is connecting research and industry for the purpose of economic development growth in the ocean sector. So it is not research for research's sake, but research as a competitive tool. So we are really an economic development agenda, and we use research as the tool of choice.

Please give to us in numbers the cumulative economic and social impact of this industry on the Atlantic Canada Region.

I can give you some rough numbers. There have been some recent studies, most recently by OECD regarding the size of the global ocean economy. In rough terms, it turns out that about 5% of the global GDP surrounds the global ocean economy. In the U.S. it's almost 5%; in China it's about 8%. Canada, as it turns out, is only about 2%. A lot of this is due simply to geography, as many of our bigger cities are toward the middle of the continent and not on the coast, so partly it is a population distribution issue. To accentuate the problem, this country has the longest coast line in the world. So we have a relatively small population of about 36 million, the world's longest coast line, and most of our population is not on the ocean. If you then zoom into Atlantic Canada, it is a significantly different picture. In Atlantic Canada about 15 to 20% – varying by definition and specific jurisdiction – of the economy is ocean based. Here it is hugely important, totally an ocean economy in this part of the country. It is really the most important sector of the economy in Atlantic Canada.

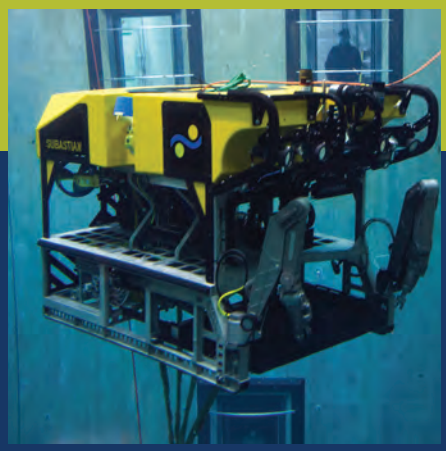
When you look at the universities, the corporations and the individuals in your region, what do you count as their greatest strengths?

I think the fact that we are small and relatively closely connected means that there is good opportunity for collaboration. The biggest city in the region is Halifax, and the total population is 500,000. Going back to the greater ocean economy I like to say there are five components:

- security and defense,
- energy from the ocean,
- food from the ocean,
- marine transportation and
- marine tourism.

Atlantic Canada has good representation in all five of those sectors of the global ocean economy, so we are not a 'one trick pony.' It's really an opportunity and a good moment in time

These vehicles have two things in common:



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Institute for Ocean Research Enterprise

to scale to the world in all of those sectors. So while we are small and well connected, yet Atlantic Canada is represented well in all of those key ocean clusters. You can go to any of the world's leading exhibitions and conferences and you will see an overweight by numbers in the presence of Atlantic Canada companies, and that is not accidental. There are a large number of those companies in our region and they are all focused on international commerce and export orientated.

So what do you see as their greatest weakness?

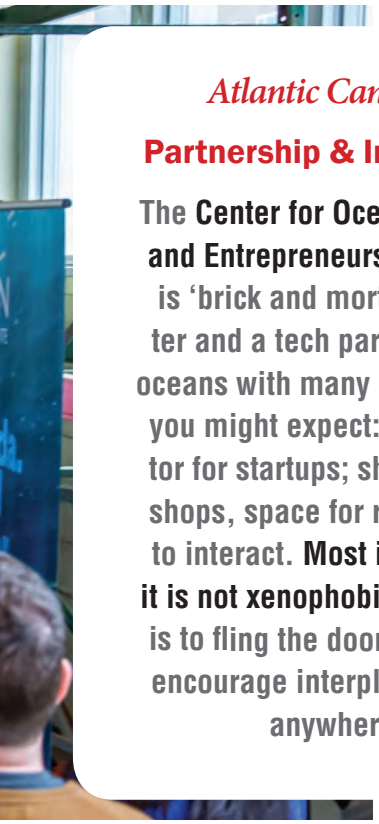
There can be rivalry amongst the different provinces and cities, and frankly (to effectively grow the cumulative business to global scale) we need to work more effectively together. Also, there needs to be a focus on the markets that are scalable. Your ideal first customer (for an ocean tech company) is a researcher; your worst 10th customer is a researcher. That means you haven't scaled to a more mainstream market and could be doomed for bankruptcy. Frankly, everywhere in the world where you find ocean tech companies, they tend to be overly dependent on those research markets and not addressing those big five pillars of the ocean economy. The challenge is taking that wonderful disruptive technology – those sensors and automation – and moving it to the navies, the oil and gas companies, the food companies.

How does Atlantic Canada cumulatively stack up versus other subsea clusters around the world?

I know most about the New England cluster because I lived and worked there. I would say compared to that cluster, Atlantic Canada is smaller (in terms of GDP, employment, number of companies, etc.) but not that much smaller. The problem in comparing our cluster to the European and Asian clusters is that they are structurally different than the North American models. They are much more government-led than the American and Canadian groups, so it is really a big challenge to compare the different clusters around the world under differing political systems. The U.S. and Canadians have a lot of similarities, and looking at the U.S. you have the clusters in San Diego and New England, as well as the Pacific Northwest, Florida and the Gulf. I would say that Atlantic Canada is probably a junior of the bigger clusters in terms of size, but certainly in the same league.

Big picture, what do you count as the two or three defining trends that are driving research and business in this sector today?

Sensors: I see a historical evolution in sensors, as I've been in the ocean sensor business for almost 38 years. The early



Atlantic Canada is

Partnership & Investment

The Center for Ocean Ventures and Entrepreneurship (COVE) is 'brick and mortar,' a center and a tech partner for the oceans with many of the things you might expect: an incubator for startups; shared workshops, space for researchers to interact. Most importantly it is not xenophobic. The point is to fling the doors open and encourage interplay for folks anywhere.

days were the physical measures of the ocean – current meters then wave buoys – then we drifted into chemistry, CTD measurements and ph … so it went from physical oceanography to chemical oceanography. The vanguard today that I'm most interested in, but as an electrical engineer I know the least about, is the bio sensors of the ocean. The stuff coming out of Monterray Bay and Woods Hole around the ESP – the Environmental Sensor Platform – these are all new first generation instruments that are purporting to measure the genome of the ocean, the bioactivity of the ocean. To my mind that is the sweet spot, that is the next vector in sensors, but understand that this is a global comment. It's really interesting because you're bringing a different mix of talent together in close proximity.

Automation: For many reasons, from productivity to health and safety, to 'it's a big ocean and small numbers of people,' everything is moving toward auto-

(Photo: National Research Council of Canada)

-mation and robotics. You look at things like the Liquid Robotics model, and the vessel of opportunity where you're doing automatic measurements on commercial vessels … all of that involve automation and data collection without a trained human involved. I think it is pretty clear that's where it is all going. For Atlantic Canada it is a latent opportunity. If you go to most parts of the world where there is a lot of marine robotics work going on … and I would argue that Massachusetts is probably the top of the hill … you find sensors from Atlantic Canada all over those robots.

Big Data: Perhaps the most ill-defined in terms of assessing the total market opportunity, but I think without a doubt the biggest opportunity of all. We have sensors coming out of everywhere, more and more sensors that are bringing in massive volumes of data, and there are not enough ocean scientists in the world to look at all of that data. So here we run the risk of creating a NASA phenomena, where the data just continues to pile up in a warehouse and nobody really gets a chance to use it because it's piling up faster than you can look at it. So that automation of the data – the collection, the filtering, the analysis, the data correlation, the hypothesis generation – is an area of deep learning. I think that can be threatening to an oceanographer of my generation, thinking, "How can a machine replace me?'"But a machine won't replace you, it will just multiply your effectiveness.

In your 'bio' it states that "Jim's personal passion is innovation and its impact on the competitiveness of Canadian industry," and your career has given you a view of technology in differing industrial sectors. When you look at attitudes toward innovation in this sector, how is it most the different, how is it most the same compared to other industrial sectors?

That is a pretty profound question. There is an overweight of science and technology in this sector so it's rich in potential, particularly the smaller companies who overspend on R&D, priding themselves on re-investing 20% of their revenue on internal research and product development. This is admirable on one hand, but on the other hand a challenge for their bankers. But we are a sector dominated by scientists and engineers as opposed to bankers and marketers. Marketers in particular, as determining how you get to scalable market is a real challenge to all of us.

NRC's ice tank in St. John's, Newfoundland and Labrador, is one of the largest facilities of its type in the world. With temperatures ranging down to -25 °C, this tow-tank facility simulates realistic northern marine conditions growing ice to a maximum thickness of 200 mm.

Institute for Ocean Research Enterprise

What drew you to the oceans/maritime sector?

I am the son of a Navy officer and literally grew up around it, the old 'salt in the blood' thing, It's visceral, it's personal. On the other hand, it is a really cool set of people in this sector. You've got interesting characters and intellects who are generally collaborative and driven by curiosity and interest and intellect instead of, frankly, crass commercialism. So on one hand while I'm saying the companies in this sector need to be more commercially orientated, on the other hand, many of these people are in it because they love the environment, the love the technology … it is an interesting and international business.

Please discuss efforts on behalf of IORE to engage global partnerships, whether it be through the inclusion of technologies and companies outside of your borders or the export of your technologies around the world.

We are focusing that effort on COVE, the Center for Ocean Ventures and Entrepreneurship, IORE is now creating COVE which is 'brick and mortar,' it's a center, it's a tech partner for the oceans with many of the things you might expect: an incubator for startups; shared workshops, space for researchers to interact. Most importantly it is not xenophobic. The point is to not make this a local club for Halifax or Nova Scotia or even Canada, but literally to fling the doors open and encourage interplay for folks anywhere. So we literally have carved out a physical chunk with open desk areas, so if someone from Baltimore, for example, wants to come up here and explore the market in Atlantic Canada because there are lots of markets evolving, come up here and spend two weeks. The only thing we ask: if you have brick and mortar in your facility, we would like a reciprocal arrangement. So the 'visiting membership' aspect has been baked in from the start.

This has been formalized with a (December 2016 signed) MOU with the University of Massachusetts Dartmouth. UMass Dartmouth has the CIE, Center for Innovation and Entrepreneurship, which is a tech center and incubator owned and run by UMass Dartmouth. It was not designed to be explicitly ocean technology, but guess what … it's mostly ocean technology because it is southeast Massachusetts, and that's what they do there. What we are trying to do now is put meat on the bones of the MOU, which will include:

- **Exchange of Students:** Not necessarily to take a course, but maybe to work a company internship.
- **Exchange of Market Opportunities:** If an RFP come out up here, we will flag it to our friends at CIE and they will do the same for us. We can't stipulate which opportunities are open to American nor can they tell us what is available to Canadians, but we at least will cross-inform each other.
- We're (eventually) going to try to do **Cross-Border Funded R&D Grants**.
- **Shared Facilities.** At first we need awareness, meaning an inventory of equipment in each facility. This is an attempt to get better utilization out of the gear. All of these facilities tend to have really interesting one-of-a-kind facilities. In the case of UMass Dartmouth, they have a Scanning Electron Microscope and in our case we have some unique tanks; they are really wonderful capital assets but they tend to get under-utilized.

