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March 2019

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Instrumentation

& China's Maritime Infrastructure Build-out

Decommissioning

Challenges & Opportunities

Volume 62 Number 2

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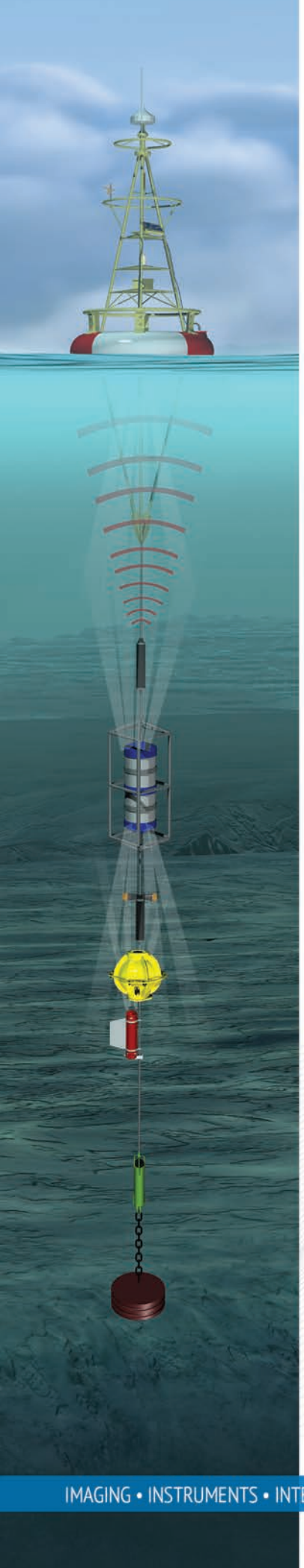

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Multipurpose winch series

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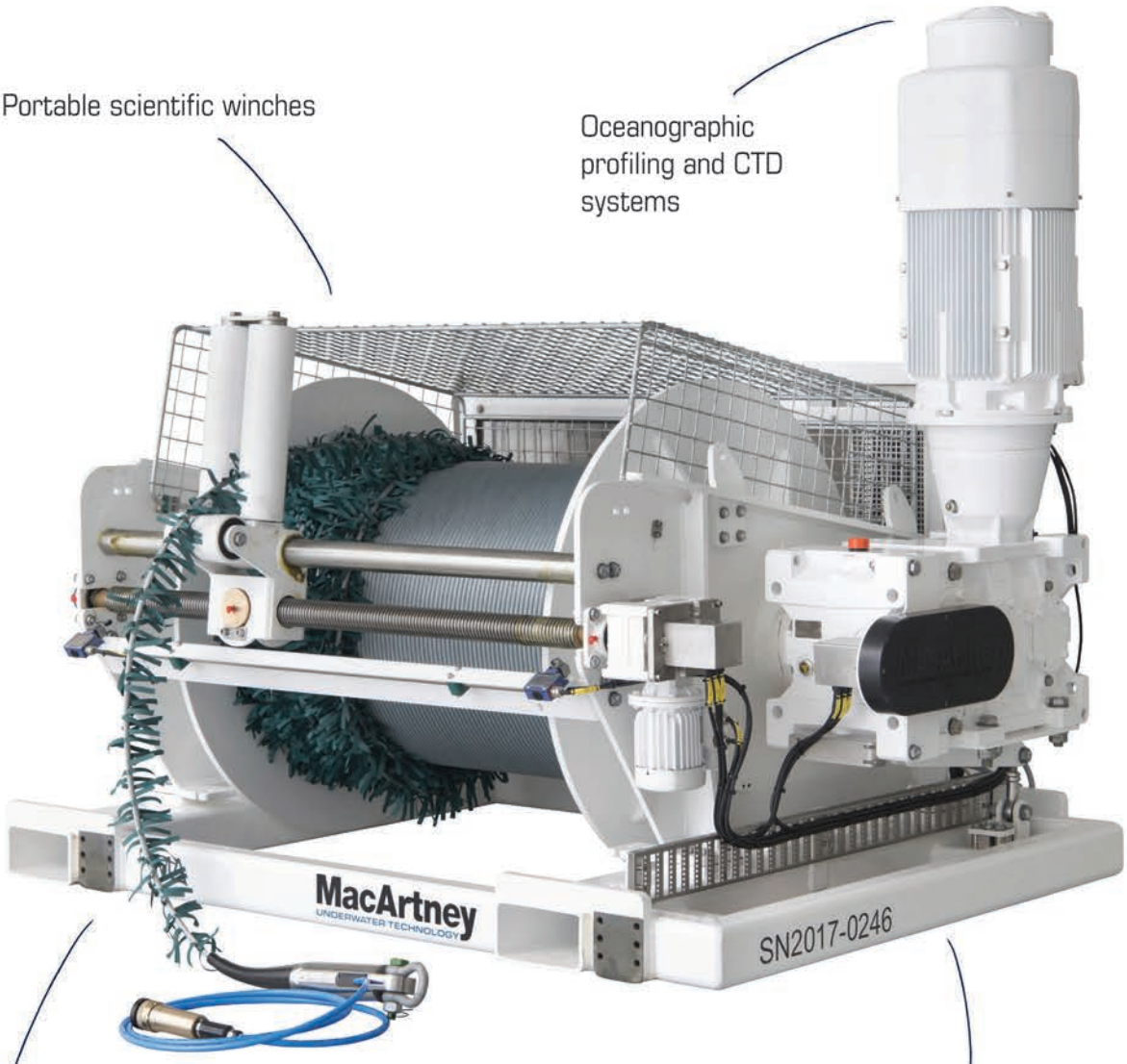

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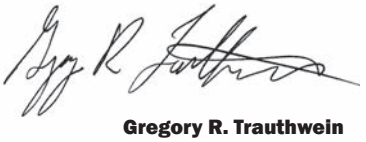
Editor's Note

Each edition of *MTR* affords us the opportunity to examine more closely not just the new and emerging technology being developed globally, but also the real world applications and (perhaps more importantly) the potential applications for this technology. In regards to the latter, this edition is packed with insights on future applications.

Contributing writer **Elaine Maslin**, as is her custom, goes broad and deep on the subject of decommissioning. Buttoning up and removing offshore energy structures that have been in place for decades is fraught with a number of logistical, technical, financial and environmental issues all balled into one. Her first feature, *"Cold Comfort for Future Decommissioning"* starts on page 20 and focuses on the environmental bit, specifically examining the challenges of removing a structure that has become 'home' to so much marine life, a particularly slippery slope when the marine life if endangered and protected. Her second report starting on page 26 looks at the business of decommissioning, and in a word, business will be booming for the coming generation. Looking at the UK North Sea alone it is estimated that in the coming decade, more than $20 billion is forecast to be spend on decommissioning offshore oil and gas facilities. For anyone still searching for 'good news' and revenue offshore, look into decommissioning.

But this edition is not only about breaking things down, it's about building them up, and Oceaneering – under the guise of **Martin McDonald**, SVP, ROVs – has built the largest ROV presence in the world with a fleet of 275 work class ROVs, 60 observation class ROVs and 2,400 full time personnel. The numbers are impressive, as is our full 'one on one' with McDonald, a nine-page feature starting on page 43.

Finally, many of you will be packing up and heading over to Southampton for Ocean Business 2019 in early April. If you've not attended the event, it is highly recommended that you consider adding it to your travel plan, as it is a high-level gathering of executives, technology, conference and in-water demos. We profile some of the new technology you can see in Southampton starting on page 70, and if you plan to attend, we invite you to stop by the MTR stand A25 for a chat about a technology or a project that you represent.



Gregory R. Trauthwein
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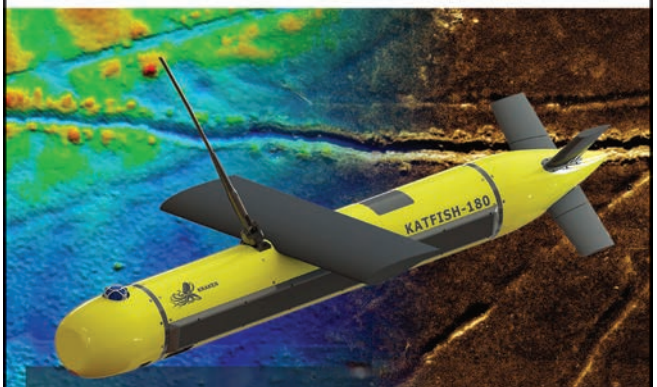

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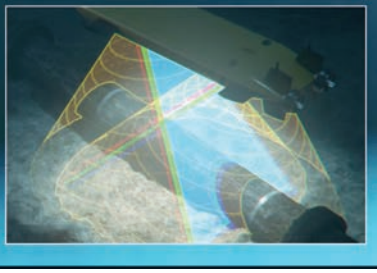

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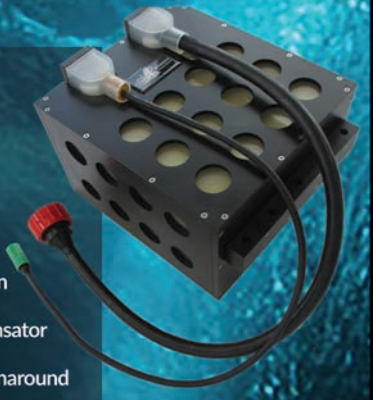

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Manley

Maslin

Paschoa

Stoichevski

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'Double Duo Lift Method'

Salvors Lift Norwegian Frigate

Salvors used a unique lift method that combined two heavy lift vessels and four cranes to raise a Norwegian frigate that had become partially submerged following a collision with an oil tanker off the coast of Norway in November. On November 8, 2018, Norwegian heavy frigate KNM Helge Ingstad collided with the tanker Sola TS near Bergen, and sank on the inclined slope of a fjord. The accident injured eight people and caused the temporary closure of the Sture Oil Terminal near Bergen and the nearby Kollsness gas-and-condensate terminal, as well as several offshore fields. In order to lift the frigate safely and in one piece, Belgian salvage specialists Scaldis said it developed a lift method especially for this project, after it was called on by the Norwegian Navy to work alongside another salvage company BOA.

The salvage technique, which Scaldis calls the "Double Duo Lift method" combined two heavy lift vessels – Rambiz, equipped with two cranes and a total lifting capacity of 3,300 metric tons, and the new heavy lift vessel Gulliver, also with two cranes and a total lifting capacity of 4,000 metric tons – creating a total combined total lifting capacity of 7,300 metric tons.

More Photos and information can be found on:
https://www.marinetechnologynews.com/news/salvors-norwegian-frigate-586722

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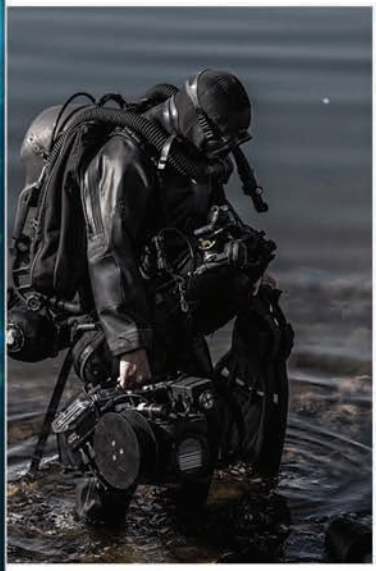

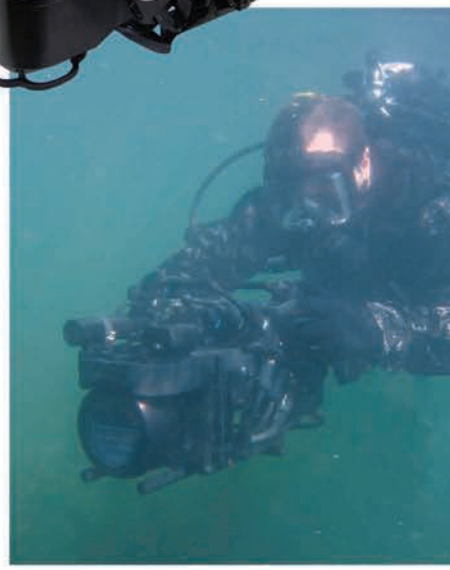

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Gibson

Chris Gibson is VP of Sales & Marketing at VideoRay, a leader in portable, inspection-class remotely operated vehicles (ROV). Gibson is a ubiquitous figure around the globe representing the VideoRay brand, and has been with the company since its inception in 1999. MTR *spoke with Gibson recently for his insights on market and tech drivers.*

By Greg Trauthwein

The familiar family of VideoRay ROVs are found globally in a wide range of industries and missions, from homeland security and defense, to inland and offshore infrastructure inspection, aquaculture, power plant inspection, and more. *MTR* caught up with Gibson recently for his insights on market and tech drivers.

How did you come to have a career in the subsea industry?

VideoRay was one of my interests from 1999 – 2006. During this time, I also ran and managed other businesses not related to the subsea industry. VideoRay provided a sense of excitement and exploration to which I became addicted. In 2006, I joined VideoRay full-time and we quickly worked to establish the company as the industry leader.

From when you started with VideoRay, how is the company most the same?

VideoRay's culture is still close knit. Everyone here knows they are an important part of ensuring our customers are successful with VideoRay equipment. While the company and our customer base has grown significantly, the sense of pride everyone at VideoRay takes regarding our customer's success is still the heartbeat of our business.

How is the company most different?

As VideoRay has grown, we now work out of a much larger, professional facility. The building is about 25,000 sq. ft. and has dedicated areas for Production, Repairs, Operations, and Sales. We also have a separate nearby Research & Development facility and remote employees in Rhode Island and San Diego.

Please provide an overview of the VideoRay ROV family today.

VideoRay is well-known for our three-thruster, yellow ROVs. These ROVs are portable, rugged, and reliable. We have sold more than 4,000 Pro 4, Scout, Explorer and Voyager models. However, over the last several years VideoRay has added the Defender and Pro 5 product lines based on our modular Mission Specialist technology. Mission Specialist technology was developed to solve additional customer requirements. Mission Specialist systems have more powerful thrusters, increased payload capacity, go much deeper, and support even more sensors and tools. They are still easy to use and are one-man portable. Each ROV system is delivered with our unparalleled, global customer service and support. The Defender and Pro 5 ROV systems have become very popular.

In what is becoming an increasingly crowded field, what is the VideoRay value proposition?

While the recreational market is more crowded, the higher end industrial market for compact inspection-class ROVs is

Photo credit to Dean Nafziger of UROV.

The VideoRay Pro 4, Pro 5, and Defender on an oil rig.

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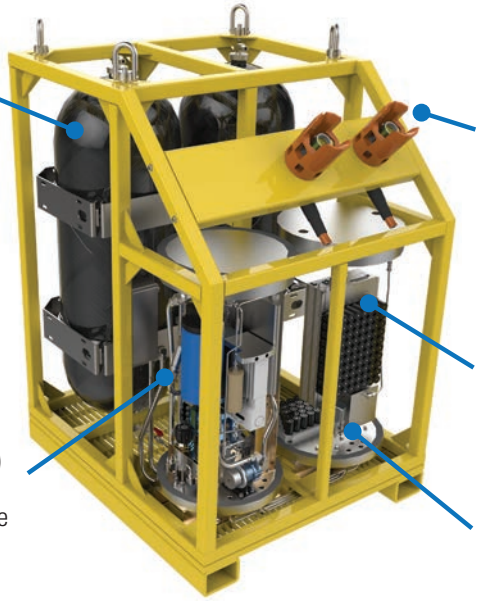

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Mission Specialist Defender modules.

thinning out a bit. We design and manufacturer portable underwater technology that easily integrates with third party sensors, software and tooling. We realize there is not one solution that solves everyone's problems, so we spend quite a bit of energy understanding what our customers are trying to do before we make recommendations – understanding that sometimes we may recommend something other than a VideoRay solution. Most of the time a VideoRay ROV will do the job, and we proudly deliver the systems with exceptional service support and reliability.

What technology do you see as the differentiator for VideoRay?

In our 20 years of experience, we are uniquely qualified to handle the toughest jobs – where deep, fast, and murky water keep less expensive or recreational systems from performing a mission. We provide the vehicle, tools, and sensors needed to get the job done, and our modular approach lets us – or, sometimes, our customers, equip an ROV with exactly what it needs to do the mission in challenging conditions. For example:

- Maintenance and repairs typically done at the manufacturer or service center are easy and can now be done rapidly and easily in the field.
- The addition of navigation sensors and software add piloting autonomy features allows operation in challenging conditions – even for less experienced operators.
- A single system can be upgraded easily in the field – for example, thrusters can be added to an existing system by simply mounting them and plugging them in.

Photo: VideoRay

Mission Specialist Pro 5 approaches an offshore rock in the Galapagos. Inset: The VideoRay Mission Specialist Defender in the Galapagos outfitted with laser, sonar, and two cameras.

How is VideoRay investing today?

Our primary investment is in Research & Development, mainly to improve tooling and sensor information collection. Another significant investment we make is employee and customer related. We regularly send employees from our sales, operations, production and engineering groups out to visit customers and assist with challenging missions to ensure their success, and our understanding of their unique challenges. It is important for us to see and understand how VideoRay products are being used so they can be improved.

Looking at the markets you serve, where do you see opportunity:

(Geographically) we have started to see investment in ROV systems being made in developing countries where divers traditionally were the only solution. By market sector:

- **Defense and Military:** Defender ROV system for MCM and EOD related tasks;
- **Oil & Gas:** Defender and Pro 5 ROV system outfitted with UT, CP sensors; and
- **Aquaculture:** for net and mooring inspections.

Please discuss recent product introductions.

In late 2018, VideoRay announced the most recent addition to the Mission Specialist Series (MSS) ROV fleet - the Pro 5. The Pro 5 configuration is designed for speed and portability, weighing in at just 10 kg (22 lb.). The three-thruster system has forward speed of over 4.4 knots and is designed to handle missions with size, space, weight, and deployment speed constraints are key. We are selling the Pro 5 for infrastructure inspections beyond the reach of divers, search & recovery, and exploring the ocean floor up to 305m.The Pro 5 builds on the strengths of the Pro 4, with more thrust, longer tether lengths, higher resolution video, and the advantages of the MSS modular systems. We anticipate releasing new tooling, sensors for the Mission Specialist Defender and Pro 5 systems. Additionally, we are working on the development and release of new system configurations.

USCG goes galactic

Coast Guard satellites aim to give navigating Arctic a greater margin of safety

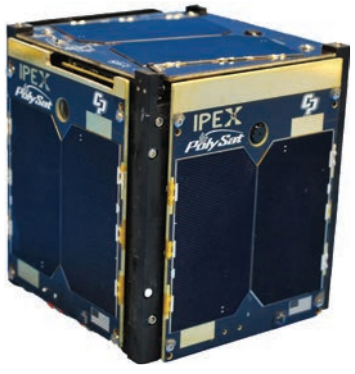
By Maura Casey

The U.S. Coast Guard's mission of keeping the seas safe will soon get an additional boost from space with two polar satellites. The two satellites, called "cube satellites" or "cubesats" for their small size of about 60 square centimeters, or a little under 2 feet, will be part of a payload on a SpaceX Falcon 9 rocket scheduled to launch from Vandenberg Air Force Base in California Nov. 28. Although the Coast Guard has used satellite technology for years, these two are the first to be entirely dedicated to a Coast Guard mission.

The initiative is part of the U.S. Homeland Security's Polar Scout program, which aims to increase technical resources in the Arctic to detect emergency position indicating radio beacons, or EPIRBs, sent from mariners in distress in that region. The project will also be a test to explore the effectiveness of using the cubesats, which are less expensive than other forms of technology, for these and other missions.

The service will also gain two ground stations to monitor and control the satellites as they orbit the planet over the poles every 100 minutes or so. One ground station has already been completed in Fairbanks, Alaska. Another is planned for construction before the end of the year atop Smith Hall at the U.S. Coast Guard Academy in New London, Conn.