When you look at the Ocean Business today, where – by region or market sector – do you see opportunity, and why?

I think it's food. (Considering that both the defense and oil and gas markets are already more mature in this sense, and perhaps not the best candidates for disruptive technologies). There are also huge opportunities in marine renewable energy; this is high velocity growth but it's starting from nothing, so it's not that big yet. But if you look at food from the ocean. I think disruptive opportunities around the use of science and technology in food extraction presents a big opportunity. The challenge is that more of the world's population is going to be reliant on protein from the sea; the carbon footprint is lower than it would be for livestock; on the other hand the level of CO2 emitted per pound of fish caught is not so good, because we are essentially hunter gatherers when it comes to fish for the most part. I think here there are huge opportunities for technology insertion, science insertion and productivity gains in this sector. Another I'm looking at with curiosity and wonder is marine tourism. Market and data analytics in that sector is ripe for growth, but I'm really not sure where that one is going yet.

What do you count as your biggest challenge to extending the scope and influence of this sector – growing the business if you will – and what specifically is IORE's strategy to meet this challenge?

Alignment and coherence are the two words that come to mind. In Atlantic Canada the political engine has woken up and said, "This is a big deal; we can work with this." There's a lot of attention on the sector now, which is great, but it simply needs to be aligned and coalesced.

Jim-Hanlon, CEO

Institute for Ocean Research Enterprise

Hanlon is a 30-year veteran of the Canadian tech industry, having worked in design, marketing and management for companies in Atlantic Canada, Ontario and New England. His career has spanned the aerospace and defence sectors as well as the marine environmental monitoring field. Over the years, Jim has worked in senior management positions with several large publicly traded multinationals. He has also sampled the waters of the entrepreneurial well as an owner in two separate high tech companies that have successfully grown and been purchased by multinationals.

Until February of 2012, Hanlon was the President of Ultra Electronics Maritime Systems in Halifax, NS. He and his partners sold their company to Ultra Electronics Inc. in May of 2008. Ultra Electronics Maritime Systems is one of the oldest continuously operating electronics design and manufacturing operations in Canada and the largest electronics product design company in Atlantic Canada.

Hanlon's personal passion is innovation and its impact on the competitiveness of Canadian industry. Jim is a proud alumnus of the Nova Scotia Technical College (now Dalhousie University Faculty of Engineering) with a degree in electrical engineering. He also has an MBA in marketing from Saint Mary's University in Halifax and is a registered professional engineer in Nova Scotia.

CNA's Wave Energy Center

(Photo: Wave Energy Center)

Established by College of the North Atlantic in 2011, the Wave Energy Research Center (WERC) was originally part of a research project to develop land-based aquaculture using water supplied by an ocean wave-powered pump. Recognizing potential research opportunities within this specialized sector, the center has since expanded to include the development of wave measurement instruments and the testing of anticorrosive and antifouling marine coatings – all set in the harsh North Atlantic waters off Newfoundland's southeast coast.

The facility, which is housed in a former fish plant in the community of Lord's Cove, has grown to include a variety of automated data acquisition systems including a weather station, Doppler and capacitive wave measurements, an inspection class ROV, and both land- and sea-based multichannel systems capable of recording outputs from a wide array of instruments.

These abilities, coupled with six fully permitted mooring sites, access to on site wharf and workshops, and high speed data connections, make the WERC a unique facility in Eastern North America for studies involving engineering, oceanography and biology in coastal high energy wave environments.

In addition to on-site facilities, researchers at the center have access to the metal fabrication, welding, instrumentation, electronics and nondestructive testing shops at the nearby College of the North Atlantic - Burin campus, as well as a myriad of other facilities and expertise at CNA's 16 other campuses throughout Newfoundland and Labrador. "While existing projects at the center continue to move forward, we are about to enter a collaboration with Rutter, to test various RADAR-based solutions for near shore monitoring, including the measurement of surface waves and currents, using these measurements to verify and compare numerical model predictions of ocean wave propagation," said Dr. Michael Graham, WERC's Project Administrator. "Rutter specializes in innovative radar solutions designed for harsh conditions and challenging environments, so having them partner on this initiative speaks highly of the facility, our surrounding environment and what we are able to offer to researchers in this sector."

Dr. Graham says another company has expressed interested in testing buoy-based inertial measurements of wave parameters, further noting that as the number and kind of wave instruments being utilized in the test area increase, the opportunity for "instrument fusion" arises. This type of cooperative environment will allow for direct comparison of instrument types and identification of which are most suitable for particular measurement conditions and data requirements.

Waves in and around Lord's Cove can be as large as 13m in just 25m depth. Although this is rare, waves in the 8m range in winter and 2m range in summer are not uncommon. Statistically, waves are larger than 1.5m 80% of the time.

"As the Wave Energy Research Center continues to develop, we are actively pursuing both public and private partners who are looking to collaborate," said Dr. Graham. "These initiatives – research and development, the testing of engineering solutions, processes and environmental effects of human activity in a harsh coastal environment – can all be done through the sharing of equipment, data, facilities and expertise. It's virtually a one-stop shop for testing sea-based technologies in a naturally extreme environment."

To further support the center's work and its clients' studies, the development of a collaborative group to design, build and test a low-cost, portable, surface-based power supply and telemetry system for submerged instruments has been put in place. Although similar systems currently exist, they have relatively low data throughput and none as of yet also provide reliable power in the needed range(s), resulting in frequent, costly and wasteful subsurface instrument battery replacements.

Seaformatics Systems

Seaformatics Systems is a new startup ocean technology company with its sights set on changing the way oceans are monitored subsea – especially in remote and difficult to access, harsh environments – through its subsea power harvesting and telemetry systems. A barrier to collecting long term data in these environments is a sustainable supply of power to the instruments and data communications infrastructure. With the challenges imposed by such environmental conditions one of the only suitable power sources are batteries. Specialized vessels must be used to deploy and recover data from the systems that have exhausted their batteries – a very costly, time consuming, and risky endeavor that can only be completed when ice and weather conditions allow access to the area.

Seaformatics' solution is to provide products that harvest power from ocean currents and communicate data wirelessly back to shore through an underwater acoustic network. Its patented turbine systems generate power from low-speed ocean currents to allow sensors to be deployed over a longer period without the need for large and expensive battery banks or frequent field excursions to conduct maintenance. Its networking technology allows these systems to be placed at low cost and are easily relocated. The team has completed an 18-month test and evaluation of four full-scale Power Harvesting Bottom Mount (PHBM) systems. The test and evaluation program was cosponsored by Husky Energy to learn more about the systems' long-term durability and performance for possible application in future offshore operations. The testing commenced in June of 2014 and was completed in January of 2016. All of the units were deployed in Placentia Bay, off the Newfoundland coast, in approximately 20m of water. During the testing period, the PHBMs realized an average current speed of 0.08 m/s and supplied continuous power to Sontek Argonaut XR ADCPs. Two of the units were exposed to higher short term peak currents of 0.4 m/s and harvested over 1kWhr, effectively doubling the life of the ADCP's batteries over the evaluation period. Today Seaformatics offers two products, the PHBM and MPG. The PHBM is a bottom deployed unit that can house multiple sensors and can include optional release and recovery mechanism. The MPG, a scaled down version of the PHBM technology, is configured to be integrated with any moored system or buoys to power sensors and systems at any level in the water column.

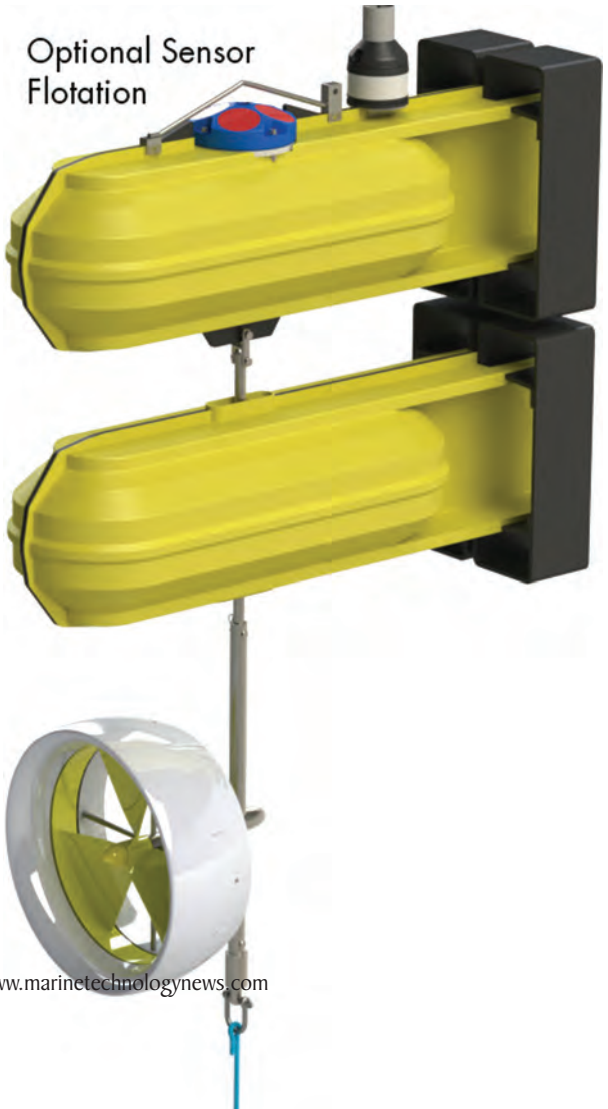


Image: Seaformatics Systems

Advanced Ice Analysis & Ice Defense

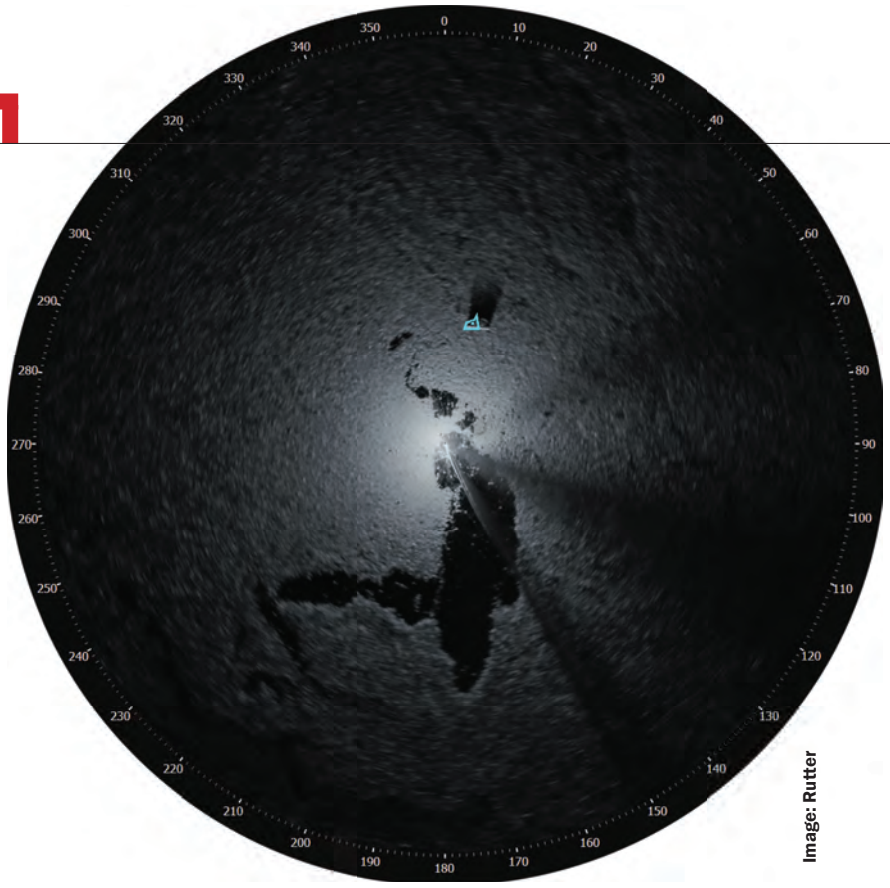


Image: Rutter

A screenshot taken from the sigma S6 Ice Navigator in use, showing an iceberg being targeted in thick pack ice.

The world of onboard navigation systems is always changing, and as such, existence of convenient user-interfaces and powerful navigation capabilities are in constant evolution. Contributing to this evolution is Rutter Inc., which in the first quarter of 2017 is releasing an update to its flagship radar system, the sigma S6 Ice Navigator, adding Advanced Ice Analysis to the system. In addition, Rutter will release the new sigma S6 Ice Defense system, an ice radar system aimed at users for whom ice management is a serious operational and safety concern when working in areas with sea ice and icebergs.

Rutter's sigma S6 product line, which also includes systems focused on oil spill detection, small target surveillance and wave and current measurement, connect to commercial marine radars, adding value to those existing navigation assets. "With the release of our latest generation of marine radar data processing software, sigma S6 9.1.0, we are able to assist vessels to improve their operations and fulfill industry demands with even greater efficiency," said Fraser Edison, President and CEO, Rutter.

Stephen Hale, Director of Sales & Marketing at Rutter, added, "Whether used in combination with one of our other products or a single system, the information provided by our new sigma S6 Ice Navigator system will help provide a safe and efficient environment for vessels operating in ice. The ability to display critical information on open-water leads, ice ridges, ice movement and bergs embedded in pack ice is not available with any other radar system. This is a cost effective system to reduce fuel consumption and enhance the safety of personnel and assets."

Advanced Ice Analysis, introduced in January 2017 as an addition to the sigma S6 Ice Navigator, makes possible the mitigation of several risks posed by ice obstacles. Ice pressure ridges, for example, are a significant navigational hazard that can damage the hull of large vessels. With Advanced Ice Analysis, users can more easily avoid these obstructions by automatically detecting and outlining ice ridges in ice fields, detecting and tracking icebergs embedded in pack ice, and detecting and outlining open water leads. Due to their irregular geometry, icebergs have a low radar profile and are therefore difficult for conventional radars to detect. Adding the ability to detect and track these hazards automatically provides information critical in route planning for navigation and during ice management activities.

Open-water lead detection finds ice-free areas within an ice field, highlighting areas suitable for easier transit and the safe deployment of equipment.

Ice ridge detection automatically detects and outlines ice ridges in ice fields revealing their location so they can be more easily avoided and managed. Ice pressure ridges pose a significant hazard that can cause hull damage during navigation, exert higher loads on offshore structures, and their keel can potentially impact subsea infrastructure in shallower operations.

The sigma S6 Ice Defense system includes all the features of the sigma S6 Ice Navigator, but also offers automatic outlining and drift-tracking of ice pans and floes, as well as drift prediction of ice in open water. For offshore operators with rigs and FPSOs in areas of sea ice, detailed information on ice floes and ice movement is essential.

SubC Imaging

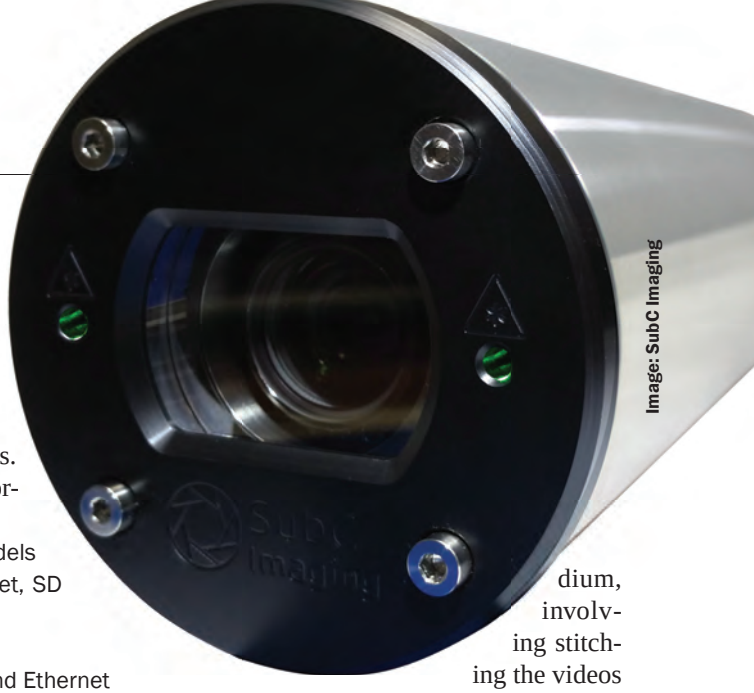


Image: SubC Imaging

SubC Imaging, located in Newfoundland and Labrador, Canada, creates some of the most advanced underwater imaging systems in the world, including state-of-the-art cameras, lights, lasers and DVR Overlay solutions for media management. Since its founding in 2010 SubC has developed an international clientele in the offshore energy, ocean sciences and aerospace and defense sectors with clients in over 20 countries.

SubC focuses on enabling its clients to more easily acquire high quality visual data using their platform of choice and helping them better manage and use that information for improved decision making. SubC also currently has two products under late stage development and soon to be available for field testing.

The first, the Rayfin Autonomous Machine Vision System, is designed for use on all platforms with special attention paid to the unique requirements of autonomous underwater vehicles (AUVs) which are becoming more widely used for underwater inspections, monitoring and surveys. Built with this platform in mind, the Rayfin has the ability to synchronize AUV data with camera data and is fully programmable to trigger based on commands or events such as altitude, depth, time, etc. Additional features under development include image mosaic and object recognition.

The automated stitching of bottom mosaics will be done using a combination of feature mapping and navigation data (dead reckoning) with the internal IMU of the camera and other data (gyro, depth, altimeter) fed in from the system over serial or Ethernet. All data will be logged with their respective images and along with the World File created for each image used to assist in the image stitching process.

The Rayfin will feature the following High Level Specifications.

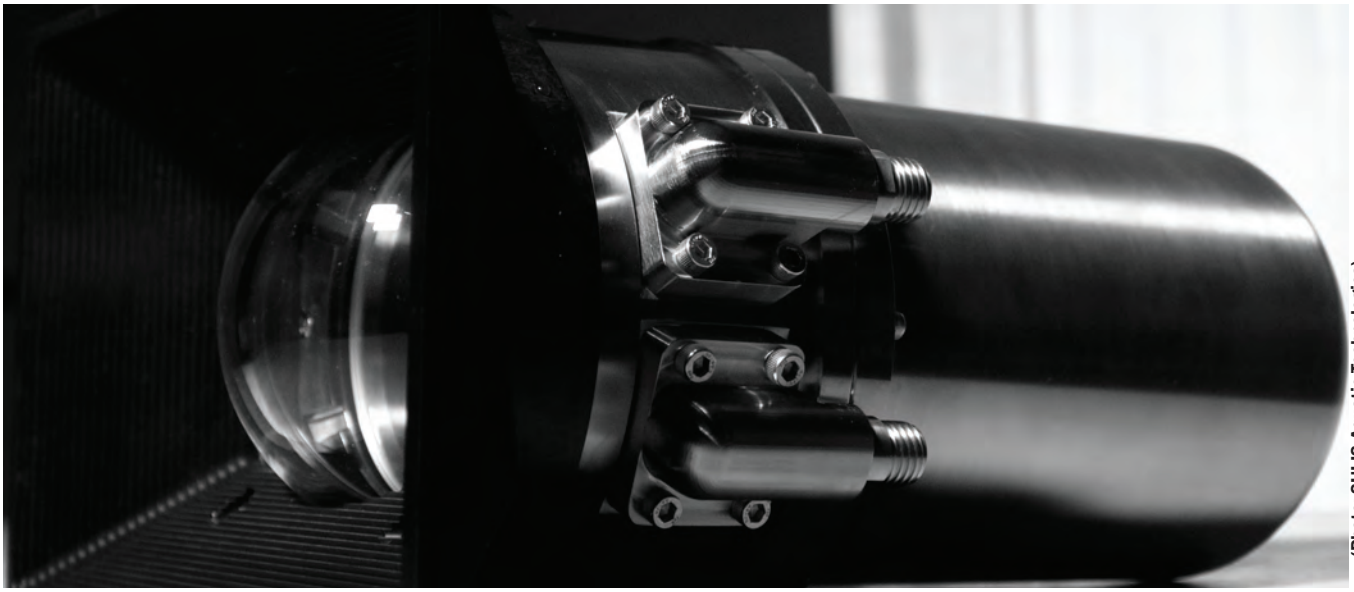
LiquidOptics water-corrected imaging:

- Video Transmission models
  * HDE: HD over Ethernet, SD over Composite
  * HDC: HD over Coax and Ethernet
  * HDF: HD over Fiber and Ethernet
- Internal 4K UHD recording and 12.3 megapixel digital stills
- Hybrid LED strobe/lamp and external laser sync direct from camera
- Dive interval programming (automated stills, recording, hibernate)
- Control via Ethernet, RS232 and RS485
- Live video and image file transfer over Ethernet
- Built in sensors: accelerometer, gyro, compass and (optional) depth
- Video, stills and data storage in SubC Dive Log format
- 1TB or optional (2TB or 4TB) of solid state storage for video, stills and data.