The increasing sophistication of technology, along with the ever-shrinking size of electronics, has made it possible for cubesats to do the job that once was performed by much larger and much more expensive satellites, said U.S. Coast Guard LCRD Grant Wyman. He is the project manager for the initiative at the U.S. Coast Guard Research and Development Center in New London, Conn.



Images Courtesy: Cal Poly Cubesat Lab and JPL

"It's really expensive to build, launch and maintain a satellite, but the technology advancements that have occurred in recent years have begun to reduce those costs," said Wyman. He explained that the two cubesats, named Yukon and Kodiak, would orbit in "low Earth orbit" of between 690 and 1000 kilometers, or about 428 to 621 miles.

The Arctic is a high-priority area for the Coast Guard, Wyman said, as commercial shipping and even cruise traffic increases in previously inaccessible areas as the ice melts with climate change. Yet the area is still an extreme environment even in the warmer months, with harsh weather, cold temperatures, and emergent areas of navigation.

The diminutive satellites will likely have some company as they are launched into orbit; the Spaceflight rocket that will launch the cubesats for the Coast Guard will have a payload of more than 70 other satellites for 35 different organizations. The mission has thus been dubbed the SmallSat Express for the variety and number of spacecraft involved, the most launched from any U.S. spaceship. This high-tech form of ridesharing has a positive upside: the more organizations and governments launching on the same rocket, the more the venture can potentially lower the cost of entry into space for all.

The reduced cost of the cubesats – and the construction of a ground station at the Coast Guard Academy – will also have an impact across the board on the education of Coast Guard cadets, for which the Academy has been preparing for the last five years, said Dr. Lorraine Allen, associate professor of physics at the Academy.

"We've rolled out a new curriculum for the marine and environmental sciences major. It fits in perfectly," she said. Data from the cubesats will also be used for independent study. "Our students can form ideas for projects, whether it is a mission gap or something they are curious about." For example, the Academy course on remote sensing, required for two majors, will use the satellite data as it detects mariners in distress. The physics and engineering students will be able to design proposed new cubesats; other cadets will help provide 24/7 coverage to read the data as it comes in.

"The students will use the information to ask 'What are the gaps? How can we supplement the data we need with what we have?," said Brooke S. Stutzman, physics section chief at the Academy.

The launch of the cubesats and building of a ground station at the coincides with the Academy's periodic review and revisions of courses to assure that the education next generation of Coast Guard officers stays on the cutting edge, said Stutzman.

The protected stony coral Lophelia pertusa and other marine growth epifauna occurring with dense schools of the fish Pollachius virens around North Sea oil and gas installations. Original photograph courtesy of Lundin Britain Ltd. Reproduced from "Cold-Water Corals: The Biology and Geology of Deep-Sea Coral Habitats", by J.M. Roberts, A. Wheeler, A. Freiwald, and S. Cairns, Cambridge University Press, 2009.

Image: Insite

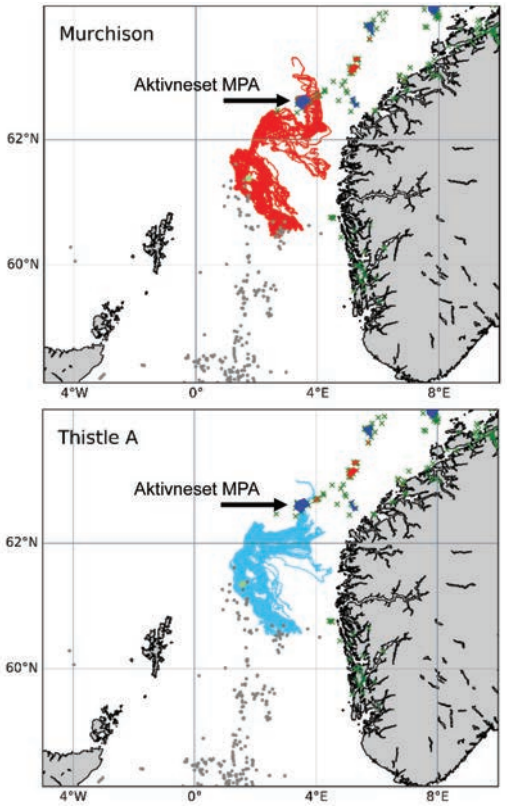
Cold Comfort for Future Decommissioning

By Elaine Maslin

Data sharing and better understanding of how marine life interacts with man-made structures is the target for the next phase of the Insite program.

What to do with offshore structures is a sticky problem for oil companies, regulators and policy makers alike, as many structures are starting to cease production in the North Sea, where some fields have been producing oil and gas since the early 1970s.

Regulations, which include the OSPAR (Oslo Paris convention) state that a clear seabed should be left behind, once production has ceased, with some exceptions (platforms over a certain age and weight). But, some have argued that more should be left behind. However, little information has been available on which to base such decisions, which cost the public money (decommissioning is treated as an operational expense in the UK and as such is subject to tax relief) and could impact the environment (negatively or positively, where facilities are supporting increased marine life).



Simulations run by the INSITE Phase 1 project "ANChor" show the oceanic pathways that protected corals of Lophelia pertusa from the Thistle A and the (now derogated) Murchison platforms may follow, including some of which end up settling in Norway's Aktivneset marine protected area. Image from the INSITE Phase 1 ANChor project.

A program to help understand how offshore platforms and structures impact North Sea marine life – and therefore make more informed decisions on what to do with them at the end of their useful life – is hopping to address some of the questions.

The Insite Program (standing for INfluence of man-made Structures In The Ecosystem) initially ran from 2015-2017. Now, a second, five-year-long phase has started, thanks to some £7.6 million funding; £5 million from the UK's Natural Environment Research Council, £2 million from the offshore industry and £600,000 from the Centre for Environment, Fisheries and Aquaculture Science.

Richard Heard, Insite Program director, told the Offshore Decommissioning Conference in St Andrews, late 2018: "This is about providing science for all stakeholders to try and understand what's going on in the eco-system, so that we are informed and can make bet-

Decommissioned structures in the North Sea reveal dense coverage of the protected species of stony coral Lophelia pertusa.

Image: Insite

Richard Heard.

ter decisions."

Significant findings of the first phase work, which involved 16 science institutes across Europe and eight oil major sponsors, included the discovery that the protected cold-water coral Lophelia pertusa on facilities in the northern North Sea (notably, Thistle A and the now derogated structure of Murchison) could potentially be supplying larvae that drift from these structures to natural coral ecosystems off Norway. Specifically, these two structures seem capable of supplying the Aktivneset marine protected area, which had been severely damaged by historical fisheries activity, and which is now beginning to recover. It could be that this is due to coral larvae drifting in from North Sea platforms.

Phase 1 of the program looked at the composition and biodiversity of marine life, from plankton to mammals. This included looking at plankton levels and distribution before oil exploration started up until now. It looked at connectivity and reef effects and aimed towards being able to model eco-systems to predict the effect of man-made structures.

While Phase 1 helped progress the understanding of the effects and connectivity of man-made structures in the North Sea ecosystem, some ground truthing is needed, says Heard, and more data is needed across the basin.

The Phase 2 work hopes to address some of these concerns. Its main objectives are to, one, understand the role of man-made structures as an inter-connected hard substrate network across the North Sea, two, understand the role of man-made structures as artificial reefs, and, three, provide ecological monitoring and assessment of man-made structures as whole systems in the North Sea ecosystem.

Heard says this work will be split into three threads: a data initiative, a science program and a technology program. A call will go out this year for science projects. The data initiative with rely on industry support and aims to gather and process existing data, develop protocols, collect and process new data, and develop data access products, eg. a portal. "We need to understand what data is out there. Is it relevant to science? How do we get it from operators?" says Heard.

Heard hopes that the industry will help by providing data, but also access to facilities for data collection, i.e. marine life surveys, sampling and monitoring, access to survey vessels and ROVs for monitoring, and the deployment and collection of data acquisition tools.

The technology program will seek out low-cost data acquisition systems and other technologies to enhance the data initiative.

TOXIC MUD

From the 2015 Fundão Dam Collapse affects Corals at Abrolhos Islands

By Claudio Paschoa

As Brazil deals with the effects of the recent Brumadinho dam collapse, which spilled around 12 million cubic meters of ore tailings and mining waste over the Vale do Rio Doce mining company´s administrative area, cafeteria and nearby towns - causing 179 deaths and the disappearance of 131 persons, at present count - before continuing on to contaminate rivers, the effects of the 2015 Fundão dam collapse are being felt on corals surrounding pristine offshore islands that form a unique environmental protection area and an important national park.

After the Fundão dam collapsed – Fundão was the name of the dam owned by Samarco, a JV between mining giants Vale do Rio Doce & BHP Billiton - near the town of Mariana in the state of Minas Gerais, on November 5th, 2015, the ore tailings and other mining waste contained within a massive wave of mud and sludge, contaminated the Rio Doce (Sweet River) for around 500 km. The mud wave destroyed everything in its path all the way downriver to the mouth of the Rio Doce, at the small coastal town of Regência, in the state of Espírito Santo, where its brown fan shaped plume reached the sea. The plume stretched for miles offshore and one of the great uncertainties was whether it would reach the Abrolhos archipelago on the southern coast of Bahia, 250 km north of the river mouth. The Fundão dam collapse released approximately 39.2 million cubic meters of tailings and other waste. The tailings reached the river Gualaxo do Norte, crossed its bed and emptied into the Rio Doce. It is believed that 20.3 million cubic meters of material was deposited in the dam of the Risoleta Neves Hydroelectric Power Plant (Candonga). Another 18.9 million cubic meters of tailings followed the flow of the watercourses and reached the sea on November 21, 2015.

"About three months after the arrival of the Fundão tailings at the river mouth, we observed at Abrolhos a corresponding increase in heavy metals that this mud carried, "recalls Heitor Evangelista, researcher and professor at the State University of Rio de Janeiro (UERJ). "It was proof that some of that invisible material had arrived. The water in Abrolhos remains transparent, but it has finer, more soluble materials that get

Foz do Rio Doce em Regência

Creative Commons - Arnau Aregio

there and, on arrival, have been incorporated by organisms. " For years, geophysicist Heitor Evangelista has been researching the corals of the Abrolhos National Park in Bahia. The chemical information contained in the skeleton of the existing species, helps to recount the history of the local marine ecosystem, such as water temperature over time.

"Corals are organisms that, as they grow, form a skeleton, which is being stacked. The fabric that forms the coral is millimetric, all it has inside is skeleton. If you cut it, you will see the layers. Each of these represents a year of growth, "explains Evangelista - "As it grows, it stores information from the water column. Everything that happens in the water, leaves a record in the skeletons. Coral is a monitor, a bioindicator, of the things that happen, with the advantage that it keeps this information year by year, and we can, through chemical analysis, rescue this information from the past." Some of these elements contained in the mud that arrived at the river mouth are formed by very small particles including trace elements, that solubilize in the water, and they are then transported by prevailing currents. When these small particles reached the corals, it was recorded in the growth lines of their skeletons.

The researchers measured the concentration of 46 chemical elements in the corals, some of which, such as zinc, copper, lanthanum and cerium, peaked shortly after the arrival of the sludge. "These materials were probably in the trough of the Rio Doce, and when the mud came, it dragged everything. It was like a shockwave, which carried this material quickly to Abrolhos, "says the scientist. "Other elements have increased constantly after the arrival of the plume, such as arsenic." In a nearly 50-page report, the researchers presented detailed analyzes of the presence of metals in the region. In addition to UERJ, the research was supported by the Federal Fluminense University (UFF) and the Pontifical Catholic University of Rio de Janeiro (PUC-Rio). Throughout the work of monitoring the dispersion of mining sludge at sea, professor Evangelista, along with his students, updated a Facebook page - Abrolhos Sky Watch - with satellite images showing the course of the sediment plume, so that society could also be informed about the impact of the tragedy. The study highlighted that more than three years after the rupture and collapse of the Fundão dam, the environmental damage caused by the mining companies have not yet been fully measured and contained, both inland and offshore. Do to the negligence of the mining companies and the Brazilian government, ecosystems will continue being contaminated and degraded. The risk is that the fragile ecological balance that favors coral formation may be affected, for example with the proliferation of other harmful organisms. Only long term monitoring will ascertain the level of environmental impact, as there are no parameters globally for this form of coral contamination.

Lifting of the accommodation module from BP's Miller platform by Saipem's S7000 heavy lift vessel.

Image: BP

Decommissioning

For some decommissioning is a dirty word. But, costs are starting to be tackled and operators are getting to grips with late-life to end-of-life operating models. But there is still a lot to be done.

By Elaine Maslin

Decommissioning is starting to become a regular business on the UK Continental Shelf (UKCS), if not a huge business. More and more operators have started to build experience, understand the challenges and reduce costs. Learnings and efficiency gains help fell spending for 2017 by 17%, from a projected £25.3 million to £21 billion, according to Oil & Gas UK's Decommissioning Insight 2018 report.

To put that into perspective, the sum for 2017 was about 8% of the total spending on oil and gas operations on the UKCS that year. However, 2017 also saw, for the first time, the number of wells decommissioned out number the number of new exploration, appraisal and production wells combined, although it is hoped that more can be done to increase the number of the latter.

Decommissioning is just starting, however. Over the next decade, £15.3 billion is forecast to be spent on decommissioning offshore oil and gas facilities in the UK North Sea, according to the Insight report. Nearly half of that spending is expected to be on the plugging and abandonment of about 2379 wells and half of the total is expected to be in the central North Sea, the Offshore Decommissioning Conference, run jointly by Oil & Gas UK and Decom North Sea and held in St Andrews, Scotland, heard late November.

Pauline Innes, director of decommissioning at the Offshore Petroleum Regulator for Environment & Decommissioning (Opred), told the event that, so far in 2018, eight projects had been approved in the UK North Sea: two Brent platforms and the Brae topside in the northern North Sea, the Rev pipeline and Jacky in the central North Sea, and Markham ST1 (unmanned platform), the Ann and Alison, and Saturn subsea tiebacks, which tie into the Audrey facilities, which is the eighth project, all in the southern North Sea. These eight projects amount to 57 wells, 120,000-tonne of topsides, 5000-tonne of subsea infrastructure, and some £2 billion expenditure.

A further 14 projects had completed consultation and were progressing towards approval, with eight of those expected to be agreed by the end of 2018. The 14 projects include three potential OSPAR derogation projects, Brae, Brent and Ninian. OSPAR derogation projects are were platform jackets installed before 1990 and weighing more than 10,000-tonne can potentially be left in place and not removed, as required under the OSPAR convention rules, which requires a clean seabed at the end of de-

Image from Oil & Gas UK

Image from Oil & Gas UK

"Talking about decommissioning is about as preferable as talking about funeral arrangements at the dinner table,"
Neil Fowler, Decommissioning Director, Taqa Europe,
who says this attitude is now changing

commissioning.

Meanwhile, 32 projects were ongoing and at various stages of completion (see table), from Murchison, whose topsides and jacket have been removed, to the most recently approved projects. The projects vary from huge northern North Sea platform removal to single pipeline decommissioning scopes.

Problematic predictions

Predicting decommissioning activity is a challenge, Innes points out, as projections don't always match reality. Some 28 decommissioning projects had been expected to be approved in 2018, for example, yet as at the end of November, only eight had been approved. Similar trends happened in 2016 and 2017, with 27 and 16 projects expected, yet only three and eight approved in those respective years.

Some of this is due to life of field extension - making platforms work for longer - and the changing plans of operators. It's also pragmatism. In two cases, decommissioning plans were agreed for topsides while deferring the decision on the jackets, because they were OPSAR derogation contenders, which is a process which takes longer. By letting the operator get on with removing the topsides, they're reducing cost exposure.

The OSPAR (i.e. Oslo Paris convention) decision 98/3 is one of the key regulations relating to the removal of North Sea infrastructure. It's overriding principle is one of leaving behind a clean seabed. There's been some discussion about reviewing OPSAR (Offshore Engineer, December 2016, Up Against Ospar), and the potential for safety zones around left-in-place facilities subsea, but, following an Offshore Industry Committee meeting in March, followed by a governmental meeting in June, it was decided not to review the decision, which can be reviewed every five years.

Increasing focus has been on subsea infrastructure and what has to be removed, which includes anchor bases and plinths. For pipelines, some of which have already been buried when installed, evidence-based decisions have to be made. One specific area of difficulty, however, is pipeline bundles, i.e. larger pipelines which contain multiple pipelines inside them and which are floated out and installed in situ, says Innes. These present a challenge in terms of removal and Innes says operators need to work collaboratively to develop technology to remove bundles.

Reducing costs

A large bug-bear for the industry is the

Image from Oil & Gas UK

Pictured, from left: Nils Cohrs, head of decommissioning at the OGA.

Pauline Innes, director of decommissioning at the Offshore Petroleum Regulator for Environment & Decommissioning (Opred).

John Clark, EMEIA leader for oil and gas transaction advisory services.

cost of decommissioning, up to 70% of which can be offset by tax relief, which means it's also an issue for tax payers. The Oil & Gas Authority (OGA) has a Decommissioning Task Force which is targeting a 35% reduction in the total cost of UKCS decommissioning, from the £57.9 billion estimate made in 2017, to less than £39 billion.

Nils Cors, head of decommissioning at the OGA, highlights that well plugging and abandonment is the biggest cost area in decommissioning – at about 46% of the total - and has the biggest potential for cost reduction. A 50% cost saving here would amount to a £14 billion saving over all, he says. He says that, between 2018-27, some 180 wells a year are expected to be plugged and abandoned, peaking in 2023-24, with about 110 of those from platforms, the rest being subsea and requiring mobile rigs or other vessels. Some of the efforts already being made are having an impact here. According to Oil & Gas UK's Insight report, efficiency gains have already helped reduce well decommissioning costs by 26% on average.

According to business consultancy EY, one way to reduce costs is aggregating work. Some 349 fields are expected to be decommissioned by 2025, comprising 2447 wells, 206 platforms, 1.4 million tonnes of facilities, costing in total £17 billion. Many of these fields have different owners and are spread about the North Sea, making aggregation hard for individual owners, especially those with small asset bases. Some could decide to sell on their assets to specialist late life to decommissioning companies, suggests EY's Jon Clark, EMEIA leader for oil and gas transaction advisory services. Indeed, in some cases, assets that major operators had planned to de-

Image from BP

Lifting the heli-deck off the Miller platform.

The Armada field conductors. While slated for decommissioning, a new operator, Chrysaor, has brought a new lease of life to the Armada hub.