The second, the VisionSphere System, provides a remotely operated vehicle (ROV) pilot full visual coverage of a vehicle's environment by strategically mounting cameras with ultra-wide (UltraOptics) overlapping fields of view (FOV) around the vehicle. The enhanced situational awareness helps mitigate the risk of collision with subsea assets and the potentially costly repairs that can result. The system can also improve efficiency with more of the subsea environment being captured in a shorter period of time and also allows for better multi-tasking since the pilot can focus on flying the ROV while the co-pilot focuses on the inspection. In its current configuration all camera feeds would be recorded and viewed simultaneously on separate separate monitors. SubC has patents pending around the viewing medium, involving stitching the videos together, to create a 360 spherical view around the ROV. Multiple clients can simultaneously digitally pan, tilt and zoom within the spherical view.

Above: The Rayfin Autonomous Machine Vision System.

Changing the Way We See the Oceans



(Photo: SULIS Aquatic Technologies)

From its inception, SULIS has focussed on improving subsea vision. "Both optical quality and field of view are significantly compromised when you put a terrestrial camera lens behind a flat port (window), underwater," said Adam Gobi (BEng, MSc), founder and CEO of SULIS Aquatic Technologies. "A dome-shaped port helps with field of view, but it is a crude optical element that adds additional optical distortions and aberrations that must be properly considered in the optical design process."

It is these sorts of optical limitations that have been the standard for years.

Before founding SULIS, Gobi developed the world's first 3D-HD and 5K full-ocean-depth cameras for James Cameron's Deepsea Challenger submersible. "Jim had very exacting standards for what he wanted. It just wasn't available on the market, so we had to start from scratch," Gobi said.

This is what SULIS was built on; taking explorers, scientists and filmmakers of the world beyond the depths, and helping them gain a deeper understanding of our world's oceans through the highest resolution possible.

SULIS has spent the past few years perfecting its first commercialized 4K deep-sea zoom camera, the SULIS Z70, built around optics specifically designed for aquatic environments.

With 12X optical zoom, full manual controls, an ultra-wide angle field of view and pristine corner to corner 4K resolution, the Z70 is what the world's leading scientists and filmmakers have been dreaming of; in fact, they even helped build it. Through a collaboration with the Schmidt Ocean Institute, SULIS has had direct feedback every step the way from SOI's top engineers and scientists.

Chosen as SOI's main science cam for its own engineering marvel, SuBastian, a new purpose-built state of the art science ROV, the Z70 will soon be producing the most publicly available deepsea footage, with live feeds streaming from some of the most poorly explored parts of the sea. It's already begun, with rare high-quality footage captured by SuBastian this past December, 2016, showing newly discovered deep-sea black smokers in incredible detail in the Mariana Back-Arc. International Business Times UK reported that "scientists are poring over the videos of the hydrothermal vents to see how many new species they can spot."

Filmmakers and producers have also taken a fancy to the Z70's capabilities. To provide the same level of control they are used to with their terrestrial cameras, SULIS has built a control panel with a precision three-axis joystick for zooming and pan/tilt control, dials for finely-tuned adjustment of focus, iris, and other settings, as well as a 7-inch touchscreen for camera status monitoring and full control of all settings.

SULIS Z70 Specs

- Deep-ocean camera with live 4K video transmission and 12X optical zoom
- Unparalleled optics designed specifically for aquatic environments down to 6,000m
- Fully-corrected 100-degree ultra wide-angle field of view (diagonal)
- Large 1-inch sensor for increased light sensitivity
- 20-megapixel stills capture
- Full manual controls, including a broadcast-quality control panel.

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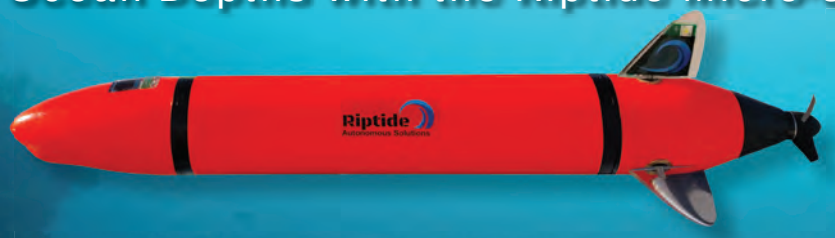
EXPLORE

the Ocean Depths with the Riptide Micro-UUV



The Riptide Micro-UUV is a second generation Autonomous Undersea Vehicle that defines a new standard for the undersea market. No longer do UUVs need to be complex and expensive. Riptide has developed a highly affordable, highly efficient, flexible platform that allows you to configure as you need.

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Agile Sensor Technologies

(Photo: Agile Sensor Technologies)gies)

AgilPose implemented on a UAV for a precision hover/land system. The company plans to launch the system for underwater precision docking in UUVs.

Agile Sensor Technologies, a manufacturer of intelligent robotic components based in St. John's, Newfoundland, has launched its new performance monitoring multi-motor controller Synapse.

Developed for industrial and military UAVs, Synapse advances beyond traditional electronic speed controllers (ESCs) to offer flight data recording, real-time propulsion system feedback, faster controller response time, and the ability to increase flight time by approximately 10%.

Typically, UAVs and other electric vehicles require one ESC per motor, adding bulk to the vehicle without any additional functionality. A traditional ESC serves only one primary function: to control an electric motor's speed. Agile compresses the functionality of multiple ESCs into one compact hub, while also adding features not possible with a traditional setup.

Synapse incorporates a black box flight recorder for on-board data logging. Essential data is automatically recorded and easily accessible to support maintenance. This data can be used to easily track all aspects of your flight history, and makes this information both transparent and accessible as further regulations are being placed on the operation of UAVs.

A recent study by RMIT University investigated 150 drone incidents and identified technical failure as the cause of 64% of incidents. Synapse allows you to take intelligent action to protect your UAV when issues arise with the propulsion system. Real-time diagnostics such as voltage, current and temperature offer the ability to set onboard performance thresholds and employ safe operating limits. Immediately, the system can relay alerts back to the autopilot, and if desired, can be programmed to take preventive actions without a pilot.

According to Gartner Research, battery life is one of the largest inhibitors to drone adoption in industrial applications. Synapse keeps UAVs in the air longer. Our ultra-efficient solution incorporates motor commutation algorithms and active braking that reduce power consumption by up to 10% per motor. What does this all mean? UAVs can stay in the air longer, carry more payload and fly further.

Synapse has been designed as an advanced motor control solution for high-performance industrial and military aircraft. It is equipped with a UAV flight recorder, real-time system monitoring and feedback, rapid response times, and ultra-efficient flight performance. All of this is packed into a single-board hub, giving users maximum performance with minimum footprint. The team is also researching the use of Synapse in unmanned marine vehicles for its future versions.

In addition, the Agile team is working on AgilPose, an autonomous precision targeting and docking system for unmanned underwater vehicles (UUVs). AgilPose allows a vehicle to calculate its position and orientation in high precision across three axes, which can then guide the vehicle to a specific docking location.

The company has already worked with Boeing to implement AgilPose into a UAV landing/hover system. As AgilPose runs on the same FPGA architecture as Synapse, the team hopes to combine the two systems on an underwater platform by the end of 2017.

Kraken Continues to Innovate & Expand

St. John's, Newfoundland based Kraken Sonar is a leader in delivering advanced Synthetic Aperture Sonar systems. Kraken's goal is to bring innovative and disruptive technologies to the maritime sector, while reducing costs and increasing capability. Kraken believes that by using the latest technologies available, and not being tied to legacy architectures, it can advance marine technology at a pace equivalent to consumer electronics sectors, while keeping it affordable.

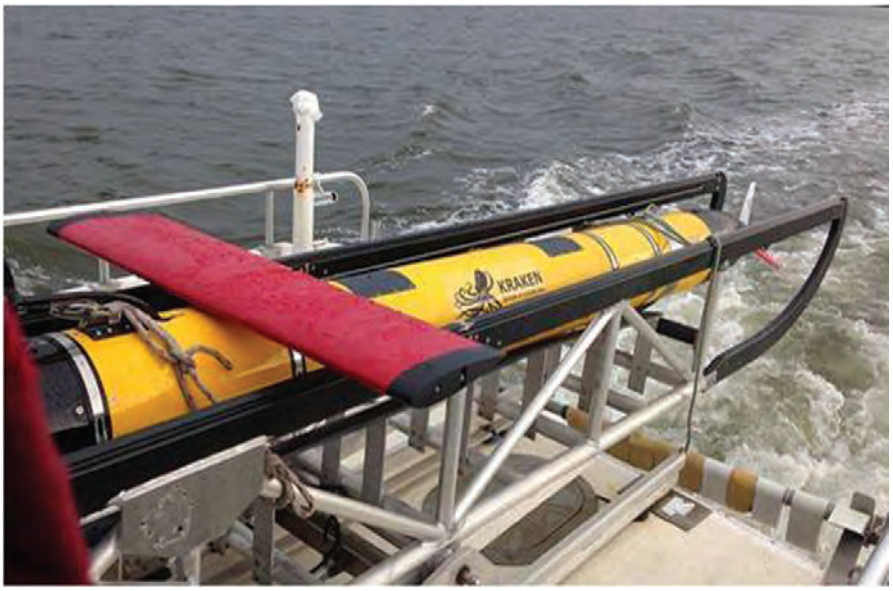
Kraken's flagship sonar the MINSAS (Miniature Interferometric Synthetic Aperture Sonar) is a high resolution (3x3 cm) SAS with simultaneous bathymetry and up to 600m swath widths. Features unique to Kraken's sonar systems are the modular arrays, which allow the system to range from 60 cm to 240 cm array length, along with an integral real time SAS processor.

RTSAS processes the full swath sonar and bathymetry data in real time, onboard the AUV or Towfish as it is running its mission.

Real time processing reduces post mission analysis, and provides for data exfiltration capabilities to export processed data tiles mid-mission.

With its modularity, small footprint and low power draw, MINSAS is suitable to a wide range of platforms from man portable to large diameter, with specific features allowing for operating environments from the VSW to deep water. Systems are available in 1,000-, 3,000- and 6,000-meter ratings. Real time processing and removable data pods allow for rapid deck turns and overall reduction in survey time and analysis.

Kraken has also developed the KATFISH, an intelligent towed SAS System. Using a 180 cm MINSAS array and a smart, actively stabilized towfish body, the KATFISH is a survey system unlike any other.



(Photo: Kraken)

Active Stabilization and Kraken's proprietary SAS algorithms provides pure, crisp 3 cm x 3 cm constant resolution SAS Imagery and 6 cm x 6 cm Bathymetry, while tow speeds up to 8 knots and 600 meter swaths provide for an area coverage rate of 3 sq. km. / hr.

While Kraken is best known for its sonar systems, the company is actively investing in additional technologies. Current technologies under development include real-time laser scanners, pressure tolerant battery systems, efficient electric thrusters, artificial intelligence, subsea resident docking systems and deep water vehicles.

Deck Machinery Showcase: RV Falkor

Schmidt Ocean Institute's (SOI) 272-ft.-long scientific research ship RV Falkor is a technology showcase. Pictured is the state-of-the-art remotely operated vehicle (ROV) SuBastian.

Over-the-Side Deployments:

- Deployments over the stern with a 88kN SWL A-Frame using the embedded single drum MacArtney MASH CTD Oceanographic Winch (Type 10000/8,2-31-RA) or add-on mission-specific winches. MacArtney MASH CTD Oceanographic Winch has a 31kN max pull at the top layer and 53kN max pull at the bottom layer.
- Deployments over the port side with a 31kN SWL J-Frame. Two articulating knuckle boom cranes provide at least two metric ton weight lifting coverage across all the Aft Deck (model HIAB Sea Crane 301-4 and 121-2).
- Deployments of equipment and recovery of samples and instruments with elevator/lander platforms
- Schmidt Ocean Institute owns and operates one elevator / lander platform depth rated to 11,000m

CTD/Hydro Winch Operations

- 10,000m of 0.322-in. EM coax wire or 9,000 meters 3/8-in. 3×19 mechanical trawl wire.
- Flag block that allows routing the cable to either J-Frame or A-Frame.

Deployments of Light Packages, Profilers and ROV (SAAB Sea Eye Falcon)

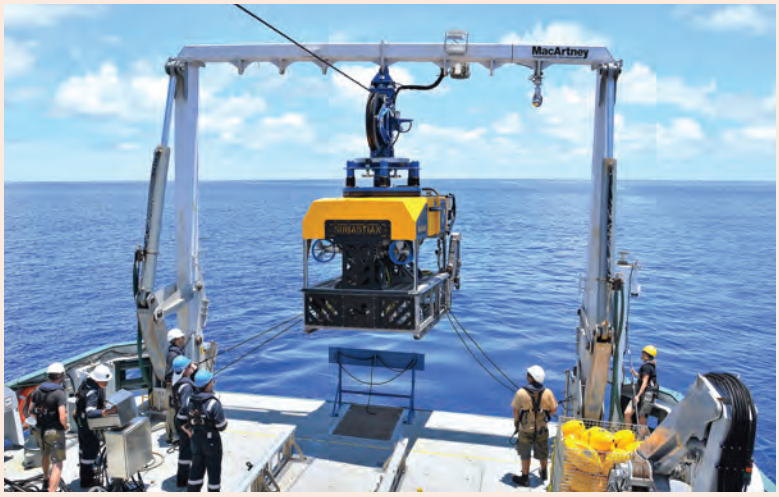
- Starboard Launching Bay on the Main Deck
- 17.7 sq. m. open deck space
- Adjacent articulating knuckle boom crane (model HIAB 301-4) on the Winch Deck over the Starboard Launching Bay
- CTD is launched with a dedicated LARS

Workboat Operations

- 6.3 meter aluminum hull 350 HP inboard motor jet-drive SAFE Boats workboat supported by a dedicated heave compensating launch davit.
- 4.6 meter inflatable 60 HP outboard motor Zodiac workboat

Photo: SOI

MacArtney supplied its MERMAC D docking head.



(Photo: MacArtney)

Photo: SOI

New Vessel for Water Monitoring

California Department of Water Resources has taken delivery of a new 60-ft. catamaran research vessel Sentinel, which will primary monitor water quality, phytoplankton, zooplankton and benthic macro-invertebrates within the San Francisco bay area. The Vigor-built vessel has on its aft deck two Morgan deck cranes and two Kinematics KAW-12X16 w/IMO Slew Drive deck winches capable of remote control operation, as well as a Morgan launch and retrieval crane on its upper deck.

Photo: Vigor

New Mort Collector for Offshore Fish Farms

On behalf of De Maas SMC, Seatools completed a feasibility and conceptual design study on a Remotely Operated Mort Collector (ROMoC). The study resulted in a highly automated mort collection system capable of effectively collecting dead fish in large-scale offshore fish farms as currently developed by De Maas SMC. This system facilitates efficient and reliable fish-farming operations in hostile and remote offshore environments. A key requirement – a 100 percent coverage of the fish pen surface within a 24-hour time span – was of critical importance during the design process. The design is backed by a self-positioning control algorithm to ensure the entire pen is covered within the given time limit.

Seatools

Photo: Seatools

Eight LARS Systems to the Kuwait Coast Guard

Ending 2016, TBV Marine Systems, part of High-Tech Solutions & Design B.V., has finished the commissioning for eight FRC/RHIB Launch and Recovery systems (LARS) that have been delivered for four new vessels ordered by the Kuwait Coast Guard. For this project, the LARS was designed to carry a craft with a length of nearly nine meters, with a maximum weight of six tons. For each vessel, the stern ramp was designed to carry two systems, which were both powered by one hydraulic power unit.

TBV Marine Systems

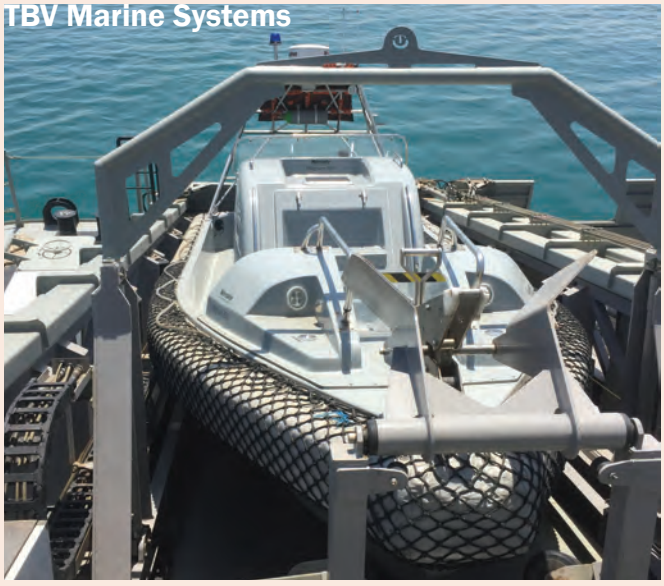


Photo: TBV

MTNW Rebrands as Rugged Controls

Rugged Controls, LLC announced its launch, evolving from Measurement Technology NW Line Control Instruments (LCI) group, who since 2001 has provided line control, tension monitoring, and winch monitoring equipment. Rugged Controls said it will continue to manufacture MTNW's previous product portfolio including running line tensiometers, smart deck machinery and LCI flagship displays, which are used in extreme, marine and outdoor environments where rugged, high visibility electronics are required for operation. "Over the past five years, our business has diversified beyond 'Line Control Instrumentation,' as we now provide solutions for a variety of applications such as pressure, torque, rig instrumentation and more with a common theme: rugged electronics and sensors, mission critical reliability, data acquisition, control and reporting features," said Tom Rezanka, president, Rugged Controls.

www.rugged-controls.com

Photo: OSIL

Giant Piston Corer for China

Ocean Scientific International Ltd. (OSIL) said it has produced a 30m Giant Piston Corer for the First Institute of Oceanography (FIO), State Oceanic Administration (SOA), China. The OSIL Giant Piston Corer and handling package was supplied to the FIO by JESSN Marine Equipment Co., Ltd (Ningbo, China). The Giant Piston Corer from OSIL is designed to achieve up to 60m core samples in soft cohesive sediments and muds. The system is a modular construction with a unique integral piston, which reduces internal friction and prevents plugging. The corer can be manufactured from carbon steel or stainless steel.

www.osil.co.uk

VRC System Ordered for SSCV Sleipnir

Heerema Marine Contractors selected Emerson Automation Solutions to provide a valve remote control (VRC) system for the world's largest semi-submersible offshore crane vessel, SSCV Sleipnir, currently under construction at Sembcorp Marine's shipyard in Singapore.

The 220-m-long vessel is designed for the installation and removal of large offshore structures, such as oil and gas platforms, subsea production facilities, foundations, moorings, and deep water floating structures. Each of the ship's two revolving cranes is capable of lifting up to 10,000 metric tons. The critical task of stabilizing Sleipnir during lifting operations will be carried out by the ship's ballast control system, which transfers water between onboard tanks to counter-balance the weight of shifting loads.

Not only must the ballast control system operate reliably in demanding marine conditions, but it must do so on an extraordinary scale. To address these unique challenges, Emerson's experts worked closely with the stakeholders to design a custom, fully-redundant Damcos VRC solution for the ship's fluid management and ballast systems that includes a total of 847 valves, actuators, local power units (LPUs), and eight interface cabinets connected by a P-NET communication bus.

(Image: Heerema Marine Contractors)

Emerson's Damcos LPUs are rated at IP68, meaning that they are able to operate while submerged at a depth of three bar (30 meters) for at least 24 hours. The LPUs are mounted directly on the actuators and connected to the P-NET network, saving the shipyard installation man-hours by eliminating hydraulic tubing and greatly improving reliability with their short circuit-tolerant design. This configuration allows any LPU to fail entirely without affecting the other units in the loop.

Lumiflex Cable Light Tech

Lumiflex Corp. has a patented cablelight technology that could take visibility of subsea umbilicals, ROV tethers and the like to a new level. Its patented technology can take any strength/data/power/control (or any combination of those) cable and embed it down the middle of our cool-to-the-touch, spoolable, industrial strength, 360 degree light emitting profiles. Being able to position those tethers would be a huge advantage to ROV pilots and divers interacting with the ROVs alike.