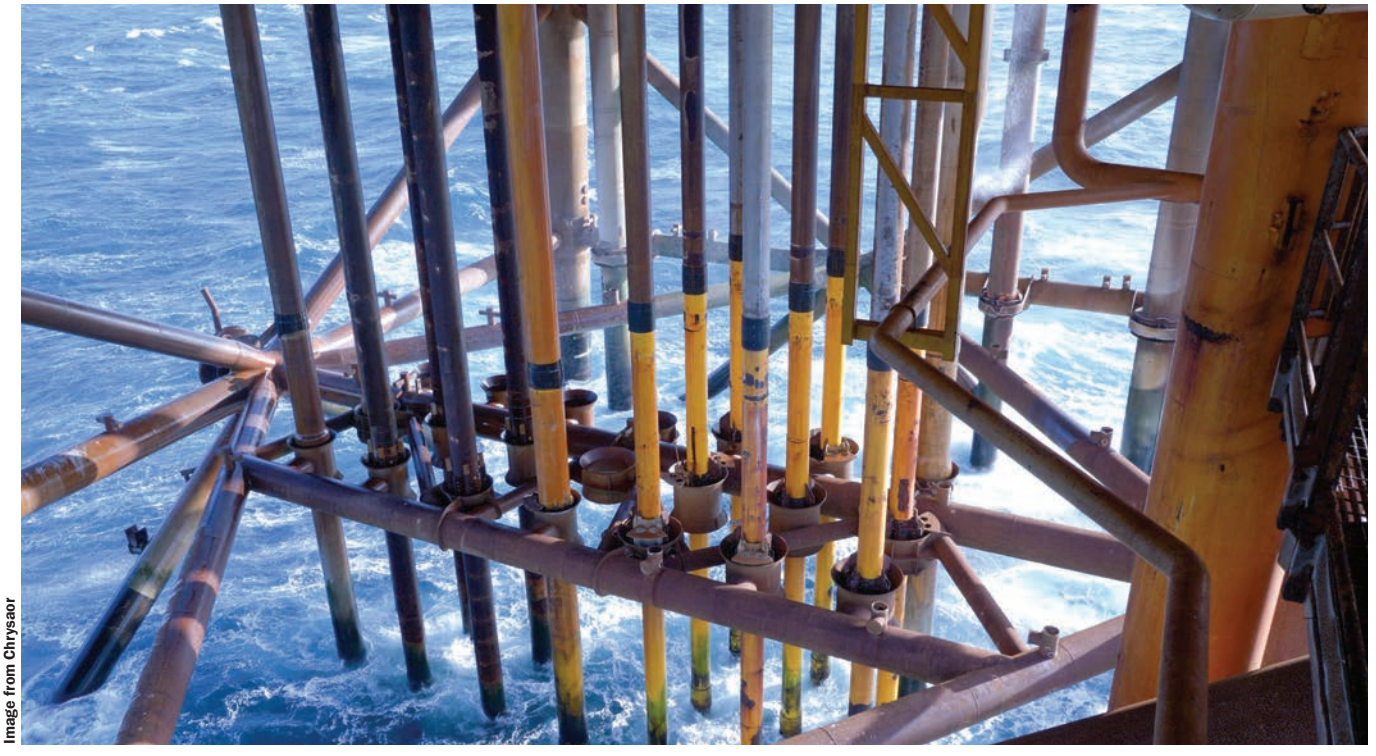


Image from Chrysaor

commission have been sold on and have now been given a new lease of life – such as the Armada hub, which is now under Chrysaor. Other options include contracting out the world as a package or outsourcing. Indeed, the supply chain has been gearing up to offer new service models, with a number of companies, including the likes of BHGE, as well as new startups like Well-Safe Solutions, offering integrated well abandonment services.

UK Continental Shelf

Decommissioning by the Numbers

- **More than 400 fields**
- **>320 platforms**
- **>4000 wells**
- **>2 million-ton of topsides**
- **75,000-ton of subsea infrastructure**
- **>20,000km of pipelines**

Data from OGA

Ongoing UK North Sea decommissioning projects – data from OPRED

Northern North Sea	Central North Sea	Southern North Sea
Osprey	Jacky	Ann and Alison
Merlin	Rev Pipeline	Saturn (Annabel)
Dunlin (DFGI pipeline)	Ettrick and Blackbird	Audrey
Brae B topsides	Janice, James and Affleck	Markham ST1
Brent topsides	Athena	Viking Satellites pipelines
Leadon	Rubie & Renee	LPD1
Murchison	Miller	Leman BH
Schiehallion and Loyal (phase 1)		Viking Satellites platforms
Don		Thames Area (6 projects)
		Stamford
		Welland

Future projects currently being considered – data from OPRED

Northern North Sea	Central North Sea	Southern North Sea
Brae Area	Beatrice	Tyne South
Brent	Atlantic and Cromarty	Guinevere
Ninian North	Curlew	VDP2
Lochranza NW		VDP3
Nevis N11		Bains
		Windermere

No More Miller

BP's Miller platform was made fast work of by Petrofac and Saipem.

By Elaine Maslin

Two years ago, the Miller platform stood complete in the central North Sea 270km north east of Aberdeen. Today, there's nothing there to see.

After six months' platform removal preparation, 15 heavy lifts and three extended lifts, over 150 nautical miles each, in the hook of the heavy lift vessel Saipem 7000, the facilities are largely removed.

The topsides, weighing some 28,200-tonne, were removed in 12 lifts over six weeks while the main 11,500-tonne section of the jacket was cut while in the heavy lift vessel crane hooks and removed in three pieces and taken in an extended lift to shore, over a period of two weeks offshore and then three weeks onshore for removal.

The result was a US$2500/tonne removal cost, a figure significantly lower than the industry benchmark, according to Jim Blacklaws, decommissioning project manager, BP.

The story goes back a little longer than that, however, and, significantly, it involved BP putting a service company in charge. Miller, discovered in 1983, came on stream in 1992, producing some 345 MMboe over its life time. Production ended in 2007, but the facility was maintained, for plugging and abandonment operations and to support a search and rescue helicopter operations base.

The decommissioning programme was approved in 2013, then, in 2016, after the facility was no longer needed, BP "listened to the industry" and awarded Petrofac a duty holder contract, so that it could over management of the platform and the decommissioning programme, says Blacklaws. Petrofac then worked with engineering, prepare, removal and disposal (EPRD) contractor Saipem.

Stephen Diplock, operations manager, Petrofac, says a different mindset is needed for decommissioning. "You're moving from an operations domain to a projects domain. Operations is status quo and dealing with deviations from the norm. These complex (decommissioning) projects are all about change. These are also not greenfield sites, you can remove hazards and operate very differently. We created a flexible team good at dealing with ambiguity. How to deal with what you find is where you can get a lot of efficiency."

The result was, following a drone survey, among other pre-

Image from BP

Left: Saipem's S7000 lifting the accommodation module from BP's Miller platform.

Below: Saipem's S7000 using the "lift and carry" method.

Right: The derrick being lifted off the Miller platform.

Image from BP

paratory work, removing sections of the platform piece by piece and then taking them to shore, at Kværner Stord in Norway, either on the deck of the S7000 or while still in the crane hooks, which is sometimes called "lift and carry" – and not a common operation. Normally, sections are lifted off and then transferred to barge, a process which can add time and complexity.

A key decision was removal of the flare tip, which, at 163m above the sea, was the tallest in the North Sea, says Christina Krachtoudi, topsides removal lead engineer for Saipem. A decision was made to leave it on, instead of adding operational hours offshore, and it being removed at the same time as the well bay it was attached to and being carried in the hook all the way back to shore. "This was an industry first," says Krachtoudi.

Cutting of the jacket was done by from a subsea construction vessel while the heavy lift vessel was on site and had the jacket in the crane hooks. The jacket was then transported to shore, partly submerged due to its weight, before being lifted onto a quayside to be cut up.

McDonald

Senior Vice President, ROV Division, Oceaneering

All images: Oceaneering International

***Martin McDonald**, an industry veteran with more than 35 years under his belt, is responsible for Oceaneering's global ROV business. With a broad based of ROV experience – from operation to repair to maintenance to management – McDonald shares with MTR his insights on the historical development and future prospects of this high-profile subsea sector.*

How and when did you know that your career would be in the maritime/subsea industry?

I grew up in Fraserburgh, Scotland, a small town 40 miles north of the oilfield city of Aberdeen. Fraserburgh is best known for commercial fishing. My father was a boat builder and, from an early age, I was fascinated by the maritime industry, so it was either commercial fishing or the oil field. I chose the oil field and, specifically, the subsea industry. I studied electric and electronic engineering at college, and began my career with a subsea construction and diving company as a hydrographic survey engineer working on positioning and navigational equipment. That company also had a small fleet of ROVs, (which at the time) were an emerging technology. I was interested in this technology, along with the variety of work scopes where ROVs could be involved, and the potential they had to develop further. I later transferred to work full time on ROVs and their associated sensors.

The Oceaneering name is well known, but can you give a size and scope of Oceaneering's ROV offering.

We currently have 275 work class ROVs in our fleet, the world's largest fleet of work class ROVs, and we operate 60 observation class ROVs. The ROV division has approximately 2,400 full-time personnel, with the majority (about 2,000) in the field. With ROVs diving every day, we conduct over 100,000 missions in a year of varying durations and intensity.

The (offshore energy) downturn has naturally reduced activity levels, and, as with other markets (vessels and rigs), we have retired units that have come to the end of their working life. Our fleet count peaked at 318 work class ROVs in 2014. While we have removed ROVs, we are also adding units, so, net-net, we are at 275 (work class) ROVs today.

When you're adding units, is there a specific technology that is most important?

Yes, when we're adding units, we're upgrading them with the latest technologies, such as the latest control systems, navigation sensors, software, pumping packages, and intervention equipment.

Looking at work class, inspection class, and observation class vehicles, are there any product gaps that still need to be filled?

We've identified some gaps in the market. As we move forward, autonomy, remote operations, speed, and reliability are all coming into play. The opportunity will come from reducing the cost of development for our customers. We see more remote and autonomous operations taking place that are in line with the industry focus of reducing risk to personnel and lowering carbon emissions with fewer assets at the worksite.

Additionally, there is a need for more specialized equipment. Today, ROVs are working in deeper waters on increasingly complex work scopes and also in harsh shallow-water environments with high-current, low-visibility areas, so it is essential to have higher-powered units with high-specification and reliable intervention capabilities that are able to work efficiently through the full range of environmental conditions in the frontier oil and gas, and renewables sectors. We see opportunities to enhance our service offerings by bringing remote operations, autonomy, and subsea residency (via resident ROVs) to the market.

How is Oceaneering working to fill these gaps?

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

Recently, we conducted a demonstration of remote operations and autonomous docking in the Gulf of Mexico, where we remotely piloted an ROV, which was stationed on board a drilling rig, from our operations center in Houston while also performing autonomous docking functions. Remote piloting technology is maturing and is currently operational in the North Sea, where we have a number of contracts. We're piloting ROVs remotely from our mission support center in Stavanger, Norway. This center has enabled us to complement ROV operations offshore with onshore operations. The same skilled pilots are working between offshore and onshore locations on rotations, and this is a new way of working.

To accomplish this, our equipment has to be reliable. We are investing significant energy and resources into improving systems reliability, along with component and material qualifications, so that today's ROVs can become resident subsea vehicles that can be controlled remotely and operated with minimum to zero maintenance.

What do you count as the most important technology, or technology trend, that has made ROVs more efficient and cost effective?

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

There's also machine learning and machine vision. As I mentioned earlier, we have been working on automated operations, such as auto docking, where the ROV pilot can direct the ROV to move autonomously to a docking point by moving a cursor on the screen, without any intervention on the joystick. It is the machine vision recognition software tied into the control

and inertial navigation systems that allows it to perform those tasks consistently. This is still an emerging technology, and it takes a little time to dock autonomously. The reality today is that a really good pilot could do it quicker, but not necessarily consistently and repeatedly. The technology is evolving, but I expect that auto docking and intervention operations will become faster and more consistent in the near future, providing more efficient and reliable operations.

The telemetry, control systems, and communication links for ROVs have come a long way as well. Faster communication and reliable telemetry, control systems, and software advancements have enabled us to get to where we are today and will help us get to where we're going.

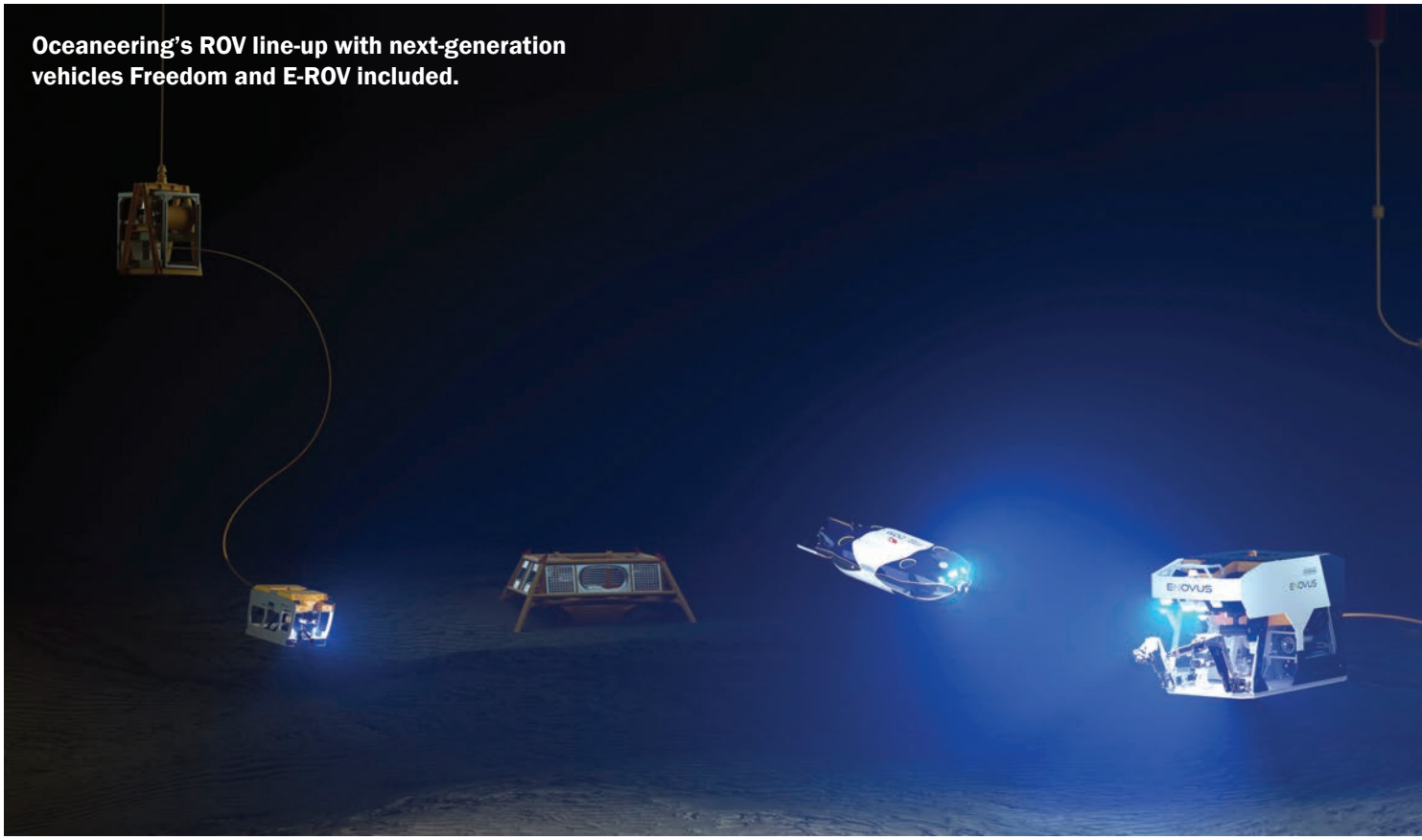
Does Oceaneering develop its software and control systems in house?

That's a key differentiator for Oceaneering: we have our own in-house software development teams. All of our controls software is developed by our staff engineers, and we're currently developing the advanced software that will run our next-generation ROVs and autonomous underwater vehicles (AUVs). Our current fleet runs on our own software and control systems, and I expect that our future vehicles will run on our next-generation software and control systems. We don't currently outsource any of this development; however, we are not averse to partnering or collaborating with other companies that have unique skill sets. We're always open and on the lookout, but, right now, we have planned our own development.

What are the prevailing technical trends driving ROV design and development today? What do you need these vehicles to do that they currently cannot do?

Keeping with the theme of residency and autonomy, electric ROVs have been around for a long time, but continued advancements in electrical systems and battery technology will be an extremely important enabler allowing increased range, durability, and more complex autonomous operations – ultimately leading to a reduction in surface vessel days. If our customers can use less vessel days in the support of their field development, operations, and maintenance, then we're going to lower the overall cost of ownership and open up new opportunities.

Robust communications systems are another important need – 4G networks didn't exist in the North Sea a few years ago, and now there is close to 100% coverage. Soon 4G networks



Oceaneering's ROV line-up with next-generation vehicles Freedom and E-ROV included.

Image: Oceaneering

will come to the Gulf of Mexico. Communication networks are expanding out into the fields, as are improvements in satellite technologies. Adding to these two are advancements in subsea wireless technologies. These three components will open up a new theater of operations for autonomy and remote operations.

Real-time data processing and subsea imaging comprise another important area – integrating the cameras and sensors to the ROVs to provide real-time 3D imaging of structures that are communicated directly to engineers onshore so they can then make asset-integrity decisions quickly. The images can also be built into a virtual reality environment, effectively digitizing the field and enhancing subsea navigation. Traditional methods use sonar and acoustic navigation, but virtual reality is here and becoming more advanced. As we move forward, we will build up 3D images of particular fields and other locations. Virtual reality is used on the surface, and its capabilities are expanding subsea. We are currently working on a project to enhance subsea 3D imaging capabilities in real time. You cut out the data processing so that the processing is done immediately. Looking for anomalies has historically been done post-processing, which takes up time and involves extra vessel days and personnel days. If it can be done on a real-time basis at the worksite, then it's going to be more efficient and, of course, more cost effective.

What evolution or improvement to ROVs – the vehicle, control elements, or accessories – would you most like to see?

It's a balance between hydraulic and electric propulsion systems. We will see

A Millennium ROV recovered from the water.

Images: Oceaneering

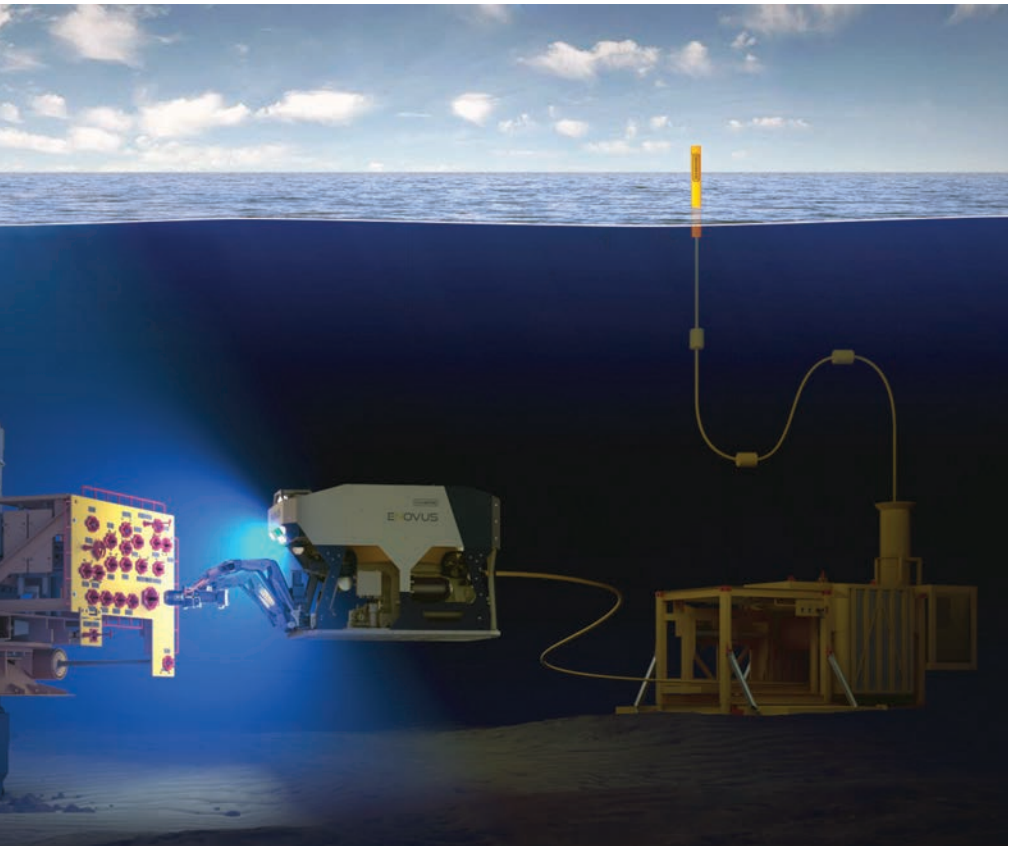
electric manipulators coming into play, reducing the reliance on hydraulic systems. ROVs today still require some heavy-duty pumping and intervention capabilities, so that's the challenge between getting the all-electric systems vs. hydraulic systems. Today, for example, electric manipulators offer less than 50% of the lift capability and efficiency of a hydraulic manipulator.