Lumiflex has proven that it can take its technology to not just a cable version but a rope version as well.

www.rescuecablelight.com

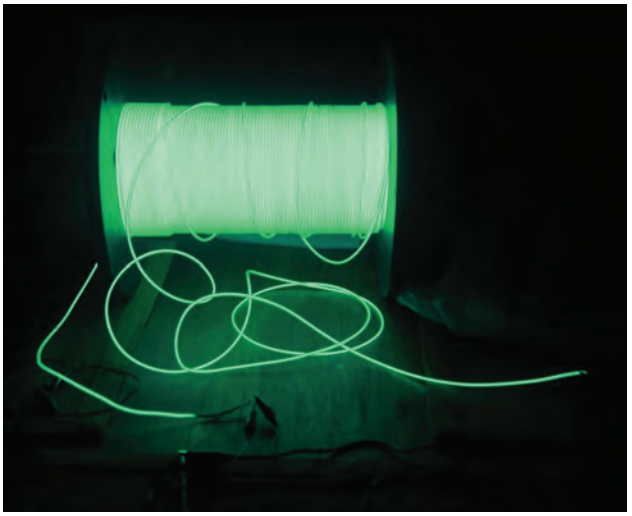


Image: Lumiflex

Image: Soundnine

New Compass Module

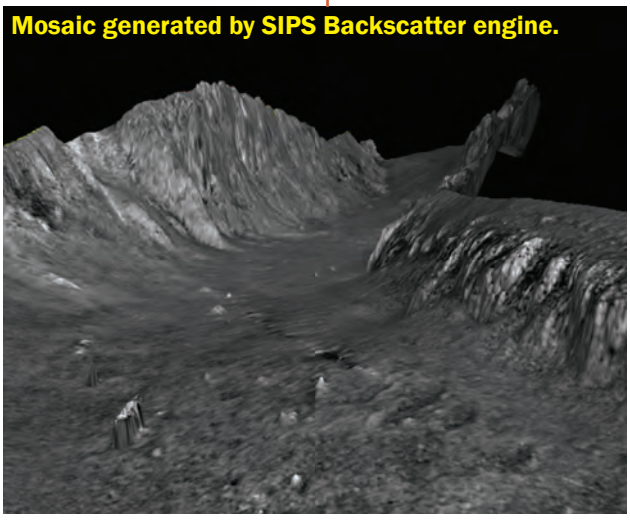
Soundnine Inc., a manufacturer of sensors, inductive modems and real-time systems for marine research and monitoring, has introduced its new Inline Compass Module (ICM) that combines heading and tilt data with wind speed data from RS-232 wind sensors to produce a serial data stream of wind speed and vector-averaged wind direction on buoys or other moving platforms. It's suited for upgrading existing sensor installations and can also be operated without a wind sensor as a digital compass and accelerometer. The ICM contains a three-axis magnetometer and accelerometer that measure heading and acceleration at up to 50Hz. Magnetometer and accelerometer data are recorded during a measurement period and appended to bytes received from a serial sensor connected to the ICM's instrument port. Magnetometer and accelerometer sample rate and measurement period can be programmed to match the wind sensor sampling. At the end of a measurement period, the collected data are transmitted via the ICM's RS-232 control port and a new measurement period is started automatically.

wwwsoundnine.com

CARIS Onboard 1.1

Teledyne CARIS released CARIS Onboard 1.1, which enables users to process data in near real-time resulting in minimized data conversion and processing times. Designed with autonomous operations in mind, CARIS Onboard will save time as less interaction is needed for automated survey activities. This release introduces several new processes including the incorporation of the SIPS Backscatter engine. Backscatter mosaics can now be generated alongside surfaces in near real-time. This version also presents the ability to compute GPS tide, and apply observed depth and attitude filters. In addition to expanding the HIPS and SIPS processes available for real-time automation, there is a new copy process that permits raw data and computed products to be backed up automatically, thereby making it transferrable to portable storage devices. CARIS Onboard 1.1 also adds automation capabilities to the CARIS workflow by enhancing the Process Designer and improving usability and flexibility.

www.teledynecaris.com



Mosaic generated by SIPS Backscatter engine.

(Image: Teledyne CARIS)

The world's premier event for Commercial Diving Contractors, Remotely Operated Vehicles, Manned Submersibles, and all other aspects of the Underwater Operations Industry!

Now in its 25th year, Underwater Intervention is jointly owned by the Association of Diving Contractors International (ADCI) and the ROV Committee of the Marine Technology Society. The show attracts thousands of commercial divers, contractors, engineers and safety professionals who converge on New Orleans for a few days of exchanging ideas, demonstrating new technology and supplies, and generating attention for a highly precise and sought-after line of work that is integral to many different industries.

ATTEND UNDERWATER INTERVENTION 2017

Join your peers at THE industry event of the year.

- Network with leaders in the underwater industry from around the world.
- Stay up-to-date on that latest industry information, strategies and technologies through numerous education track sessions and a massive exhibit hall.
- See the latest and greatest products and services for the underwater industry.

Register today!

Registration information is on our website at underwaterintervention.com/registration17

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Exhibit space is quickly running out, so don't delay!

Contact Your UI Show Management Team at (703) 259-6118 or ui@naylor.com, or visit www.underwaterintervention.com for more information.

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BLUEFIN-21

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Oceanology International North America 2017

Oceanology International North America (OINA) will bring the latest from the marine science and ocean technology industries to San Diego, Calif., February 14-16, 2017. More than 2,500 visitors and delegates are expected to partake in the three-day event at the San Diego Convention Center, where members of industry, academia and government will gather for a conference and exhibition showcasing the industry's latest advancements.

Conference programs will focus on key issues for North America and globally, offering a look at the present and future technological requirements and opportunities of the Blue Economy via keynote panels, technical tracks, breakout panel sessions and the Catch The Next Wave conference.

The exhibition will house booths from some of the biggest names in industry and research from the U.S. and across the world to present a glimpse into the next generation of products and solutions. On the ensuing pages are a sampling of the technologies to look for in San Diego.

Aquabotix

The Aquabotix Endura is the next step in Aquabotix's proud history of innovative, advanced ROV systems. The Endura has been engineered for dependability and functionality across a wide range of underwater applications. With maximum stability and 5 knots of thrust, it outperforms other mini ROVs in power, dependability and software performance.

Booth B37 | www.aquabotix.com

Birns, Inc.

Birns, Inc., an ISO 9001:2008 certified global leader in the design and manufacturing of high performance connectors, cable assemblies and lighting systems, will be demonstrating the latest advancements in custom cable assemblies and wire harnesses at the show. The company has seen a huge increase in both demand and complexity of intricate termination orders, and its expert technicians use advanced technology equipment and are J-STD-001 Class 3 and WHMA-A-620-A Class 3 certified and trained for the requisite skill.

Booth A25 | www.birns.com

Blue Robotics

As the latest addition to the Blue Robotics product lineup, the brand new Ping sonar altimeter and single-beam echosounder aims to provide high quality and performance at a low price point. With a 30 m range, 1 cm accuracy, 25 degree beam width and robust digital communication, Ping is well-suited for use as an ROV/AUV altimeter, for obstacle avoidance and for hydrographic surveying. On display for the first time at Oceanology North America, the Ping sonar is available now for $199.

Booth E37 | www.bluerobotics.com

D-2 Marine

At OINA 2017, D-2 Marine will introduce its new line of high-performance 'hybrid' conductivity, temperature and depth, (CTD) sensors designed to improve oceanographic data collection on a variety of deployment platforms, especially UUV/AUV and Global Ocean Observation Systems (GOOS).

Booth E36 | d-2inc.com

Aquabotix

Birns

Datawell

Datawell will show its Waverider system. A spherical buoy made of stainless steel or Cunifer, Waverider measures wave height, wave direction, wave period, sea surface current speed/direction and sea surface temperature. The company will also have the DWR4 with Acoustic Current Meter at OINA 2017.

Booth B59 | www.datawell.nl

DEEP TREKKER

Deep Trekker

Deep Trekker Inc. builds underwater remotely operated vehicles (ROVs), otherwise known as underwater drones. The company's flagship product, the DTG2 ROV, is being used in-field around the world on thousands of aquaculture sites, hydro-electric dams, S&R operations and more. Using its patented pitching system, Deep Trekker ROVs navigate through the water in all directions using only two thrusters. As interest in the camera systems built over the years, Deep Trekker expanded its product line to include various ROV packages, models such as its larger four-vectored thruster system, the DTX2 ROV, and even introduce a portable pipe crawler system for municipal water inspections.

Booth E31 | www.deeptrekker.com

DimEye

DimEye will showcase for the first time at Oceanology International 2017, the diver version of its 3D Subsea Inspection System: VLS (Video Laser Scan). This system (like the ROV unit) can be used for any kind of subsea high accuracy 3D Measurement project, whether it's about capturing the as-built of any equipment or inspecting anomalies such as pipe dents or cracks. Operator just needs to move around or above the object to be measured and record the HD video-laser to be post processed by DimEye. The achievable accuracy is 1/2000 on large volume objects and +/- 0.5 mm (at 2 sigma) on local anomalies.

Booth D51 | www.dimeye.com

ECA GROUP

ECA Group

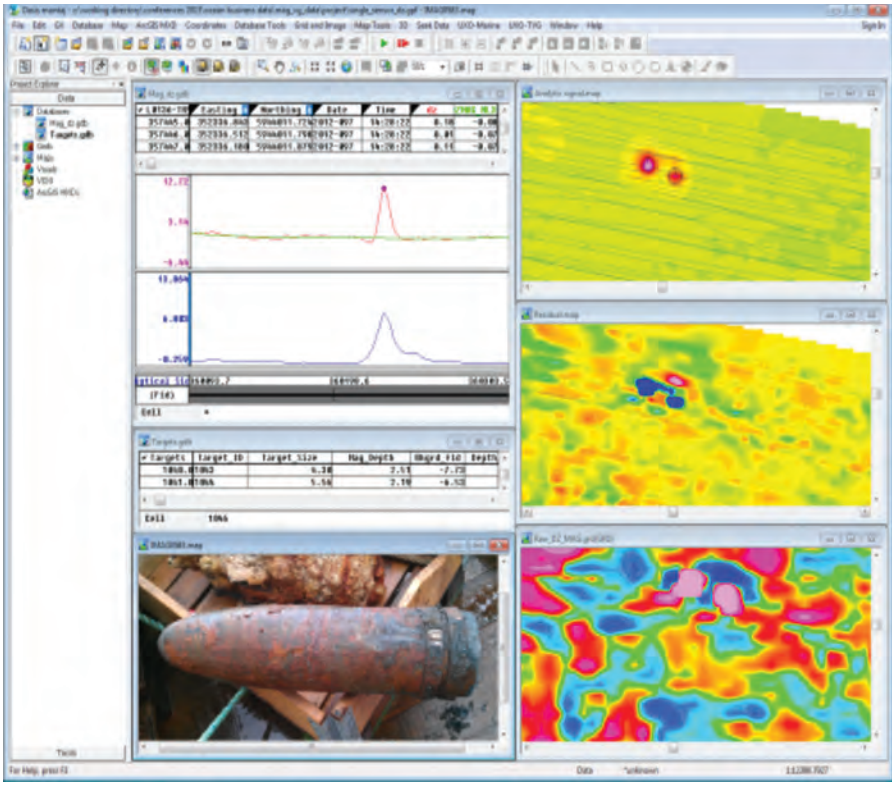
Since 1936 ECA Group has been designing, producing and supporting advanced solutions in the Maritime sector. Its robotic and integrated systems meet the requirements of the constantly evolving oil and gas, subsea, hydrographic, oceanographic and equipment industries. ECA Group offers a wide range of unmanned (AUVs) or remotely operated vehicles (ROVs) to carry out deepwater exploration, pipeline inspection, seabed survey to mission training. These solutions are supported by high-performance software tools for seafloor mapping with bathymetric, sidescan and subbottom systems. ECA group also offers solutions for simulation training as well as naval architecture.

Booth E70 | www.ecagroup.com

DimEye

EdgeTech

Geosoft



EdgeTech

EdgeTech is a provider of side scan sonars, sub-bottom profilers, bathymetry systems and combined sonar systems. The company's underwater actuated and transponding solutions include deep sea acoustic releases, shallow water and long life acoustic releases, transponders, USBL acoustic tracking and positioning systems and custom-engineered acoustic products.

In addition to exhibiting at OI North America, EdgeTech will also present as part of the session on Hydrography, Geophysics & Geotechnics - Integration & Automation (February14, 4:30 - 6 p.m.)

Booth E57 | www.edgetech.com

Energy Sales

Energy Sales, Inc. announced its newest design for deep ocean battery applications, Pressure-Tolerant Battery System. Leveraging its 40 years in developing custom battery packs, the company designed its cost-effective alkaline battery solution for the oceanographic community to replace the need for titanium or other costly composite materials. Energy Sales will feature its pressure tolerant solution and its other ruggedized battery pack solutions for harsh environments at Oceanology International North America in San Diego. Energy Sales powers devices from tsunami buoys to self-locating datum markers (SLDMB) to manned and unmanned submersibles.

Booth B35 | www.energy-sales.com

Geosoft

Geosoft's UXO Marine software package provides comprehensive processing and visualizing of magnetic and gradiometer geophysical data for marine surveys. UXO Marine helps to detect and analyze cables, pipelines and unexploded ordnance (UXO) as well as other seabed and buried features. With UXO Marine users can:

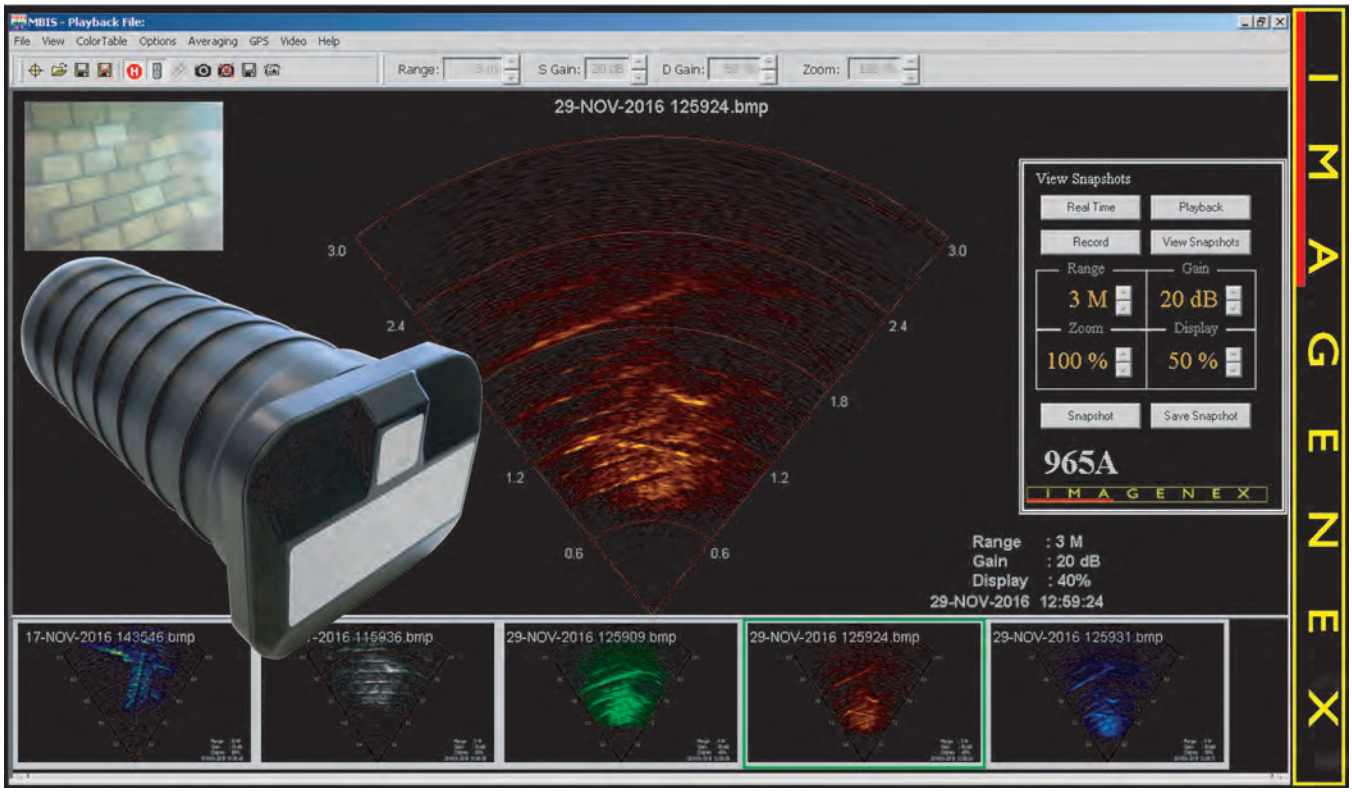
- Process large volumes of geophysical data
- Perform positioning, location, and data corrections
- Run Quality Assurance and Quality Control tests
- Calculate target location, depth, size and magnetic moment
- Optimize seabed survey planning and reporting

An updated version of UXO Marine was released in 2016. Highlights include improved automated modelling of the magnetic data (with support for sparse data), support for rotated maps and expanded support for multiple gradient sensors in any configuration. Further innovations are planned for 2017 including updated workflows and the addition of EM61 data processing.

Booth D59 | www.geosoft.com

Gnostech

Cybersecurity solution with maritime needs in mind: The maritime industry needs solutions to deal with persistent cyber threats. Gnostech Inc. will showcase its cloud-based, automated vulnerability management solution, VulnX, at



VulnX™

OINA. Suiting the needs of maritime companies, VulnX's highlights include:

- Deploying patch and software updates without interference to mission critical systems
- Reducing administrative burdens
- Mechanisms to account for low bandwidth and connectivity loss
- Real time compliance monitoring with secure baseline management
- Customizable to meet compliance and functionality requirements
- Scalable and modular solution

Gnostech will offer VulnX demonstrations at its stand to show how to improve security posture against maritime cyber threats.

Booth E76 | www.gnostech.com

Imagenex

At Oi North America, Imagenex will feature a selection of multibeam, sidescan and mechanical scanning sonars. Imagenex will showcase the next generation in multibeam imaging sonar, the Imagenex Model 965A, an advanced, high-speed, high-resolution system that has been designed to provide fast, reliable and accurate underwater images. The 965A is available in a variety of frequencies and depth ratings.

Booth C59 | www.imagenex.com

INSPIRE Environmental

INSPIRE Environmental joins the expertise of Germano & Associates (G&A) and CoastalVision to deliver Sediment Profile Imaging (SPI), environmental baseline survey and contaminated sediment management services to governmental and commercial clients. Demand for SPI services was exceeding both companies' capacities to serve the market, so INSPIRE was formed to meet this increasing demand and train the next generation of expert SPI scientists. INSPIRE will continue to deliver the services that both G&A's and CoastalVision's existing clients expect, and the company will engage new clients in the oil and gas, offshore renewables and other industry sectors.

Booth: A60 | www.inspireenvironmental.com

InterOcean Systems

InterOcean Systems, LLC holds more than 70 years of continuous experience and product development of high quality oceanographic and environmental equipment. With a full product line that in-

INSPIRE Environmental

cludes S4 Current Meters, wave and tide gauges, winches and marine handling systems, meteorological/oceanographic (METOC) buoys, acoustic releases and the Slick Sleuth remote oil spill monitoring system, InterOcean Systems, possesses the experience, customer support and dedication to quality products to help solve difficult application problems in the challenging offshore environment.

Booth A13 | www.interoceansystems.com

JW Fishers

JW Fishers Mfg. has introduced a new metal detector for 2017. It is specially designed for use by dive teams that need to locate metal objects in poor visibility underwater environments. The SAR-1 alerts the operator to the presence of metal by vibration transmitted through the handle. The detector also has a high intensity LED display. Other key features are its "snareless" design with no external wires, rugged construction, streamlined configuration, and bright yellow search coil. The 8-inch coil has excellent detection capability on a range of targets from small shell casings to weapons and explosive devices.

Booth C58 | www.jwfishers.com

JW FIshers

Kongsberg Maritime

Kongsberg Maritime will focus on its portfolio of state-of-the-art AUVs at OINA 2017 with Hugin and Munin (booth # C35), in addition to subsidiary Hydroid's Remus AUVs (booth # C31). Advanced Subsea Monitoring systems for scientific, environmental and industrial applications will be on display alongside the leading subsea technology developer's extensive range of single- and multibeam underwater mapping systems, including the advanced new GeoSwath 4 system.

Booths C31, C35 | www.kongsberg.com

Linden Photonics

Offering high strength optical fiber cables and cable coatings, Linden Photonics specializes in thin and strong cables, as well as buoyant cables. Linden's fiber optic and hybrid cables are optimized for underwater use, as well as use in larger umbilicals. Linden produces optical cables that combine high strength, low weight and small size. High strength hybrid designs are also available.

Booth A37 | www.lindenphotonics.com

Marine Technology Reporter

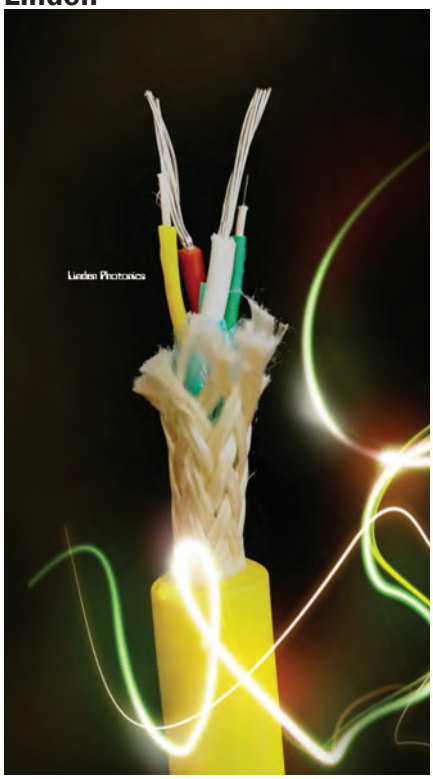
Marine Technology Reporter (online *MarineTechnologyNews.com*) is the largest audited circulation magazine dedicated to the global marine technology and subsea markets. *MTR* provides relevant news and information from around the world to a powerful and highly responsive audience of more than 25,000 third party verified subscribers. From offshore energy to subsea defense to science and technology, *MTR* covers it all.

Booth A33 | www.marinetechnologynews.com

Noliac

Piezoelectric products for underwater applications: Noliac designs, develops and manufactures piezoelectric products used in many different types of sonar systems, for instance, for detailed 2D or 3D mapping of seabeds, underwater

Linden



MTR

Kongsberg

noliac

communication, etc.At Oceanology International North America 2017, Noliac will present the full catalogue of piezo products. The company will display its piezo components featuring capabilities to manufacture large sizes, and the many possibilities of custom designed shapes. Also, a selection of ultrasonic transducers will be on display to show Noliac's capabilities to develop custom designed solutions matching specific customer requirements.