We're talking specifically about ROVs, but critical components of the ROV system are the handling systems and reliability of the deepwater umbilicals. Oceaneering has invested a significant amount of money on the research and development (R&D) of umbilical design and maintenance. As a result, we have been able to implement better maintenance plans that result in improved life expectancy, lower cost of maintenance, and improved life expectancy of our umbilicals and handling systems. In the automated space, ultimately, we see ourselves going toward automated launch and recovery systems as well.

When you look at the market today, what do you see? Where do you see opportunity?

The opportunities exist in the themes I mentioned earlier. We have been affected like everyone else in this prolonged downturn. We are a leaner and more efficient organization. We have a significant geographic spread across the globe. The opportunities lie in us collaborating with our customers to not only lower the costs of their field developments, but to also lower the operational costs of their fields. We are designing our next generation of vehicles to participate in those themes: autonomy and remote operations, residency, and reliability of those systems.

Our industry has structurally changed. We are living in a low oil price environment, and this is the new norm. We are designing our systems and service offerings to be profitable and sustainable in this low oil price environment.



Oceaneering's E-ROV vehicle.

How has this offshore energy slump materially impacted the Oceaneering ROV unit? How is it different today from four years ago?

We're a leaner organization today, having consolidated groups and support functions together. We're more efficient, and we maintain strategic locations around the globe. Having a dedicated installations group that deals only with the installation, reactivation, and demobilization of systems is important to our business. Today, we have less than 50% of the onshore support group prior to the downturn, yet we are still efficiently serving our customers and business. We've been able to streamline our operations globally by implementing operational excellence initiatives.

At one point, prior to the downturn, we were manufacturing ROVs at the rate of one approximately every week. There was an overcapacity in the market, however, so we turned our attention to refurbishing and upgrading existing equipment. Instead of building new ROVs, we've been refreshing our existing fleet and advancing them by introducing cutting-edge technologies.

We have also become a lot more efficient at mobilization and demobilization activities. Prior to the downturn, we

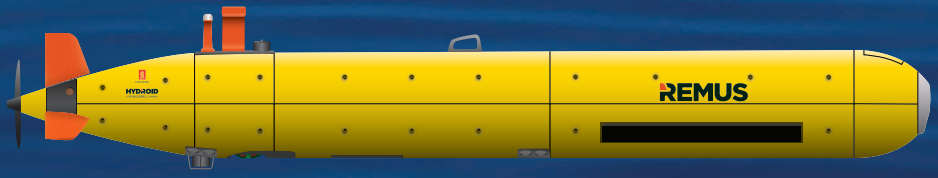
HYDROID
A KONGSBERG COMPANY

KONGSBERG

REMUS 100
- 100 Meter Rated
- Industry Leading Man-Portable AUV

REMUS 600
- 600 Meter Rated
- Modular AUV

REMUS 6000
- 6000 Meter Rated
- Deep Water Workhorse



UNMATCHED RELIABILITY

SEAGLIDER™ C2
- 200 Meter Rated
- Endurance up to 3 Months

SEAGLIDER™ M1
- 1000 Meter Rated
- Endurance up to 10 Months

SEAGLIDER™ M6
- 6000 Meter Rated
- Endurance of Over a Year

Our heritage for reliability in autonomous underwater vehicles (AUVs) and marine robotics technology is unmatched. Our vehicles explore 99% of the world's oceans and, with the ability to be used for numerous applications from under-ice exploration to missions in the Caribbean, they allow you to complete your mission efficiently and accurately.

With a history of success stories for defense, marine research and commercial applications, our reputation speaks for itself. **Learn More at www.HYDROID.com/UnmatchedReliability**

REMUS 6000 = Unmatched Reliability

The New Generation REMUS 6000 Autonomous Underwater Vehicle (AUV) has been redesigned for increased endurance and modularity, with a focus on the integration of the latest cutting-edge technology.

By Graham Lester, Senior Vice President, Hydroid, Inc.

The Hydroid REMUS 6000 is legendary as far as autonomous underwater vehicles (AUVs) go. It has played a key role in several historic missions and discoveries and, as a result, has a reputation that speaks for itself. And, to continue this unrivaled heritage for unmatched reliability, Hydroid has recently announced the new generation version of this vehicle that is even more capable than it was before, while boasting the same proven software and electronic subsystems that are found in our highly successful REMUS 100 AUV.

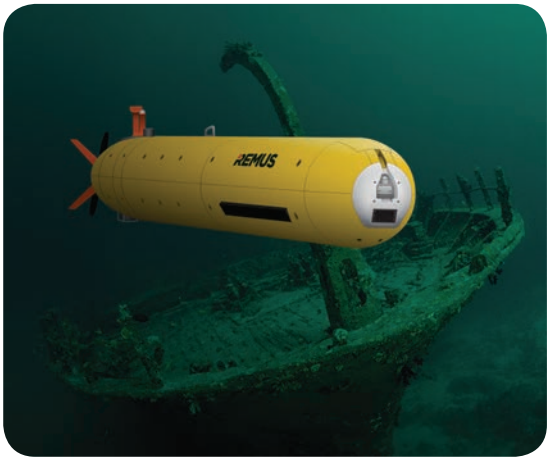
Key customer feedback was instrumental during the design and development of the REMUS 6000. The engineering team took advantage of miniaturized components to relocate the main electronics housing to the tail, freeing up space for a third battery bottle. The field exchangeable batteries provide long mission duration with the flexibility to perform continuous operations, and the compact design of the vehicle requires minimal deck space. The REMUS 6000 also features low power core electronics, an advanced navigation suite and an open architecture platform for advanced autonomy.

With the ability to add multiple payloads, the REMUS 6000 can be configured with a wide range of customer-specified sensors including, but not limited to, a dual frequency side scan sonar, synthetic aperture sonar, eco sensors, a multi-beam echo sounder, video camera, electronic still camera, sub-bottom profiler, inertial navigation systems and forward-looking sonars. Its sensor suite can easily be reconfigured in the field to meet specific and varied mission requirements.

The REMUS 6000 proven launch and recovery system (LARS) is designed to function off the stern of the ship but has the option of side launch. This is a big advantage for ships of opportunity and vessels where the stern is already in use with other systems. It can be containerized and operated in mid-ocean conditions.

With a history of unmatched reliability and the latest cutting-edge technology, the new generation REMUS 6000 ensures deep water surveying with confidence.

www.HYDROID.com



Key Role In:

- ✓ Search and recovery of many World War II wrecks including the USS Indianapolis, a U.S. Navy heavy cruiser that was torpedoed by the Japanese Navy during World War II.
- ✓ Search for the wreckage of Amelia Earhart's plane.
- ✓ Search and discovery of Air France 447 wreckage.
- ✓ Exploration of the Titanic site including the first 3D images of the debris field.

USS Indianapolis – Found by Vulcan, Inc. with their privately-owned REMUS 6000; Air France 447 search lead by Woods Hole Oceanographic Institution with REMUS 6000 vehicles from WAITT Institute and GEOMAR; Amelia Earhart search led by WAITT Institute with their REMUS 6000, Titanic survey led by WAITT Institute with their REMUS 6000)

would mobilize ROVs for a two-year or three-year contract. The new reality sees shorter-term contracts where, for example, three-week and three-month contracts are common. We have also spent a lot of time improving our installation and reactivation processes.

We're focusing our capital investment and R&D spend on selective projects, and, as I said earlier, we're listening to our customers, so we're confident that we are headed in the right direction. We have a five-year technology roadmap that will be rolled out during this period. The first success is our self-contained, battery-powered E-ROV contract award. This concept is generating a lot of industry interest, and we see more opportunities for E-ROV in the near term in field and drilling support. Through 2019 and 2020, we'll be rolling out more technology advancements from our portfolio.

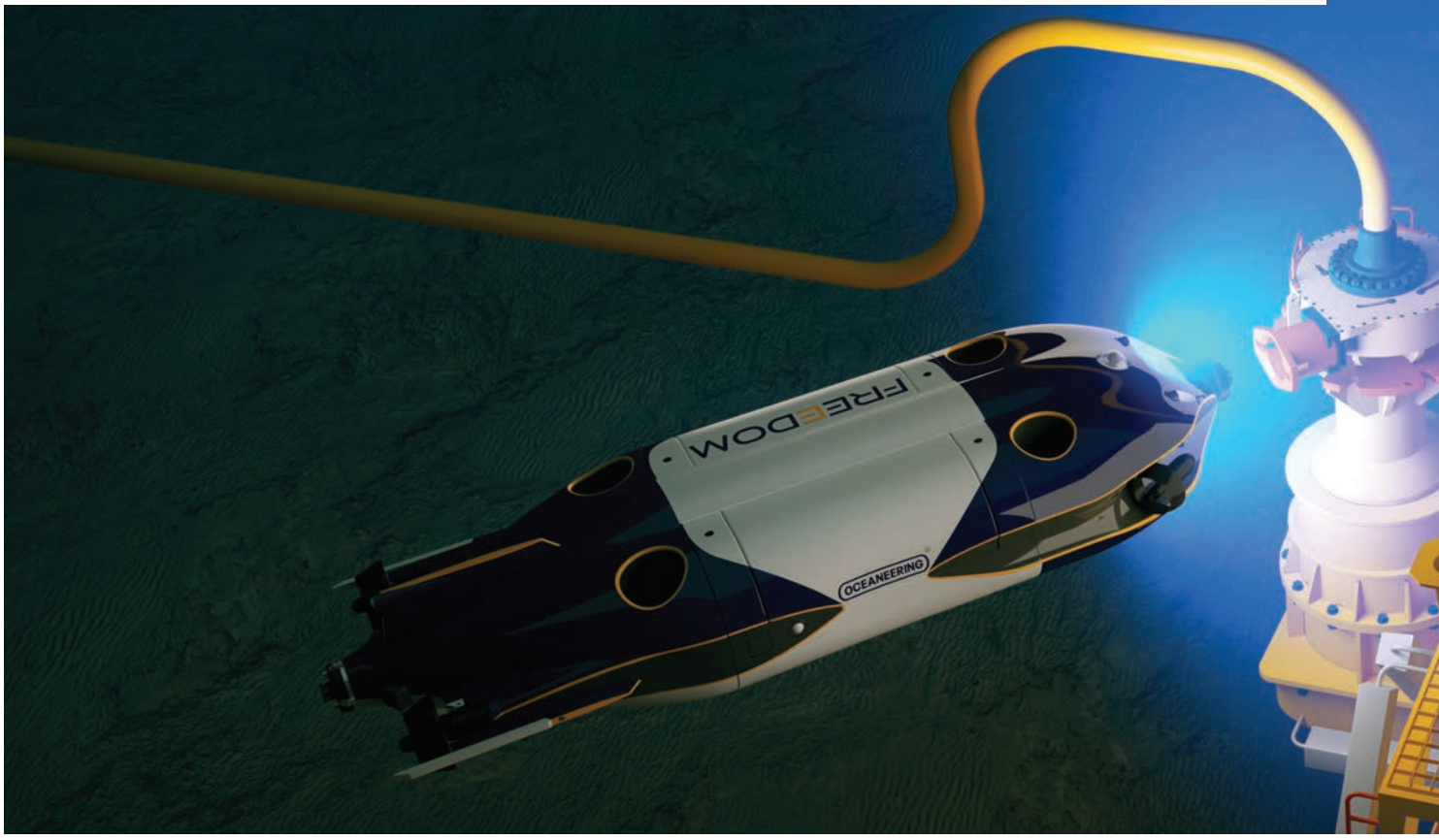
Please discuss in depth a case study or two that you believe best exemplifies your ROV unit's capabilities.

We were awarded a contract from a major operator in the North Sea to deploy the first version of our resident vehicle, the E-ROV, which stands for "Empowered ROV." The E-ROV is a resident, battery-powered ROV that will go subsea with a surface buoy. It's a work class electric vehicle with a hydraulic power pack to support its manipulator functions, and it is controlled remotely from our onshore mission support center with communications via the 4G broadband network, using a self-deployed surface buoy. We're very proud of this achievement. Subsequent to the initial scope, we've been awarded a three-year contract with options from the same customer, where the E-ROV will be deployed in a variety of locations and work scopes, servicing multiple fields. The E-ROV can be placed subsea in a particular location by a vessel of opportunity with a self-deploying buoy, and it can be recovered similarly by a vessel of opportunity and redeployed to another location within 48 hours.

It was a worldwide effort to develop the E-ROV system, combining the expertise of a number of groups within Oceaneering. We believe it is a significant technological advancement to the next stage of subsea ROV residency. Our next generation of vehicle (the Freedom ROV) will be supported by a docking station at seabed and will have a hybrid functionality that will enable it to operate in two modes: remotely piloted via tether to provide real-time control – or operated in an autonomous and tetherless mode, using battery power.

What is the E-ROV's current duration capability?

The E-ROV is currently battery-operated, but it can also be



Images: Oceaneering

connected to a subsea power source in order to have an unlimited duration. Current battery-operated subsea residency is designed for three months, but we are working to extend that. Our next-generation vehicle will be designed for six months.

The duration is dependent on the intensity of the intervention work scope that the E-ROV is performing. If it is purely observational, then it uses less battery power and will have a longer life cycle. If it is a manipulative or an injection skid intervention, then it is going to require more battery power, which will result in a shorter work life cycle.

Are you looking into any other power options?

Yes, we're exploring fuel cells and kinetic power buoys. A power buoy obviously works where there is wave action, so it may not be suitable in certain benign locations. It's possible to access power on selective existing subsea production systems, and we are working with customers to explore opportunities for deployment.

What other developments are most crucial to subsea residency?

Advancements in through-water communications is crucial. If that technology can be perfected, then it opens up another and more direct method of communicating with the subsea vehicle. For example, today, AUVs have to recalibrate and verify their positions. If we can do that subsea and also on the move, then that extends the duration and efficiency of any particular mission.

Performance, reliability, and innovation continue to be our priority. Current fleet performance is in excess of 99% uptime and, with two industry awards in 2018 for ROV technology and innovation under our belt, we are confident that these successes will continue. It takes dedicated resources: project planning, maintenance, operations support, R&D, and, of course, the most important component: our dedicated and skilled team of professionals.

Oceaneering's Freedom vehicle inspecting a subsea tree.

All images: Nortek

Current Profiling & China's Maritime Infrastructure Drive

Nortek staff in China mobilizing the Signature VM package under the attentive eye of end user Wang Yan, Senior Manager of Hydrology at CCCC's Zhongjiao No.1 Hangwu Engineering Reconnaissance Design Institute. As Signature VM is a straightforward plug-and-play system for current surveying, the crew were able to sail out for a test survey after only approximately 30 minutes of setup.

China's recent wave of infrastructure renewal has included a large portfolio of developments, such as ports and other developments, that have a subsea component. Accurate, efficient and cost-effective current profiling is vital in the successful implementation of major maritime projects.

Nortek has been able to play a role in this side of China's economic revolution, through its collaboration with a subsidiary of China Communications Construction Company (CCCC), a Fortune 500 listed firm that has been at the forefront of the infrastructure drive.

CCCC & Nortek

CCCC's hydrological surveyors have been using Nortek instruments on a number of projects over the last 12 years, using both Signature1000 and Signature500 acoustic Doppler current profilers (ADCPs) to provide hydrological data that informs construction of ports and offshore developments.

Deploying the instruments as part of Nortek's Signature VM package enables the company to obtain measurements in a diverse range of scenarios. These scenarios include cross-section, multi-point, velocity profile measurements and fixed-point measurements for offshore platforms, ports, bridges and other structures in or near the sea, as well as establishing navigation parameters at specific locations at sea.

The integrated package is designed to ensure high data quality and that both errors and initial installation time are reduced. The ADCPs and the linked software provide accurate profiles in conjunction with an Advanced Navigation GNSS compass mounted on the vessel, which provides navigation and heading data based on GPS.

"Without this essential data, as well as the verification of the mathematical model, the design and construction of ports and offshore developments would have no basis," said Wang Yan, Senior Manager of Hydrology of the Geotechnical Investigation Division at CCCC's Zhongjiao No.1 Hangwu Engineering Reconnaissance Design Institute.

The company has become a leading force in the field of coastal engineering construction in China. Since its establishment in 1958, it has been responsible for the survey and design work behind more than 4,000 projects.

A Diversity of Sites

Wang said the Signature ADCP's versatility makes it a good fit for the company, since the hydrological conditions and operating requirements at its sites are complex and diverse. He said the Signature's ability to work both at fixed points and while navigating, and to record measurements both online or as a self-contained unit, have proved invaluable.

The main task of Wang's hydrology survey team is to observe and analyze waves, tides and flows in different sea areas, to issue related reports and to provide basic data for the design and model checking of major offshore projects. Its work focuses include long-term and short-term observations of waves, fixed-point currents, nautical flows, sediment concentrations and tides.

Wang's team has used the Signature VM package in a range

Nortek China crew explaining the Signature VM software to end user Wang Yan of CCCC's Zhongjiao No.1 Hangwu Engineering Reconnaissance Design Institute.

of projects. One of these projects encompassed current measurements for a new port in the vicinity of Caofeidian District, in Hebei, China.

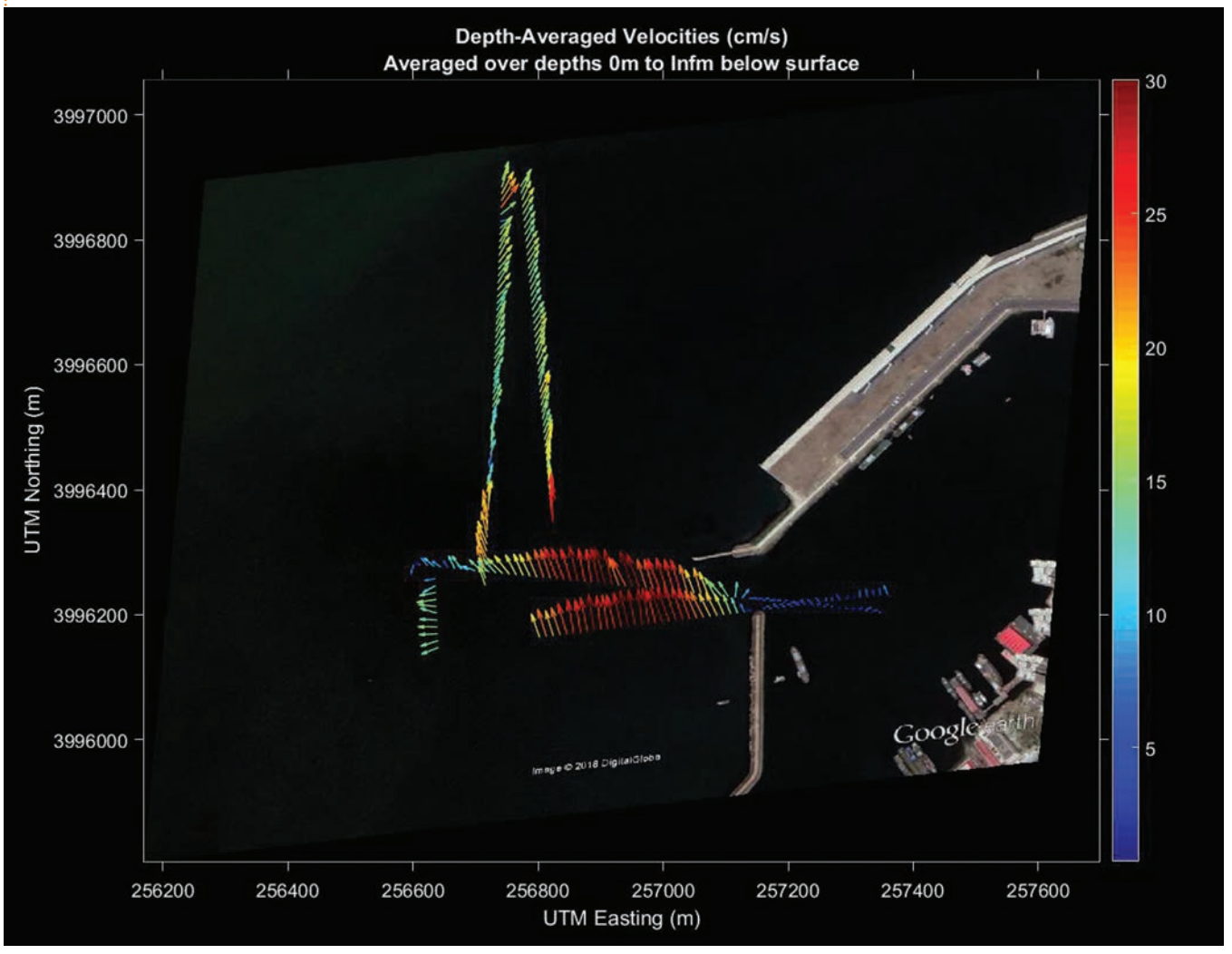
"Our customer needed site-specific raw data of currents, waves, depth, turbidity, etc. for a new port in Caofeidian. Their purpose was to use the data to build a mathematical model for the port area. This was very important for the engineering work in connection with the construction of the new port and adjacent buildings," said Wang.

His team selected two measurement sites according to their customer's technical requirements.

"We surveyed along these two sites back and forth in several rounds to obtain complete datasets of the whole tidal process in the area. Each round of measurements took about an hour, and we performed the measurements continuously 24 times, or almost 24 hours in total," says Wang.

"This was really a great challenge for the technical system, as well as for the people in my team who conducted the survey. But the results proved to be excellent," Wang adds.

Visualization of data showing current velocity and direction.



All images: Nortek

Developing infrastructure – such as the Qingdao harbor seen here – has been an essential component of China's economic revolution. Accurate current profiling has been vital in the successful implementation of major maritime projects, ensuring that structures are built to the correct specifications.

All images: Nortek

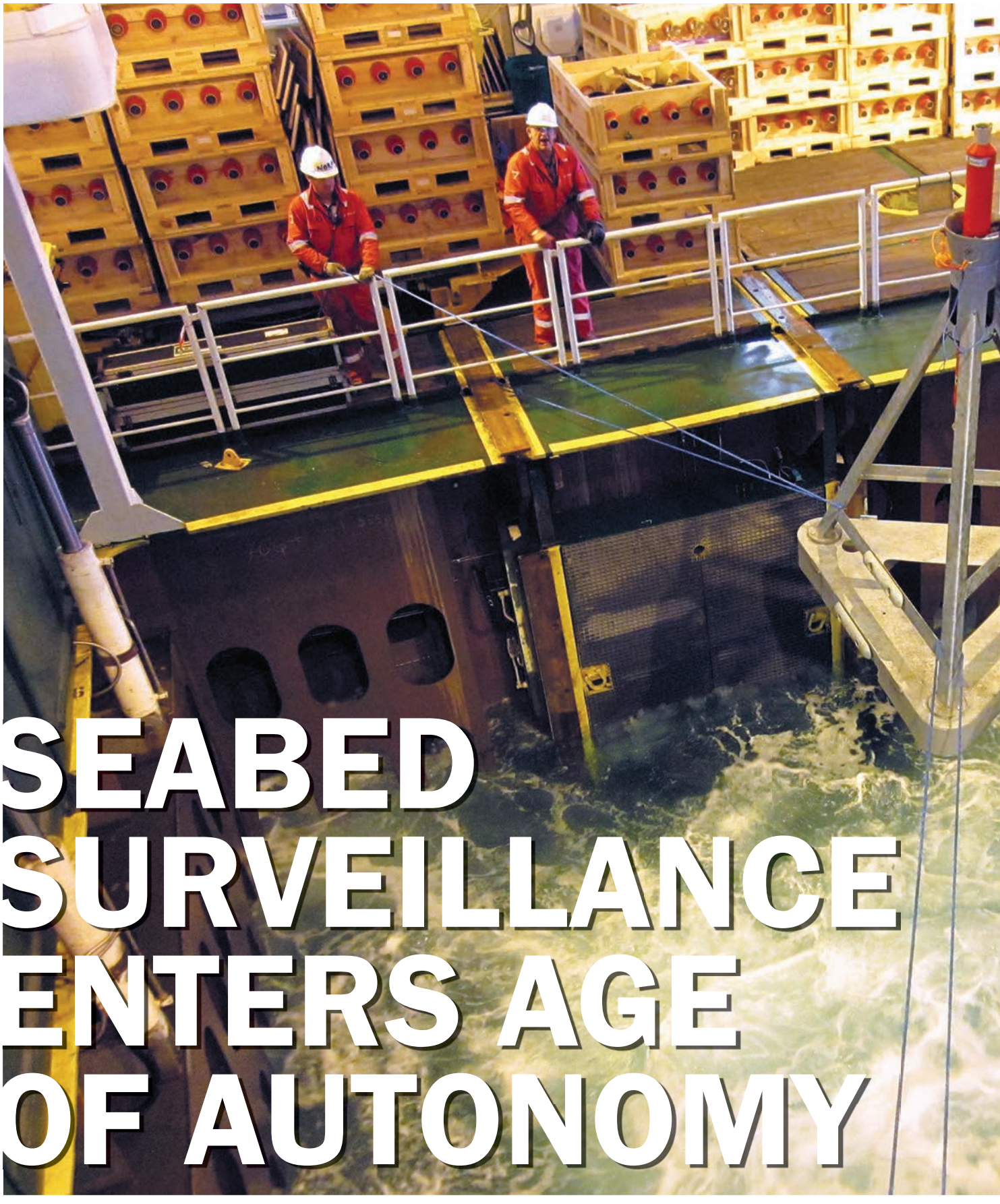


Image: Sonardyne

SEABED SURVEILLANCE ENTERS AGE OF AUTONOMY

Seabed deformation monitoring is moving into new realms of capability, as self-calibration, autonomous deployment and data collection open up new possibilities for extending the life of oil fields. Shaun Dunn, Global Business Manager, Exploration & Surveillance, explains.

Image: Sonardyne

German research vessel Sonne and a Wave Glider unmanned surface vessel (USV) were used to harvest data from AMTs. USVs can now also perform GPS-Acoustic measurements.

In the recent downturn, one of the measures oil companies took to sustain production was to focus more on improved oil recovery (IOR) programs at existing fields rather than exploring new frontiers.

Proactive management of existing reservoirs to maximize recovery, without the need for major upfront capital investment that developing new fields requires, was and remains a profitable way to get more product out of the ground, using less resource and reduced environmental impact. Yet, with IOR comes additional risks including fault-reactivation and other geo-hazards, such as seabed fractures, deformation or subsidence.

Seabed movement is often to be expected above reservoirs as they are produced and pressure levels fall. Several centimeters of movement a year is quite typical. As pressure levels in a production zone reduces, so does the ability of the reservoir rock to support the rock layers or overburden above it, leading to seafloor deformation phenomena such as a gradually increasing subsidence bowl.

While this movement might not cause a major hazard in itself, knowing how much movement there is, in what direction and how fast it's happening helps operators to learn more about how their reservoirs are performing and therefore how to operate them more productively.

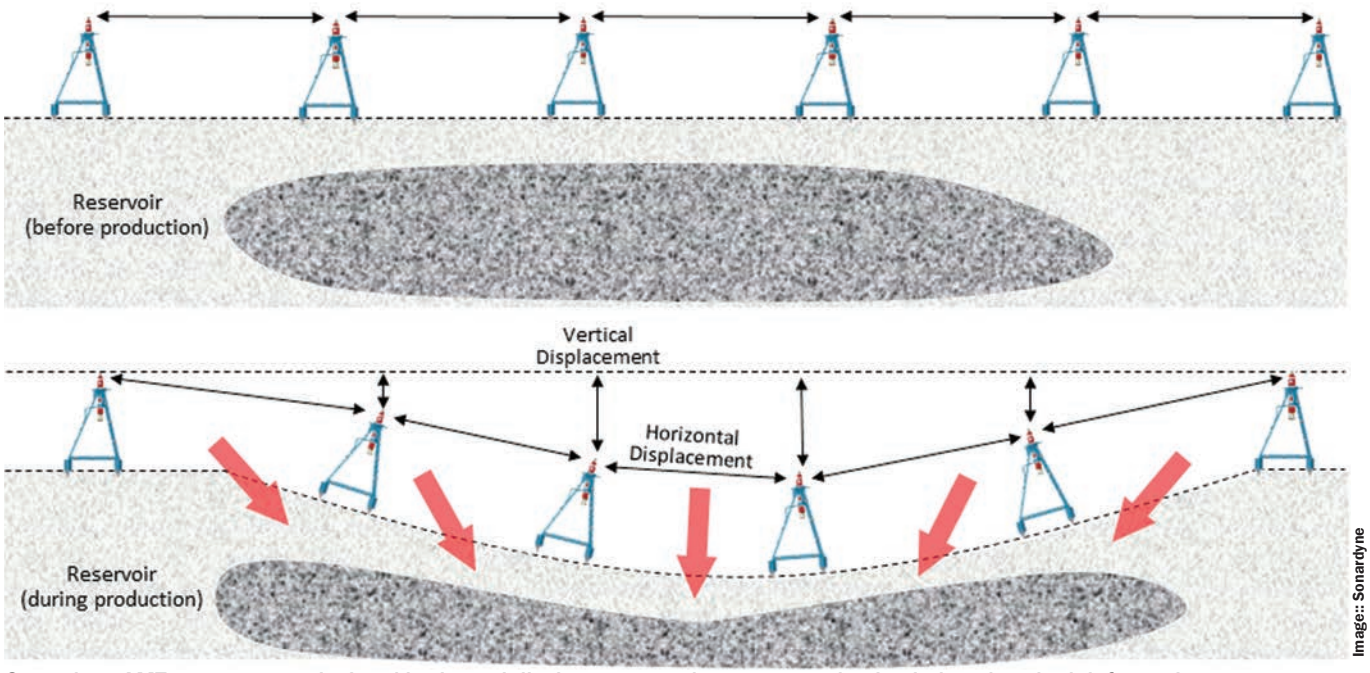
The ability to measure seafloor movement, laterally and vertically, over time, enables geophysicists to fuse this information with other production data to infer fluid flow, pore pressure, reservoir level compaction, etc., and then tune their reservoir management plans and improve recovery rates accordingly. During drilling and production activity, seafloor monitoring can also help to avoid geohazards, such as fault reactivation and mud slips.

WHAT WORKS ONSHORE, DOESN'T WORK OFFSHORE

However, in the past, it hasn't been easy to measure these small movements offshore. Onshore, GPS positioning, laser ranging and satellite altimetry systems can be used to determine the positions of, and distances between, objects on land to within centimeters or even millimeters. These techniques don't work subsea.

Traditionally, bathymetric sonars have been used to measure subsidence offshore, but their precision is severely limited, particularly in deep water, and the deployment logistics involved hinders their practical application for detecting slow subsidence rates, where long duration measurements are required. Portable Gravimeters are also used to detect changes in density brought about by water replacing gas for example. But, these sensors have to be moved between permanently deployed seafloor monuments using a remote operated vehicle (ROV), and repeated gravity and pressure measurements taken at each location. It's a lengthy, personnel, asset-intensive and therefore costly process and is only usually undertaken at multi-year intervals, which limits the usefulness of the data.

Over the last decade, a more cost-effective alternative has been developed, thanks to an idea Shell research geophysicists Dr. Paul Hatchell and Dr. Stephen Bourne had in 2006. They were aware that, because seabed deformation causes vertical



Sonardyne AMTs measure vertical and horizontal displacement to detect any production induced seabed deformation.

and horizontal displacements, a more continuous method of monitoring subsidence could be possible by taking vertical and horizontal measurements using long-term deployed subsea instrumentation. At the time, suitable long-endurance and highly sensitive monitoring equipment was not available, so Shell approached Sonardyne, because of our long history in high-precision instrumentation design.

INTRODUCING SEABED DEFORMATION MONITORING

Working with Shell, we developed the first seabed deformation monitoring system, which was deployed at Shell's Ormen Lange field on the Norwegian continental shelf in 2007. The system measured the horizontal distances between two locations on the seafloor using acoustic ranging and made vertical depth measurements using pressure sensors. These techniques are not new in underwater survey. Indeed, Sonardyne has provided these technologies to the offshore oil and gas industry for more than four decades. However, to create a seabed deformation monitoring system, a number of innovations were required.

To measure horizontal displacement, acoustic waves are transmitted as signals between pairs of our Autonomous Monitoring Transponders (AMTs), which are separated by hundreds of meters, and two-way round trip time of those signals is determined. The wave speed is also measured locally and in real time using integrated sound velocity sensors, so that the distance between AMT pairs can be monitored very accurately. Vertical displacement is measured using integral pressure sensors. By comparing the results from multiple AMTs, the effects of tide, water column density and barometric pressure changes can be removed from the results leaving only the relative seabed depth changes remaining.

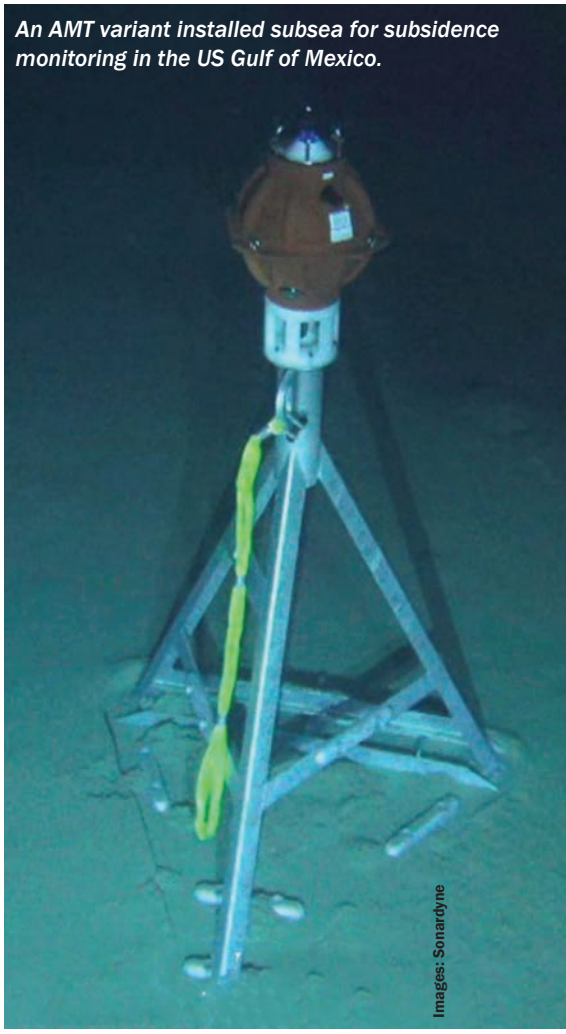
Sounds simple? It's not. A lot of hard work has gone in to developing this system so that it can provide both the sensitivity and long-duration service needed, at the seafloor depths required. This has included innovations in high-performance acoustic signaling, pressure sensing, low power electronics, waterproof pressure tolerant and corrosion resistant marine housings, battery technologies and acoustic transducer designs. We've also added an in-situ pressure sensor calibration in a process known as Ambient Zero Ambient (AZA) – to address the inherent drift that pressure sensors experience - without having to retrieve them to surface.

These systems are field-proven. Following our first sea trials at Ormen Lange, we conducted a longer-term deployment at the same site, from 2010 to 2015. During this deployment, nearly 220 AMTs were deployed, enabling five and a half years of continuous subsidence monitoring over the site, collecting some >600 million range observations. Versions of the system have been deployed by operators in U.K. North Sea, the U.S. Gulf of Mexico and offshore Asia.

LEVERAGING MOVES INTO MARINE AUTONOMY

But, we have not stood still. Using unmanned vehicles, we have been able to take this system even further: we can localize the precise positions of our AMTs using GPS-Acoustic

AMTs and their frames following recovery after more than five years deployment.



An AMT variant installed subsea for subsidence monitoring in the US Gulf of Mexico.

Images: Sonardyne

box-in (GPS-A) and then perform wireless data retrieval using unmanned surface vessels, such as Wave Gliders. Using unmanned systems saves cost, as they typically have running costs that are one or two orders of magnitude lower than average manned vessels. The result is that we now have instruments that are: fully autonomous; can be deployed to the seabed, remaining in place for 10 or more years without any direct intervention; make highly precise measurements of horizontal and vertical movement; and, using remote unmanned wireless data gathering capabilities, can routinely report information back to a user sat at his or her desk. It can therefore be used for the most challenging and high sensitivity settlement monitoring projects globally.

IMPROVING ACCURACY, IMPROVING RESULTS

But, the work doesn't stop. We're also continuously looking to improve the precision of our seabed settlement monitoring equipment. Through our work to enable regular in-situ calibration, as well as a research program to select and pre-characterize the best pressure sensors, and to localize the positions of equipment from surface drones, we have been able to achieve close to 1cm/year measurement sensitivity.

This is exciting – it could revolutionize seabed settlement monitoring because it unlocks a whole new global capability for monitoring fields that subside very slowly, including deep water fields, such as those in the Brazilian pre-salt and the Gulf of Mexico. What's more, this technology is also providing data that ocean scientists previously couldn't access, for subduction zone and tectonic plate movement monitoring. Until recently, scientists almost exclusively depended on the use of manned research vessels to undertake observations at sea. This meant they only had sporadic and limited data acquisition projects, which in turn meant that they were unable to satisfactorily model subduction zones. These are areas where an oceanic crust submerges under a denser continental crust and creates the frictional energy build-up that is typically associated with the world's most damaging earthquakes and Tsunamis. Now, they not only have the ability to acquire this subsidence data, but, with the ability to perform GPS-acoustic box-ins, we can precisely locate the absolute positions of each AMT so that this data can be used with models. This data has previously been out of reach to scientists.