Booth E33 | www.noliac.com

Norbit Subsea

Norbit Subsea's team of multidisciplinary engineers has pioneered the new ultra compact iWBMSe, a high-end sonar integrated with GNSS/INS. Weight is now below 20kg including NORBIT sound velocity profiler all packed in a Pelican case, portability reaches new heights.

Booth B34 | www.norbit.com

Prevco Subsea

Prevco Subsea are using 'Ceramic' for subsea enclosures. As the first company to do this on a commercial basis, Prevco sees opportunities for deep sea (6,000m) use. Benefits include lighter in-water weight and cost. Samples and more information will be available at Prevco's stand.

Both B31 | www.prevco.com

Riptide Autonomous Solutions

Riptide Autonomous Solutions will display latest upgrades to its micro-UUV. With a base system price under $15,000, the micro-UUV is designed to be a flexible and affordable tool suited for developers of autonomy and behaviors, power systems, subsea sensors and new payloads. The micro-UUV has been delivered with sonar payloads, acoustic communications, 360 degree cameras, as well as flooded payload sections for custom end-user applications.

Booth A58 | https://riptideas.com

RoweTech

Rowe Technologies Inc. (RoweTech) specializes in the design and manufacture of underwater acoustic Doppler products and imaging systems for the oceanographic, navigation and hydrographic markets. Founded by Dan and Steve Rowe in 2009, RoweTech is a technology-based private company with the main office located in Poway, Calif. RoweTech's ADCP/DVL electronics suite is provides a powerful compact single-unit configuration which allows simultaneous current profiling and bottom tracking.

RoweTech will introduce the SeaSEVEN. This is the first coordinated seven-beam profiler on the market and is designed to solve difficult application requirements. Data can be used for turbulence, waves, sediment transport, renewable energy, Reynold's stress and

Norbit

Prevco

bottom boundary layer research. With its 24-bit high-speed A-D convertor, and its optional high capacity 32-gigabyte recorder users no longer have to decide "what data not to record". The SeaSEV-EN is unique in its capability to collect multiple data types and allows scientists to easily archive research data.

Booth B35 | www.rowetechinc.com

SEACON

TE Connectivity (TE) will exhibit at the SEACON booth at Oceanology International 2017 in San Diego. One of the many products being showcased at this ocean technology event is TE's SEACON 55 dry-mate connector series. These connectors have been developed for a variety of applications, including remotely operated vehicles (ROVs), umbilicals, underwater cameras and diver communications. The SEACON 55 series benefits from a design incorporating features, such as gold plated contacts with contact band interface technology. The product line also boasts industry standard compatibility and reliable sealing technology.

Riptide

(Photo: NUWC Newport)

SEACON is part of TE's growing portfolio of brands within the marine oil and gas market, which also includes brands such as DEUTSCH and Rochester Cable. These brands will also be featured at the booth. TE will also showcase its SEACON OPTI-CON series of optical hybrid dry-mate connectors, SEAMATE wet-mate connectors and rubber molded connectors at the show.

Booth A55 | www.seaconworldwide.com

Seafloor Systems

Seafloor Systems will exhibit its next generation EchoBoat-G2. This remotely controlled and autonomous survey vehicle features powerful brushless thrusters for higher speed and battery endurance of eight hours, allowing a full day's work on one charge. Users can pre-plan survey waypoints, upload via RF to the vehicle and automatically carry out the survey without user input. The portable vehicle performs singlebeam or multibeam surveys in shallow waters, hazard areas, and remote areas where it is difficult to launch conventional survey boats.

Booth D29 | www.seafloorsystems.com

Silicon Sensing

Two all-new IMUs from Silicon Sensing are enhancing its range of MEMS inertial products on show at Oceanology International. DMU11 combines MEMS angular rate and linear acceleration sensors to create a precision, low-cost, 6-DOF IMU for complete motion sensing and control in three-dimensional space. Suitable for a wide range of marine applications, DMU11 is calibrated over the full rated temperature range.

DMU30 is the first of a family of High Performance IMUs. Due into full production in January, DMU30 creates a non-ITAR, MEMS IMU alternative to more costly FOG-grade IMUs for use in exacting marine motion sensing applications.

Booth D25 | www.siliconsensing.com

Star-Oddi

New Robust Temperature-Depth Recorder: Star-Oddi introduces the robust logger Starmon TD measuring temperature and depth. Starmon TD is designed with a fast response temperature probe which makes it suitable for profile

SEACON

Seafloor Systems

Star-Oddi

VideoRay

Rowe

measurements and fishing gear studies. Housing is designed for easily mounting to gear or moorings. The long life battery is user replaceable. Various depth ranges are available up to 2000 m. Depth accuracy is better than +/-0.3% of selected range. Temperature accuracy is better than +/-0.025°C.

Booth B52 | www.star-oddi.com

Teledyne Marine

Teledyne Marine will be out in force at OINA 2017 in San Diego. In addition to its full line of instruments, imaging, vehicles and interconnect products, the company will promote the newest product developments from across its brand portfolio, including the Teledyne Oceanscience rapidCAST underway profiling system, four new multibeam sonar systems from Teledyne Reson, a new line of acoustic releases by Teledyne Benthos and new underwater cameras from Teledyne Bowtech, new ADCP and DVL technology from RD Instruments and the latest technologies from Teledyne Gravia and Teledyne Impulse-PDM.

Booth D20 | www.teledynemarine.com

Turner Designs

Turner Designs will demonstrate ICAM, its in situ Integrating Absorption Meter. The patented integrating cavity design means that little or no scattering correction is needed. Factory configured with nine wavelengths from UV (365nm) to Red (676nm), ICAM enables absorption measurements over a wide spectrum. Built with solid-state optics and electronics, ICAM provides excellent reliability with low power requirements in a relatively small package. Absorption can be measured from 0.001 m-1 to a maximum of 15 m-1.

Booth B57 | www.turnerdesigns.com

Valeport

Valeport, a manufacturer of instrumentation to serve the oceanographic and hydrographic communities worldwide, will focus on several recently released products, including fastCTD, which allows quick and accurate CTD profiles (with Fluorometer option), rapidCTD, which is developed primarily to interface with the Teledyne Oceanscience RapidCAST winch system, SWiFT SVP, the latest generation SVP with geo located data and optional iOS App control, and the new range of Hyperion Fluorometers.

Booth E20 | www.valeport.co.uk

VideoRay

With more than 3,700 ROVs in service around the world, VideoRay is a leader in observation ROV technology. VideoRay's underwater robot systems are versatile, portable, affordable and reliable solution for underwater operations including surveys, offshore inspections, search and recovery, homeland and port security, science and research, aquaculture and many other underwater applications. The latest Mission Specialist systems provide solutions for particularly difficult underwater challenges. VideoRay is available on the General Services Administration (GSA) Schedule.

Booth A59 | www.videoray.com

MARINE TECHNOLOGY REPORTER

2017 EDITORI

	FEATURE	MARKET	TECH
JAN/FEB AD CLOSE 1/20	Underwater Vehicle Annual: ROV, AUV, and UUVs	HD Cameras & Sonar for Vehicles	Underwater N
	MTR White Papers: Oceanographic - February 2017 Bonus Electronic Edition Publication Date: February 27, 2017		
MAR AD CLOSE 2/28	Oceanographic Instrumentation: Measurement, Process & Analysis	Fiber Optic Connectors & Slip Rings	Ocean Bus Southampt
APR AD CLOSE 3/30	Offshore Energy Annual	Subsea Engineering: Subsea Field Architecture	Buoyancy Tec
MAY AD CLOSE 4/28	Underwater Defense	Offshore Renewable Energy: Wind, Wave & Tide	Magnetomete
JUN AD CLOSE 5/25	Hydrographic Survey	Comms, Telemetry & Data Processing	GPS, Gyro Co Motion Tracki
JUL/AUG AD CLOSE 7/28	THE MTR 100 - The 12th Annual Listing of 100 Leading Subsea		
	MTR White Papers: Hydrographic - July 2017 Bonus Electronic Edition Publication Date: July 15, 2017		
SEP AD CLOSE 8/25	Ocean Observation: Gliders, Buoys & Sub-Surface Networks	Research Vessels	Seafloor Engi Operations
OCT AD CLOSE 9/22	AUV Operations	Harsh Environment Systems for Arctic Ops	ROV Technolo Micro System
NOV/DEC AD CLOSE 12/1	Acoustic Doppler Sonar Technologies ADCPs & DVLs	Fresh Water Monitoring & Sensors	Offshore Insp Maintenance
	MTR White Papers: Unmanned Marine and Subsea Vehicles - November 2017 B Publication Date: November 7, 2017		

AL CALENDER

HNOLOGY	PRODUCT	SPECIAL	BONUS DISTRIBUTION
avigation	Scientific Deck Machinery	The Atlantic Canada Subsea Cluster	Oceanology Intl North America Feb 14-16 San Diego, CA Underwater Defence & Security March 6-8, 2017, Portsmouth, Uk TUSEXPO Amsterdam, Netherlands
			Delivered to Over 30,000 Recipients Worldwide
siness 2017 ton, UK	Sonar Systems & Seafloor Mapping	Southern California Subsea Cluster	Ocean Business Apr 4-6, Southampton,UK Sea-Air-Space Apr 3-5, National Harbor, MD
hnology	Work class ROV's & Seafloor Trenchers	The Norwegian Subsea Cluster	OTC May 2-5, Houston, TX AUVSI XPONENTIAL May 8-11 Dallas, TX USA
rs & Streamers	Subsea Housings	Subsea Mining: The Time is Now	UDT 30 May- 1 Jun, Bremen, Germany MAST Asia Jun 12-14, Tokyo,Japan
mpasses & MEMS ng	Interconnect: Underwater Cables & Connectors		Oceans 2017 Jun 19-22, Aberdeen, Scotland

n Companies

			Delivered to Over 30,000 Recipients Worldwide
neering & Remote	Geospatial Software Systems for Hydrography	The Northeast U.S. Subsea Cluster	Oceans 2017 Sept. 17-22, Anchorage, AK
gy: Workclass to s	Underwater Tools & Manipulators	The Southeast U.S. Subsea Cluster	OTC Brazil Oct 24-26 Rio De Janeiro,Brazil
ection, & Repair (IMR)	Underwater Imaging: Lights, Cameras & Sonar	The 2018 Subsea Market Planner	Underwater Intervention 2018

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SeaAirSpace

April 3-5, 2017

Gaylord National Convention Center,
National Harbor, MD USA

Attendance is Free to military, government and other qualified individuals; visit SeaAirSpace.org for details.

www.SeaAirSpace.org

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Hosted by: National Oceanography Centre

* The exhibition, workshops, associated meetings and Ocean Careers are FREE to attend. There is a fee to attend the conference.

MTR Marketplace

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Goodwin Marine Services

55' R/V *JAMIE HANNA* *New for Charter*

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