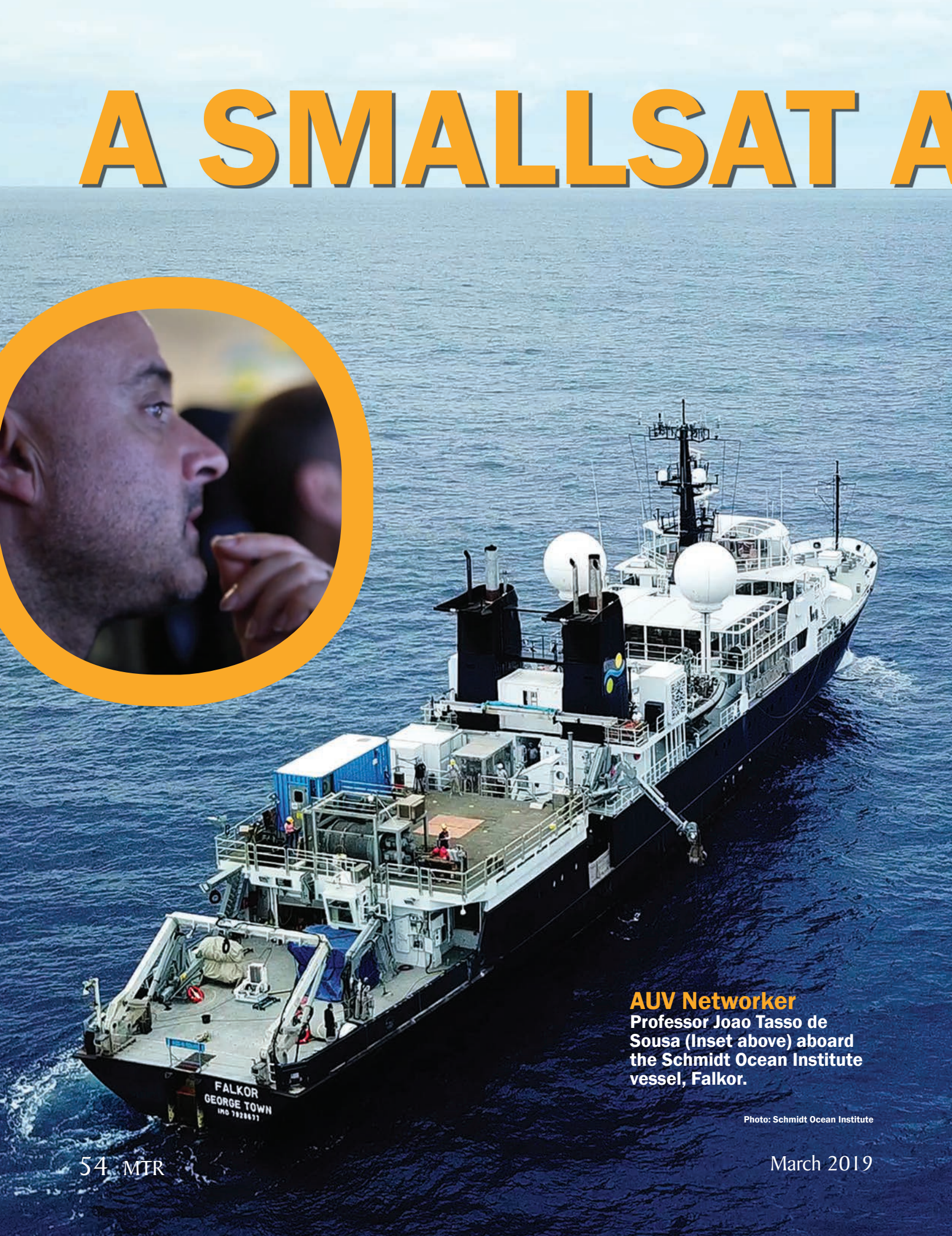
ENABLING TSUNAMI AND EARTHQUAKE RESEARCH

GEOMAR, among others, have deployed Sonardyne's seabed deformation monitoring system in a number of European and South American locations to measure the build-up of strain associated with tectonic plate movement. For one deployment along the Nazca-South American tectonic plate off the coast of Chile, GEOMAR were specifically interested in the build-up of horizontal strain that can be used to predict when large displacements might occur in the subduction zone. This system is unique in being configured with lower frequency acoustic signals that propagate readily over considerable distances, a set-up required for effective wireless communication in the extreme depths (>5,000 meters) in which some of these instruments have been deployed. Scripps Institute of Oceanography, which first used this technology in 2013-14, is working with the United States Geological Survey (USGS) to better understand the Cascadia Subduction Zone in order to better predict when a major event is more likely to occur. It is using Sonardyne's Fetch instrument (functionally equivalent to the AMT, but with a much bigger battery that enables deployments of up to 10 years) for the seabed component of the study. The technology is also the basis of a Japanese Government funded collaboration between the University of Kyoto, Universidad Nacional Autónoma de México and New Zealand's GNS Science; "Hazard Assessment of Large Earthquakes and Tsunamis in the Mexican Pacific Coast for Disaster Mitigation". Further significant programs are also being proposed.

PRECISE, ACCESSIBLE INSIGHT

Our seabed deformation monitoring system is giving operators and scientists centimetric detail of seafloor movement, to help manage and maximize their resources and monitor submarine plate tectonic movements in far greater detail than they have ever been able to do before, all at a fraction of the cost of previous methods.

A SMALLSAT A



AUV Networker
Professor Joao Tasso de Sousa (Inset above) aboard the Schmidt Ocean Institute vessel, Falkor.

Photo: Schmidt Ocean Institute

AUV NETWORK

By William Stoichevski

There's more to a global network than satellite links, and yet sat-linked remote operations experts can heap huge scientific and technological gains on the world. That's what's happening in the background — a smallish network of the best scientists from around the world are orchestrating the communications and robotics that'll yield groundbreaking achievement in the networked use of autonomous underwater vehicles, or AUVs.

If you contact Professor Kanna Rajan, as we did, he'll tell you he's not the world's foremost "drone" researcher, yet he's programmed at least two Mars missions and advises a transatlantic network of scientists on the use of AUVs and satellites. Prof. Rajan suggests AUV-network control guru, Professor João Tasso De Figueiredo Borges De Sousa of the University of Porto, is the go-to guy if you're contemplating what's possible in the world of AUVs. Dr. Rajan is affiliated with Porto in Portugal, and he's quoted at length (about 50 times) in a vision statement written by the Norwegian university NTNU on their planned use of small satellites, or SmallSats, to control AUVs. NTNU post-docs, Ph.Ds and masters students are nearing their SmallSat launch day, after which North Sea AUVs will have taken a step toward being able to relay data to scientists onshore for long periods. Both SmallSats and AUVs will have hyperspectral cameras able to detect chemicals, metals, plankton or do survey work.

The California-based Prof. Rajan is a senior scientist known for planning, executing and creating autonomous systems and robotics at NASA's Ames Research Center. Prof. De Sousa leads an international network of AUV-keen scientists akin to NTNU's. Both have highly evolved AUV labs. The three research communities have combined to make lasting AUV operations controlled or augmented by Micro or Nano satellites — SmallSats of 10-100 kilograms or 1-10 kg — a reality. Apart from the command and control of networked AUVS (and other drones) en masse, which is Prof. De Sousa's specialty, it is hoped that SmallSats will do for ocean understanding and marine operations what the Internet did for marketing and instant knowledge.

Image: NTNU

Changing AUV World

NTNU's SmallSat vision includes hyperspectral sensing of ocean surfacing, the visualization of this for ground control and the routing of networked AUVs.

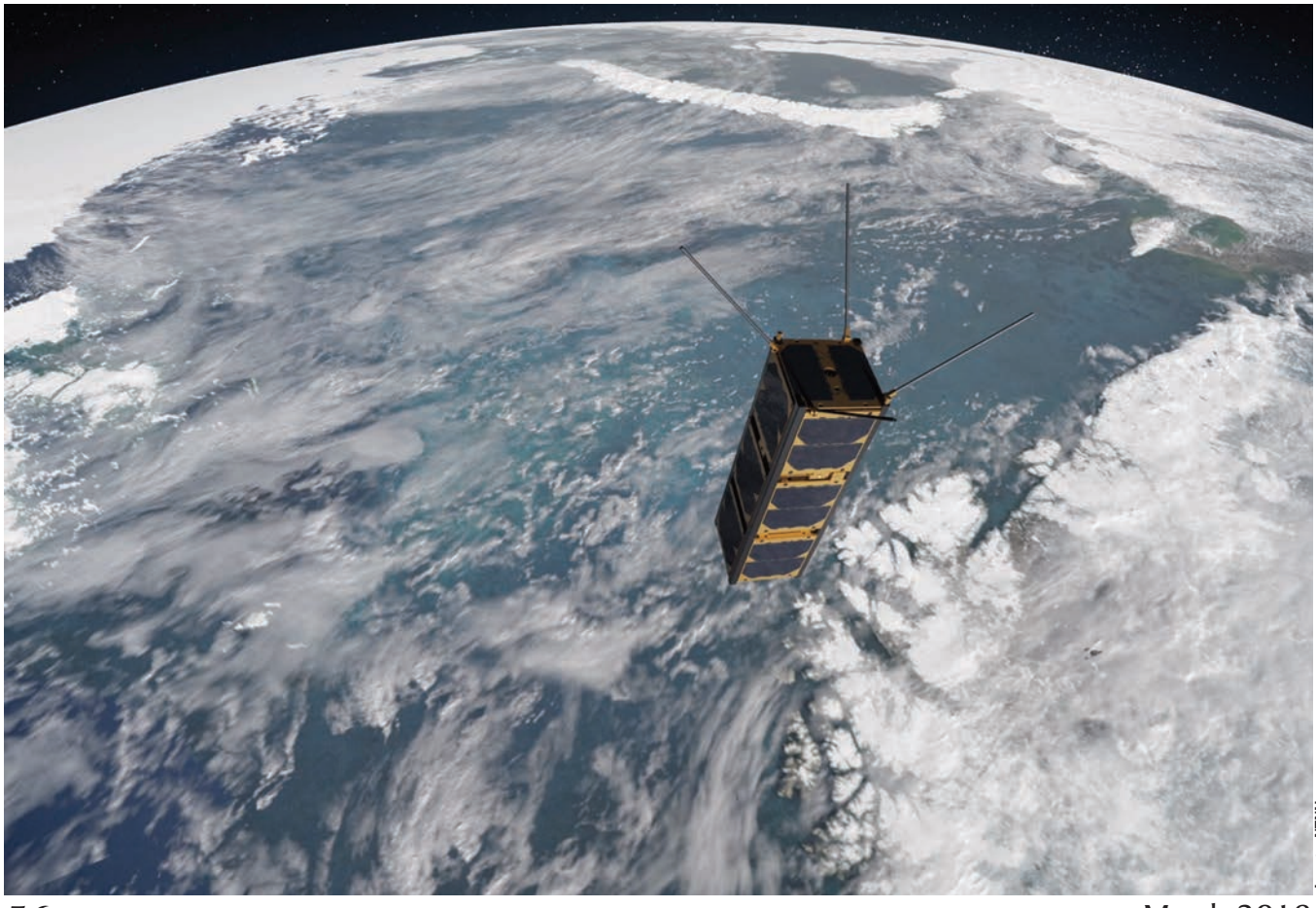


Image: NTNU

AUV control

"Most of our work is joint, and strategically we all (NTNU, Porto, NASA) are moving in the same direction," Dr. Rajan says, adding, "So this is both institutional and collective." Rajan admits switching from Mars rovers to "piloting" AUVs at sea was harder than expected. "The infrastructure came with the tasks associated with commanding the Rover in 2004 and the Deep Space 1 spacecraft in 1999. But the nitty gritty of getting to a coastal zone on a reasonable vessel in weather that can be harsh and not trivial to work with, is something most people don't understand … So yes, both the Rover and an AUV are an extension of the human senses per se, but there's a lot more work involved in getting to sea and making things work."

That's why Prof. Rajan, Prof. De Sousa (who we failed to contact) and their NTNU colleagues are so looking forward to launching SmallSats: detailed, long-standing ocean examinations. That focus will revolutionize ocean research. In the networks of this heavyweight science network, the limitations of AUVs are acutely known, and researchers from Hawaii to Hong Kong will attest, that it is harder to communicate with AUVs than it is with space probes and their "infrastructure of Deep Space Network for spacecraft." While "power is an important shortcoming", too, it's the communications problem that keeps this triad of researchers awake at nights.

Portuguese explorer

Rajan is right about Prof. Tasso: "The superpower in AUVs and marine robotics is our close friend and collaborator, Joao Tasso (De Sousa)."

In fact, Portugal is a powerhouse of AUV development and research. Apart from hosting the biennial IEEE OES Autonomous Underwater Vehicle Symposium, the country boasts both Tasso's Underwater Systems & Technology Laboratory, or LSTS, and the researchers of INESCTEC. Prof. De Sousa recently led a Schmidt Ocean Institute expedition aboard their Falkor research vessel that explored ocean salinity fronts using multiple areal and underwater robots. He's also been known to lecture NATO navies on combined AUV operations.

De Sousa is a pioneer of and continues to work on the managing of multiple autonomous vehicles simultaneously. He has helped develop commercial and researcher software which incorporates mobile devices for easy control of networked AUVs. While applications might one day include mass ocean surveillance, mass inspection, mass survey or massive attack, the oceanic study involved AUVs (and aerial drones) in contact with each other via a ship-based ocean controller. SmallSats could provide these expeditions with the researchers own' dedicated bandwidth (understood to only be NTNU, for now).

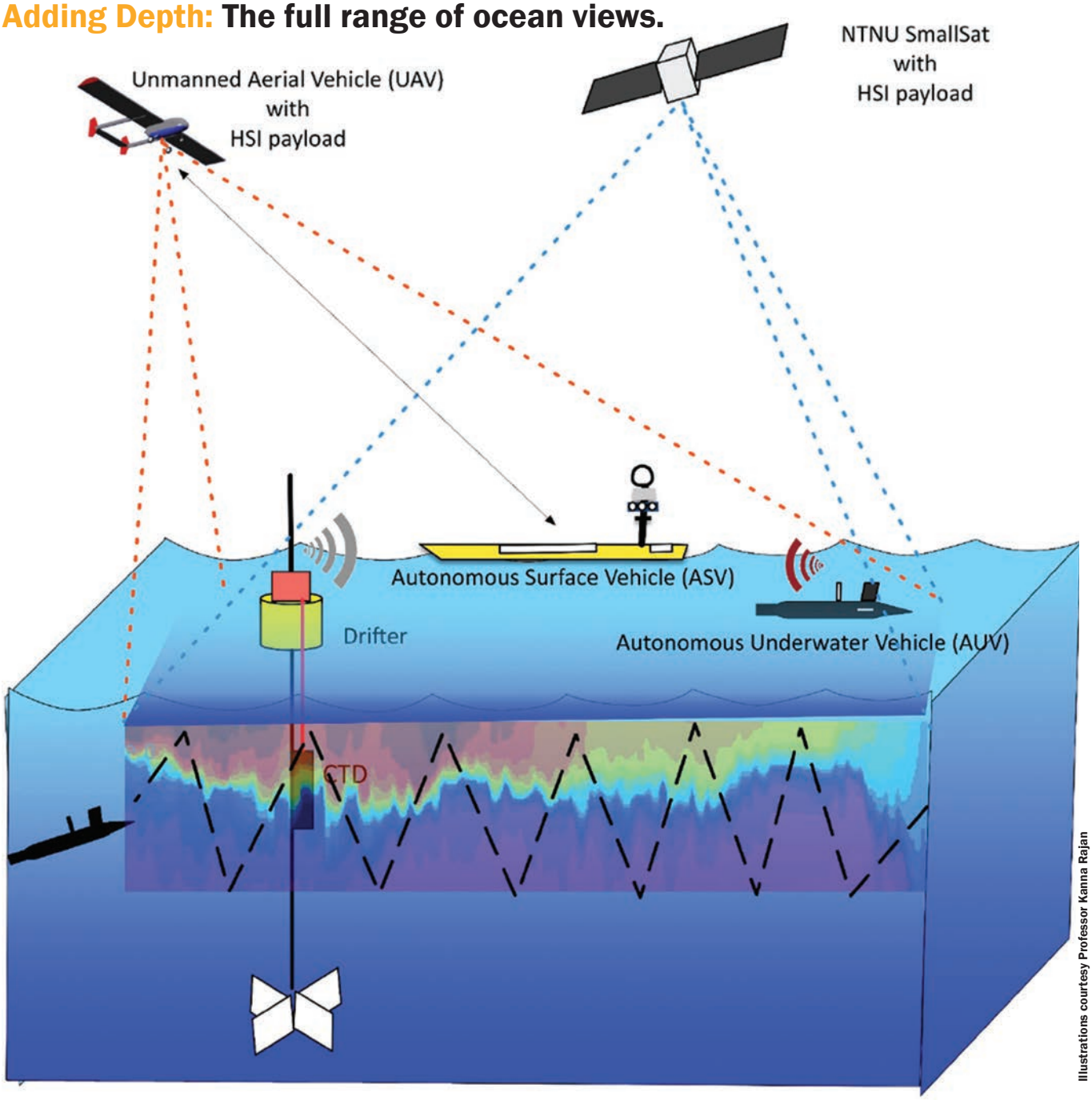
Networking AUVs need open-source control software like that developed by the U. of Porto's LSTS. Several AUVs communicating via their own satellite can, with their onboard sniffing payloads, relay in real-time an accurate picture of the dramatic changes developing across a vast ocean area: or they can confirm by sensing, sampling or photographing what the SmallSats sense or see. The Schmidt Institute chronicled Prof. De Sousa teams deploying "several autonomous vehicles to find, track, and sample various physical, chemical, and biological features of the ocean, on time-space scales not previously possible by ship or aircraft studies alone". Given their own spectral cameras, the SmallSats would then add another layer of real-time data. During the Schmidt journey, "onboard AI," Rajan's shared area of interest with Prof. De Sousa, was used to coordinate AUVs, unmanned aerial vehicles and autonomous surface vessels doing "complex sampling tasks". Multiple vehicles "at times" were said to have worked in "combined effort", monitored and controlled by software dubbed Ripples and Neptus. To do that over the long haul, you need dedicated bandwidth for the expected torrent of ocean data. To get that, your AUVs need their own SmallSats in space.

NASA-quality supervisor

Enter the Norwegians. Funding that's hard to fathom, for some, and experience storing and processing vast volumes of data (like the results of seismic surveys) are part of Norway's contribution to AUV and AUV-based research.

Add to that a growing SmallSat faculty, two AIS satellites and a handful of "space" outfits, including some with military ties. While the researcher haul of all three "schools" — Porto, NASA and NTNU — is large and international, it's the Norwegians and their invited talent that'll provide the SmallSats triad's space-side boost. There's also NTNU students with satellite launch experience, and then there's the supervision of Prof. Rajan with his combined space and robotics experience. Rajan is listed as an NTNU employee, a NASA employee and an associate of the U. of Porto. He executed NASA's 1999 New Millennium Deep Space One Remote Agent Experiment (RAX) and was principal investigator of the 2003 Mars Exploration Rovers MAPGEN controller for the twin rovers — "the longest running AI system anywhere and still in-command of the Opportunity rover on Mars", according to an NTNU text. He was also principal researcher for autonomy at the Monterey Aquarium Research Institute, where he designed, built and deployed the AI-based embedded T-REX autonomous controller on AUVs, as well as a shore-based support system!

Adding Depth: The full range of ocean views.



Illustrations courtesy Professor Kanna Rajan

Cost-efficient coms

While the Norwegian AUV lab at NTNU is poised to log the great achievement of a SmallSat launch at sea, the funding of the Norwegians cannot be overstated. The finance outmatches EU funds, and it does for AUV and oceanographic research in Norway what the Schmidt Institute did for Porto's ocean fronts study and the work of other oceanographic researchers.

"Funding is a serious issue in doing marine robotics and/or ocean science," Prof. Rajan writes. "In the US, we have multiple agencies and stakeholders who believe they need to do something about the ocean. This includes NSF, NOAA, DARPA, ONR all of whom have interests which intersect and compete. In Norway, this is less so, but (the Research Council Norway) has done a good job in streamlining the funding process. Not so in the US. Contrast this with going to space — there is really one entry point. And that is NASA. So the process of sending up a spacecraft is a lot better understood, clearer and more reasonable (via the US National Academies) than going to sea, quite often."

Prof. Rajan says space agencies also tend to engineer the hell out of their vehicles while spending "enormous sums of money" on duplication and robustness. That's not quite the Norwegian SmallSats approach. In their SmallSats whitepaper, NTNU acknowledges a need to focus on small dedicated satellites with cameras and coms rather than asking for periodic bandwidth on a more robust but costly commercial satellite. However giving to research, NTNU knows that the state's finance isn't always forthcoming. So, they've focused on a SmallSat program that'll cost between $100,000 and $7 million. Cash is king, even for this network of giants. However, AUVs make ocean research of scale affordable. In a mission brief for the Schmidt Ocean Institute, Prof. Joao Borges de Sousa wrote the following: "We need to develop sustained ocean studies with unprecedented spatial and temporal resolution. Ships alone cannot help to achieve these levels of resolution, scale, and economic feasibility." He might already have been thinking "SmallSats", and NASA's Prof. Rajan is affiliated with both NTNU's Center for Autonomous Marine Operations and Systems (AMOS) and Porto's Underwater Systems and Technology Laboratory.

Sometime between this spring and 2020, a Norwegian launcher will send up a SmallSat, and then there use is expected to expand in tandem with the proliferation of AUVs. A Norwegian Space Centre already supervises satellite launches in Norway, including those by Norwegian students who design their own micro satellites (under 1 kg). NTNU's stated vision is to be a SmallSats leader, starting with the hyperspectral camera they built using off-the-shelf parts and parts they 3D-printed themselves. Apart from NTNU, Norway's near-arctic, island Space Centre is getting ready to expand its SmallSat launch program. Defence outfit, Norske Nammo, is reportedly readying an eco-friendly micro-rocket to carry SmallSats into pre-defined orbits.

Photo: Schmidt Ocean Institute

Aerial and Underwater

A range of AUVs and aerial drones were networked during a Schmidt Ocean Institute survey of ocean fronts.

Send in the Drones

Drones for Coastal Environmental Management

By Justin Manley

Unmanned aerial systems (UAS), commonly called drones, have been making increasing impacts in the maritime domain. As the capabilities of these platforms have increased, so have their contributions to maritime science, defense, and industry. Recognizing this, the Alliance for Coastal Technologies (ACT) and the Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOS), with support from the U.S. Integrated Ocean Observing System (IOOS), convened a workshop on Practical Uses for Drones to Address Management Problems in Coastal Zones at the Wells National Estuarine Research Reserve (WNERR) in Wells, Maine, in late 2018. The workshop was designed to facilitate sharing of information and best practices to support the rapidly expanding applications of drones in coastal management.

Workshop Summary

The goals of the workshop were to summarize the state of technology in research- and monitoring-grade UAS, compile examples of current use in this area, understand the limitations and logistical challenges associated with UAS, develop operational and data management/analyses best practices, and describe future developments and applications for coastal ocean observing systems. A comprehensive workshop report is available from the ACT website (www.act-us.info).

The workshop also sought to explore the challenges of truly quantitative multispectral and hyperspectral remote sensing in coastal marine environments and the legal and privacy issues associated with using drones in public and private lands and ocean spaces.

To promote broad input and cross-sector information-sharing, workshop participants included private-sector UAS technology developers and service providers, academic researchers developing and/or using UAS, and government agency staff members with experience in using UAS or UAS data or working on management issues that could be addressed with

Credit: J. Manley

Credit: J. Manley

UAS.

The first day of the workshop featured field demonstrations of three types of UAS: quadcopter, fixed wing, and hexacopter.

The second and third days were panel sessions with presentations covering topics such as:

- Drones to survey habitats
- Drones for harmful algal bloom (HAB) detection and monitoring in Florida
- Drones as a tool for surveying tidal marshes at three sites on the East Coast, Gulf Coast, and West Coast
- Using drones for coastal/offshore transects and other research in Monterey Bay
- Development of drones that operate in the air and sea environments

Each panel session was followed by breakout group discussions. Plenary sessions included report-outs from the breakout groups and large-group discussions of the panel and breakout topics. Among the key takeaway messages from the presentations and discussions were the following:

. While UAS are a new tool for coastal management, their value has been demonstrated for a wide variety of applications such as habitat mapping, wildlife monitoring, detection of coral bleaching, shellfish management, marine debris detection, monitoring shoreline change, management of beaches and sand resources, mapping flood zones, and inspection of bridges and other structures.

. UAS could also be useful in many other management contexts such as harmful algal bloom (HAB) detection and tracking, monitoring of human/animal interactions, water quality monitoring, pollutant tracking, and monitoring tidal marsh stability.

. Managers are eager to use drones, but how to use them is not always well understood. It is important to begin by asking, "What is the management question or problem?" This will determine what data are needed and how they should be collected, which may be drones.

. As with any data, drone data need to be translated into information, which can then be used for management.

. Using drones to acquire accurate quantitative geospatial data is challenging and requires advanced technical skills and knowledge. Hiring experts in drone operations and data processing is typically necessary.

. Best practices for using drones to collect geospatial data are well established. Guidance on best practices is available in publications such as the PrecisionHawk e-book Beyond the Edge, and the USGS Unmanned Aircraft Systems

Photos, L to R, starting opposite page:

Wells National Estuarine Research Reserve welcomes drones.

A Commercial Survey Hexacopter Demonstration.

A VTOL Drone over Monterey Bay.

Credit: MBARI

A Timelapse of EagleRay Transitioning from Sea to Sky.

Credit NCSU

Data Management Plan 2015.

. Workshop attendees identified short flight times due to battery constraints as one of the biggest limitations in drone technology at present. Other desired technological improvements include expanded payload capabilities, modularity to allow drones to carry different payloads/sensors, all-weather capabilities, "smarter" drones with situational awareness, increased data storage capacity, standardization of data types, improvements in data management such as on-board data processing, and capabilities that go beyond imagery and remote sensing, such as deploying water sampling devices.

. Laws and regulations constrain the use of drones for ocean and coastal research and management. For example, drones can be flown only below 400 feet and must remain within the pilot's line of sight at all times. Each drone must be flown by a dedicated, licensed pilot, meaning multiple drones cannot be controlled by a single pilot as in a swarm. Another important consideration is that uncertainty about potential changes in laws and regulations makes it difficult to plan research.

. Testing and evaluation of UAS platforms and sensors by an independent entity such as ACT would be useful to researchers, managers, and technicians.

Technology Highlights

There were several innovative technologies presented at the workshop. A key concern for all unmanned systems is payloads. During this workshop researchers from the Monterey Bay Aquarium Research Institute (MBARI) discussed the use of a Flightwave Edge, a hybrid tricopter fixed-wing aircraft. It can take off and land using Vertical Take Off and Landing (VTOL) technology. It can also seamlessly transition from hover to forward flight and back again. Its swappable twist-lock payload system allows operators to fly multiple missions using a single aircraft. The MBARI operators used this drone combined with a FLIR imager for thermal front mapping. They also used very high-resolution cameras and were able to identify animals in the water, in this example jellyfish, as well as birds in flight.

In addition to the field results from MBARI, and other science users, the workshop presented new ideas for drones that can operate both in the air and underwater. North Carolina State University presented concepts for cross-domain autonomous vehicles (XAVs). With DARPA sponsorship and a partnership with Teledyne Scientific, this team built a fixed wing drone that can fly and swim. This system, dubbed EagleRay, was developed and tested extensively between 2015 and 2016. The EagleRay vehicle is a UAV-UUV hybrid based on a fixed-wing VTOL design. Two iterations have been built and demonstrated a full swim-fly-swim cycle. Version 2 includes autopilot hardware and sensors for autonomous operation. Passively floodable/drainable compartments allow the vehicle to achieve near-neutral buoyancy, but quickly shed ballast water upon egress. Two active buoyancy compensator designs have also been tested. Propeller propulsion is driven by brushless electric motors. Both separate air and water propulsion and dual use systems have been tested

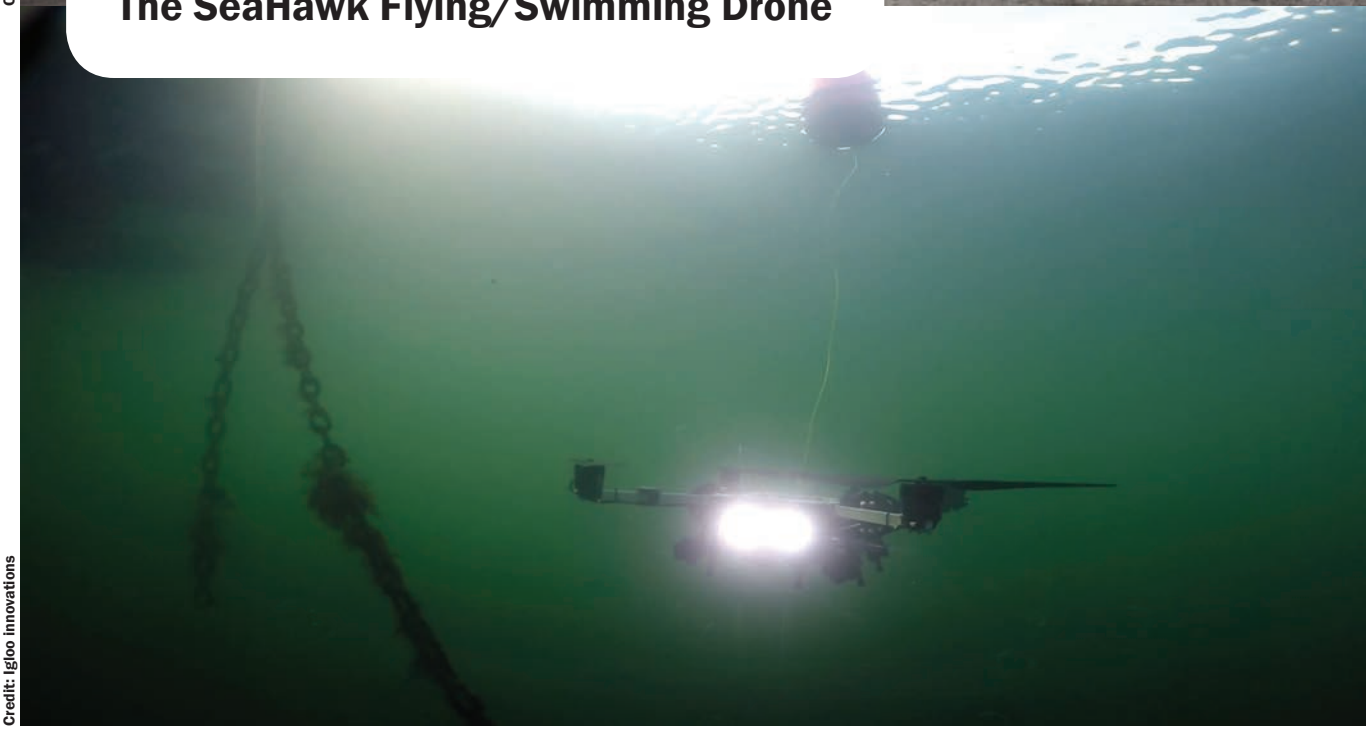
Another new technology discussed at the workshop was the SeaHawk from Igloo Innovations. There are two variants of this novel design, SeaHawk Alfa and SeaHawk Chimera. The Alfa looks much like a typical quadcopter and performs similarly in air. Unlike a quadcopter, atop the Alfa is a detachable buoy containing wireless telemetry to the control station.

When the vehicle submerges, the buoy remains on the surface and tethered to the vehicle thus maintaining communication. The buoy may be removed for fully autonomous underwater operations.

The Alfa has a payload capacity of 5 kg (10 lbs) and a maximum flight speed of 60 km/hr (37 mph). A dedicated underwater propulsion system moves the Alfa at speeds of up to 4 kts while submerged. Its operational depth is 50 m (150 ft), and it can operate for approximately 60 minutes combined in either medium. The Chimera appears similar to the Alfa, except that the vehicle stays at the surface and only the payload is deployed under water. With a payload capacity of up to 20 kg (40 lbs), the vehicle is intended as a modular platform to carry a wider range of payloads than the Alfa. For example, the payload can be an ROV or AUV providing advanced underwater capabilities. The Chimera can also hover above the water and lower down a sampling device to collect samples with minimal disturbance to the water surface.

Credit: Igloo Innovations

The SeaHawk Flying/Swimming Drone



Credit: Igloo Innovations

Canada's New Business Park for the Ocean Economy

By Jim Hanlon, Chief Executive Officer, COVE

COVE (Centre for Ocean Ventures and Entrepreneurship) is an ocean tech business park that encourages collaboration across sectors to connect local and international companies in the ocean industry. Our focus is to bring together people, ideas, companies and research to forge new opportunities for the industry. COVE occupies a decommissioned Canadian Coast Guard base in Halifax, Nova Scotia. The facility spans an eight-acre urban waterfront property with 53,000 square feet of building space and excellent marine access with 3,000 linear feet of deep-water wharfs. COVE provides test and deployment facilities, within a 13-acre water lot, and workshop space for product development and testing.

A contribution of almost $6 million CAD from Irving Shipbuilding Inc. supports COVE in its mandate to grow the Canadian ocean economy by supporting the adoption of innovative ocean technology. This is different from the more general role taken by ocean industry trade associations and marketing sup-port organizations. COVE believes that the biggest most sustainable opportunity for growth comes from the use of ocean technology to gain international competitive advantage and the development of a competitive workforce. We focus on technology as our key growth lever.

COVE goes beyond conventional concepts of shared workspaces or incubators and accelerators. It is a hub for all ocean tech stakeholders. As of March 2019, COVE has 50 tenants including: 13 start-up companies, a full-service machine shop, private sector ship operators and a range of small and medium sized ocean tech companies. Large companies like IBM, Lockheed Martin, and Lloyd's Register have established a presence as well. Dalhousie University, one of Canada's prominent ocean research universities, as well as the Nova Scotia Community College which provides applied ocean focused training for students are also on site. The day-to-day interaction among these diverse tenants is the true mag-ic of COVE. In addition to Canada's multi-billion dollar National Shipbuilding Strategy, our region is the host to more than $500 million in strategic investments focused on the ocean. These include Canada's Ocean Super-Cluster, the Ocean Frontier Institute, DeepSense, and others. COVE is partnering with these organizations to bring our valuable network of tenants and partners to these programs.

The H2O Conference, June 5-7, 2019, is an event to engage with the ocean technology industry in Atlantic Canada and at COVE. The conference will include: an ocean industry showcase, international delegates, research, development and commercialization presentations, networking events and the oceans gala dinner. This year's conference will also include a day of on-water demos at COVE. Find more information about COVE at **www.coveocean.com** and the H2O conference at **www.h2oconference.ca/**.

Overall, COVE is a place where new ideas are developed and brought to market, and where companies are inspired, encouraged, and provided the opportunity to connect with leaders in the ocean industry. We invite you to come see for yourself in June.

Untethered Subsea Power

U.S. based tech conglomerate Teledyne has long supplied fuel cell technologies for NASA and other customers for space and terrestrial applications. Now its Teledyne Energy Systems, Inc. (TESI) arm is looking to take the technology to new depths as a source of untethered power for applications below the ocean's surface.

"In everything that we've seen from doing our market study and research, there is a gap in providing untethered power for various [subsea] applications," according to Mitch Icard, TESI's Vice President and General Manager, who said TESI's Subsea Power Node can provide persistent power for underwater vehicles and subsea oilfields.

Icard said the initial plan was to use fuel cells to power underwater vehicles directly, but "we deter-mined that there is too many configurations and it probably be a tough price point". He explained, "Given that most of the vehicles are powered by lithium ion batteries, we felt that it would be a much better solution to put energy subsea and recharge those assets on location."

The Subsea Power Node uses Teledyne's proven proton exchange membrane (PEM) fuel cell technol-ogy, which provides more than 10,000 hours of life, according to the developer. The stack design is specifically tailored for operation with pure oxygen. The fuel cell system features an integrated balance-of-plant (BoP), which allows the fuel cell stack to be fed reactants in a "dead-ended" configura-tion maximizing energy delivery, as well as ejector driven reactant (EDR) technology for reactant recir-culation.

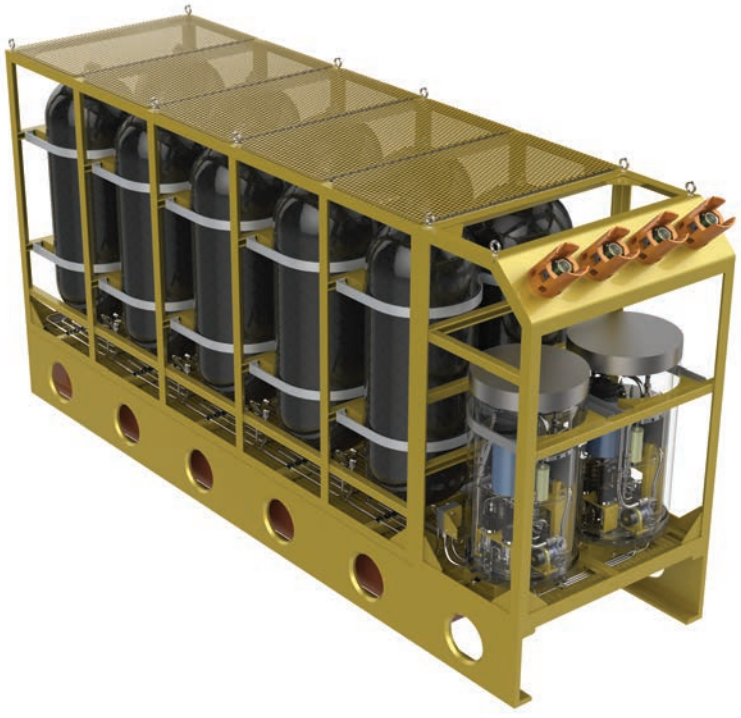
The fuel cell system is reactant storage agnostic, meaning reactants can be supplied via compressed, cryogenic, or solid-state reactant storage systems. The Subsea Power Node is equipped with a com-pressed-gas reactant storage system that is commercially refillable.

"The engine, or fuel cell, was something that we had developed for space flight to go in the upper stage for the space launch system," Icard said. "We had converted that technology to operate in a similar environment from deep space to deep water."

"Everything except the fuel cell engine is all commercial off-the-shelf parts," Icard said, noting that the steel head tanks, electronics package, Teledyne ODI wet mate connectors, Teledyne Benthos modem are all commercially available. "All of these things have had sea trials. What we're providing is a sys-tems integration package that we think solves a really pressing problem."

A 100Kwh system (8kW continuous power) expected to launch in 2019 is 4 x 4 x 5 feet and weighs in at approximately 840 kilograms, while a 600kwh (16kW continuous power), 3,000 kg version is in devel-opment to offer greater capabilities. TESI expects to scale up the system to 20Kwh by 2021.

By Eric Haun, *Offshore Engineer*



Subsea power node 100kWh (above) and 600kWh (left)

Image: TESI

OPT Expands Power Options

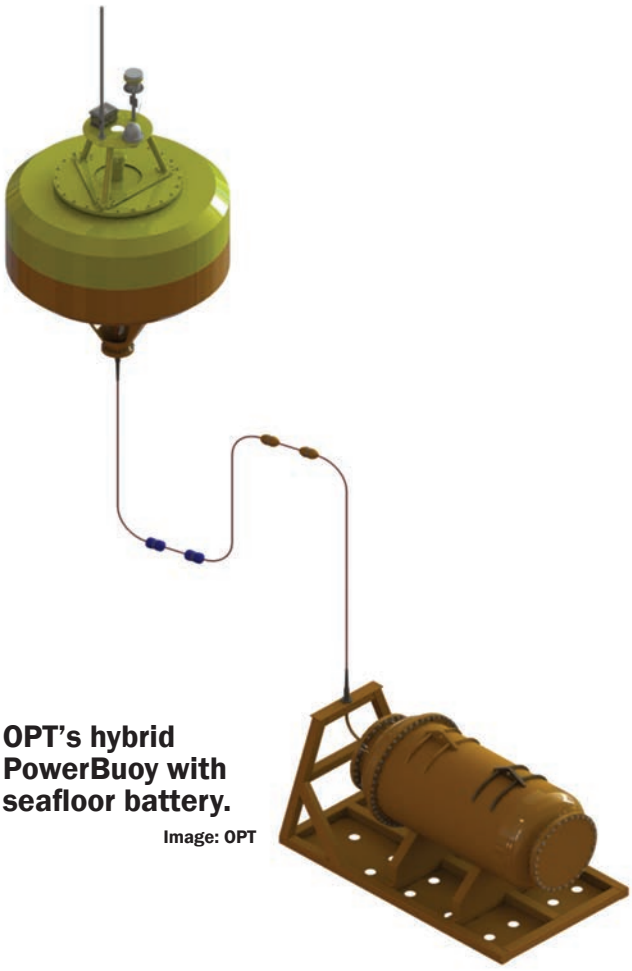
Ocean energy solutions developer Ocean Power Technologies, Inc. has expanded its suite of complimentary products that leverage the core technology of the PowerBuoy, which include subsea batteries and a hybrid (liquid-fueled) PowerBuoy.

George H. Kirby, President and Chief Executive Officer of OPT, said, "Our team has been working diligently to identify opportunities to leverage our technologies to address the needs of current and potential customers in subsea environments. These new product offerings provide OPT with the means to better serve customers by expanding its product and service offerings. In addition, this allows us the opportunity to have broader discussions during each customer visit, providing more comprehensive solutions and further establishing our credibility and our ability to address each unique market.

"Our new products, subsea batteries and the hybrid PowerBuoy, along with our existing PB3 Power-Buoy and backed by our existing support services, provide more comprehensive solutions that can meet the needs of more customers requiring reliable power and communications in their subsea work across the globe."

OPT's entry into the subsea battery market presents a complementary product to the PB3. Subsea batteries create a sea floor energy storage solution for remote offshore operations. These subsea batteries use lithium ion batteries (often replacing traditional lead acid batteries) to supply power that can enable subsea equipment, sensors, communications and autonomous underwater vehicles (AUV) and electric remotely operated vehicles (eROV) recharge. OPT's PB3 PowerBuoy is complimentary to subsea batteries by providing a means for recharging during longer term deploy-ments, or the batteries can be used independently for shorter term deployments. Ideal for many re-mote offshore customer applications, these subsea batteries are anticipated to be high performance, cost-efficient, and quickly deployable. Although OPT's subsea battery solutions are currently under development, OPT has already begun marketing its subsea battery solutions to potential customers around the world and anticipates quoting to customers as early as the first quarter of calendar year 2019.

The hybrid PowerBuoy will be a smaller liquid-fueled surface buoy, with significant energy storage and capable of providing reliable power in remote offshore locations. This product is to be highly comple-mentary to the PB3 PowerBuoy by providing OPT the opportunity to address a broader spectrum of customer deployment needs, with the potential for greater OPT integration within each customer pro-ject. It is primarily intended for shorter term deployment applications such as eROV and AUV inspec-tions and short-term maintenance,



OPT's hybrid PowerBuoy with seafloor battery.
Image: OPT

topside surveillance and communications, and subsea equipment power purposes. The hybrid PowerBuoy will be a light weight and quickly deployable option designed to be cost-effective. It will have a high payload capacity for communications and surveillance, with the capability of being tethered to subsea payloads and battery packs, and/or PB3 PowerBuoys, or with a conventional anchor mooring system. The hybrid PowerBuoy will be designed to outperform tradi-tional diesel buoys, which we believe have more frequent service and refueling intervals. We believe the hybrid PowerBuoy will be able to operate for years without service, with no internal combustion engine, using environmentally safer and more robust fuels, while operating in a wider temperature range than diesel buoys. Although OPT's hybrid PowerBuoy is currently being developed, OPT has al-ready begun marketing it to potential customers around the world and anticipates quoting to custom-ers as early as the first half of calendar year 2019.

Subsea Connect with BHGE

New lightweight, modular subsea technologies could reduce not just lead times for equipment delivery but lower the total cost of ownership for the full life of the field.

Baker Hughes, a GE company, revealed its thinking on subsea developments during a launch event in Houston in November. The Subsea Connect system is centered around Project Connect, reservoir to topside technology solutions, flexible partnerships and commercial models and digital enablement, and BHGE believes the combination of these four pillars can reduce the economic development cost of subsea projects by an average of 30 percent.

Neil Saunders, president & CEO of BHGE's Oilfield Equipment business, said that price reduction could make a marginal asset attractive for development and improve the economics of one that already meets breakeven requirements.

Historically, said Graham Gillies, BHGE vice president for subsea, the subsea portion of a field can claim 30 percent to 50 percent of the project development costs.

The downturn of the industry forced rounds of cost-cutting measures, with many subsea vendors bringing prices for technology and equipment down by about 30 percent and thereby driving down the breakeven price for projects.

"But that 30 percent is not enough. We needed to do more," Saunders said.

As a result, BHGE looked at different ways to further lower costs. The answer, Saunders said, lay in removing costs at an opex level over the life of the field, rather than purely during the capex portion of a project. The result was Subsea Connect, which he said the company believes will make a "long-lasting, sustainable change and driving value from concept to commissioning and over the full life of field."

A major component of that is the newly revealed Aptara TOTEX-lite subsea system, which includes the lightweight compact tree, modular compact manifold, composite flexible risers, SFX wellhead solution, modular compact pump and subsea connection systems.

The Aptara technologies are modular, structured, compact and designed to be more responsive to changing conditions across the life of field, cutting total cost of ownership by up to 50 percent. For ex-ample, at the outset of a field's productive life, a high-integrity pressure protection system (HIPPS) tree cap may be required, but eventually the field will need a standard production tree cap, then a boosting tree cap, Saunders said. That equipment may be there for the entire life of the well, even though it is not needed during the entire productive life of the well, he added.

With the modular Aptara subsea system, Saunders said, first a HIPPS tree cap can be placed on the wellhead, and it can be removed and replaced with the production tree cap, then the boosting tree cap as the well's production stream changes. The Aptara subsea system can contribute up to 50 per-cent cost saving over the total cost of ownership, he said.

The Aptara system fits under the reservoir to topsides technology solutions pillar, which draws on BHGE's fullstream capability to offer reservoir management, field development, well construction, topside optimization and subsea engineering. With Project Connect, BHGE helps customers target specific project outcomes and increase speed to financial investment decision. The third component – using flexible partnerships and commercial models – is designed to leverage relationships with partners to improve project economics.

Digital enablement is aimed at driving uptime and enhancing productivity. BHGE's engageSubsea asset lifecycle management solution, for example, could drive up to a 20 percent reduction in maintenance costs, and up to a 5 percent reduction in downtime through predictive analytics.

"We're already delivering against Subsea Connect," Saunders said, noting the company has invested significantly in structuring its subsea production systems portfolio to ensure shorter lead times and quicker responses. "We have also signed an agreement with a major operator to provide the Aptara lightweight compact tree for deployment next year."

By Jennifer Pallanich, OEDigital.com

Image: Baker Hughes

Thwarting Mobile Underwater Threats

While underwater vehicles can be used to make subsea operations safer and more efficient, there is also an increasing threat posed by underwater vessels and divers for operators of ports and ships carrying sensitive cargoes; cruise ships, fuel/chemical tankers and warships. While there are a multitude of potential detection and mitigation solutions, Maritime Arresting Technologies (MAT) was approached by the U.S. Navy to devise a non-lethal counter measure that could be deployed once an underwater threat was detected. The initial brief envisaged a detection range of 500 yards for a target traveling at up to four knots. In the best possible case this gives security forces three minutes to contain the threat. The primary asset available to deploy countermeasures is a small (28-ft.) patrol boat.

Meet the Stingray Net

Maritime Arresting Technologies' solution was to deploy an entanglement net across the path of the underwater threat, with the intent of the underwater target colliding with and becoming trapped in the net.

The net needed to be able to be deployed at speed and to rapidly self-set to form an impenetrable barrier from sea surface to seabed.

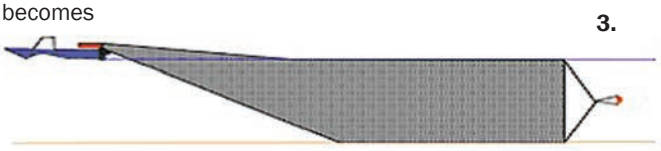
Tests carried out by the U.S. Navy revealed that a net 200-ft. long would guarantee capture without becoming unmanageable. The net currently used is constructed from monofilament nylon making it almost invisible in the water. The key to the system is the storage box that transforms into a launcher. The net is kept in a storage box mounted on the transom of a patrol boat. When needed the storage container transforms into a deployment system.

1. Drogue pulls net from storage box.

2. Net self sets to form barrier from seabed to surface.

3. At 20 knots net takes 6 seconds to deploy.

4. The target UUV/ diver collides with the net and becomes entangled.



The key to the system is the storage box that transforms into a launcher.

All images: maritime Arresting Technologies

Idronaut CTD: OCEAN SEVEN

Ocean Business 2019

Ocean Business is set to take place from April 9-11, 2019 at the National Oceanography Center in Southampton, UK. While the schedule is packed with social networking functions, exhibitions, in-water displays & conferences, the new technology on display is the star of the show. Following is a preview of some of the tech set for display at Ocean Business 2019 in Southampton

Chesapeake Technology: SonarWiz 7.4
Booth: S5

Chesapeake Technology will be releasing SonarWiz 7.4 in April, with updates to many of its software modules. Sidescan updates include automatic processing and real-time directory monitoring to enable unattended workflows, along with two new bottom tracking algorithms designed to work better in noisy environments. New file compression reduces project size by as much as four times, and vastly improves export speed of large, high-resolution mosaics, reducing processing time from days to hours. The bathymetry updates support drag and drop file import, new 3D visualization tools and ability to import many new file formats including GSF, Kraken TIL and WASSP. SonarWiz 7.4 can directly import and process QPS sidescan *.db files. Additionally, Chesapeake continues to add interfaces for its real time servers for sidescan, multibeam, magnetometer and sub bottom sonars, now including Jetasonic and Sonardyne.

EvoLogics: Tiny Modems
Booth: E6

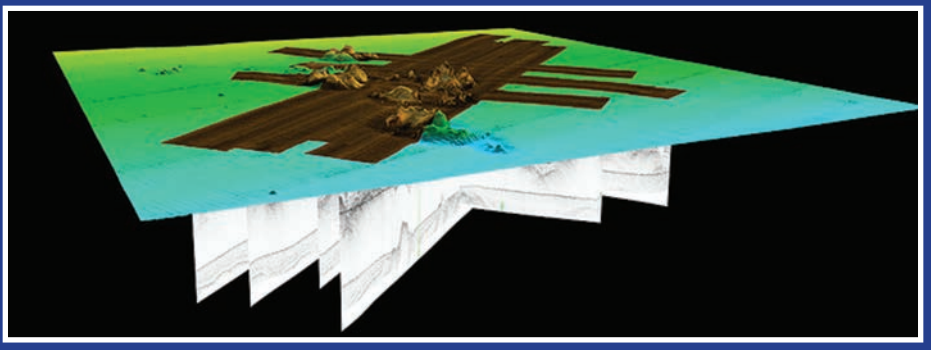
EvoLogics introduces the latest addition to its underwater acoustic modems range: the new generation S2C T modems. The new light and ultra-compact design represents a size reduction of almost 20% compared to the S2C M mini-modems at only 25 cm standard height and 1200 g weight. Still, the new model packs a fully-fledged S2C engine with no compromises in acoustic performance. It is a great fit for small AUVs and ROVs where size and weight are critical. Perfect as transponders for positioning, the S2C T are capable of simultaneous tracking and reliable bi-directional data transmissions with advanced networking. The S2C T series form factor will be available for the high frequency models, catering to various applications with 4 frequency range/directivity options.

Fugro: Next Level of Autonomy
Booth: H1

Fugro is boosting its global survey capability with the launch of the next generation in marine autonomous operations at Ocean Business this year. Leveraging 10 years of autonomous survey experience and more than 100,000 hours of autonomous surface vehicle development, Fugro's new unmanned surface vehicle (USV) has been specifically designed for safe and efficient operations on medium- to large-scale hydrographic survey projects and will deliver better than IHO Special Order quality data. Long endurance and operational flexibility are among the key features of the 9-meter USV, which was designed in partnership with L3 ASV, a leader in unmanned and autonomous vessel technology.

Coupled with its smart data management and a global network of remote operating centers, Fugro will soon be utilizing a variety of fit-for-purpose USVs.

Chesapeake Technology: SonarWiz 7.4



GeoSpectrum: C-Bass

EvoLogics: Tiny Modems

Fugro: Next Level of Autonomy

GeoSpectrum: C-Bass
Booth: D1

At Ocean Business GeoSpectrum will showcase its C-Bass very low frequency (VLF) sound sources. C-Bass is a family of VLF electrodynamic sound projectors. These powerful projectors are less expensive, lighter, smaller, more efficient, and have a broader bandwidth than their peers. C-Bass makes possible applications that were previously impractical. GeoSpectrum Technologies specializes in underwater acoustic transducers and systems for the oil and gas, defense and surveillance, and environmental sectors. GeoSpectrum has expanded their manufacturing capabilities to include end-to-end systems for a variety of marine applications.

Hydro Group: Connecting Innovation Underwater
Booth: F8

Hydro Group, the underwater connectivity firm, manufactures bespoke-engineered cable/connector assembly solutions for subsea oil and gas, renewable energy and defense applications worldwide. Hydro Group's stand at Ocean Business will host technology used in a variety of marine applications; all designed and manufactured at its facility in Scotland. Stand visitors will view detailed 3D models of Hydro Group's Hull Penetrators, 36kV renewables connector and Power Distribution Hub, alongside product samples of precision-engineered armoured/hybrid cables, connector assemblies and submersible electrical penetrators. Hydro Group, including Singapore-based Hydro Group Asia Pte and Hydro Group Systems Inc in Florida, has three decades of experience and business partners across the globe. The company's subsea technology has been used in applications including the world's first carbon-free island in Jeju, South Korea, and in the defense systems of the UK Ministry of Defense.

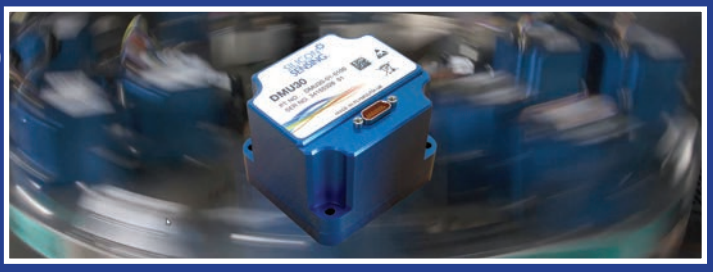
Idronaut CTD: OCEAN SEVEN 333
Booth: A333

IDRONAUT will present the OCEAN SEVEN 333, a CTD that can be a stand-alone CTD or a high-performance accessory of the OCEAN SEVEN 316Plus. The OCEAN SEVEN 333 uses both hardware and analytical redundancy to enhance the reliability of measurements by using a third CT sensor pair. Endurance during long term deployments can be further enhanced by the addition of UV led (280nm) to each sensor which sterilizes the sample under measurement, thus retarding early growth of bio fouling inside the quartz cell. The OS333 CTD can guarantee sampling rates up to 28Hz without degradation of the measurement performance. The OS333 CTD does not require pumps or any other external device to flush the 3 x C/T pair. The OS333 delivers real time data, including Salinity, Density and Sound velocity in engineering units through

Hydro Group: Connecting Innovation Underwater

Innomar's "SES-2000 smart"

Silicon Sensing



the built-in RS232C and data telemetry (10Km) interface.

Innomar's "SES-2000 smart"
Booth: L1

During Ocean Business 2019 INNOMAR presents its new "SES-2000 smart" parametric sub-bottom profiler, operating on the DotOcean "Calypso" autonomous USV. An overview on this new product and possible applications will be given on Tuesday (14:00) in room 344/44. Live demos are shown on Wednesday (12:00) and Thursday (13:30) at dockside 2. Another INNOMAR presentation (Wednesday, 13:30, room 064/03) will focus on using a parametric 3D SBP for offshore site explorations. INNOMAR is the leading manufacturer for parametric sub-bottom profilers with more than 400 sold units. The "INNOMAR SES-2000" SBPs are perfectly suited for high-resolution sub-seabed visualization in water depths between less than one meter and more than 11,000 meters. Applications include the geophysical imaging of sediments and sub-seabed structures for dredging purposes, for route and offshore site surveys and to map buried pipelines/cables.

Pro-Oceanus Systems: CO2-Pro Atmosphere sensor
Booth: D1

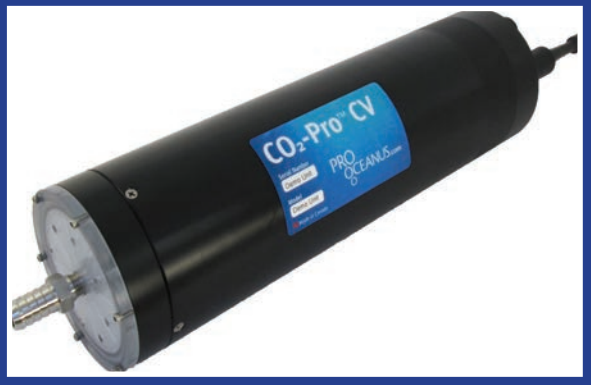
Pro-Oceanus Systems provides instrumentation world-wide with the most advanced technologies for in situ measurement of dissolved gases. The CO2-Pro Atmosphere sensor provides long-term accurate and stable air and surface water CO2 measurements that are required for the determination of CO2 fluxes at the ocean surface. Easily integrated onto most buoy platforms, this sensor provides reliable data that can be used to understand the interaction of atmosphere and ocean with respect to carbon budgets. The CO2-Pro CV sensors on mooring lines and slowly profiling platforms can additionally provide knowledge of carbon dynamics. Response time and accuracy in a submersible package, proof to depths of up to 6000m, as well as internal battery options for fully autonomous operation, allow for a multitude of monitoring options.

QPS: Qinsy 9.0 and Qimera 2.0
BOOTH #: U1

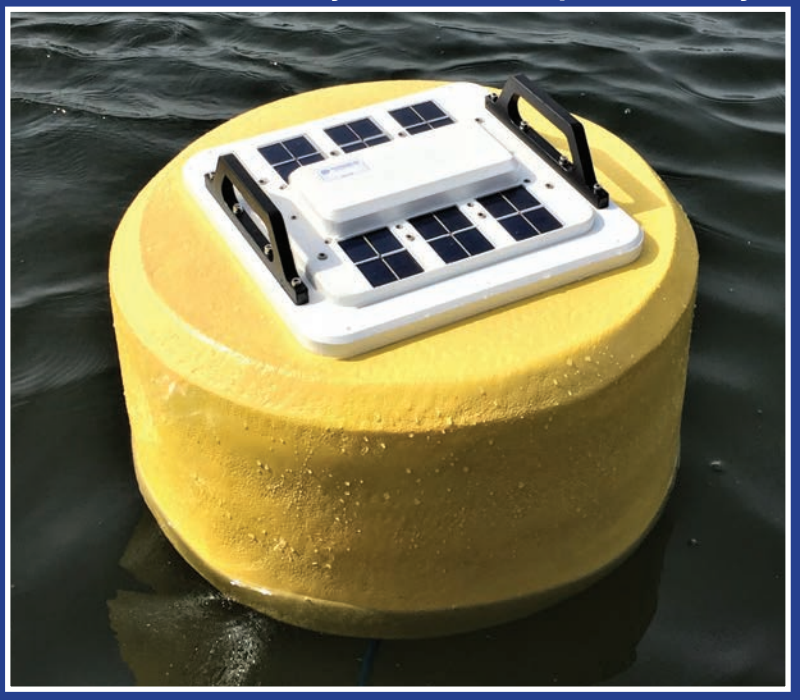
QPS will introduce Qinsy 9.0 and Qimera 2.0, and offer a preview of Fledermaus 8.0, to be released later this year. Please visit us to see new product demonstrations. Qinsy 9.0 offers SVP folder monitoring for automatic application, integrated screen capture tools, and the new Survey Manager—our PM suite enhanced with several new features, including direct integration with Oasis Montaj from Geosoft for streamlined geophysical and magnetometer workflows. Qimera 2.0 offers the full power of the Qinsy geodetic engine,

QPS: Qinsy 9.0 and Qimera 2.0

GeoSpectrum: C-Bass



Soundnine Inc. (S9): New Models of Ulti-Buoy Real Time Temperature Buoy



and new bathymetric LiDAR capabilities (to include color by RGB; data in image courtesy of 4D Ocean), among many other enhancements. Fledermaus 8.0 previews will feature 3D mesh technology, integrated video playback, and an enhanced presentation mode as the ultimate way to show off your data. All new software versions will feature a new and cutting-edge grid format for even faster updating and visualization, while also facilitating additional grid functionality.

Silicon Sensing: DMU30
Booth W47

The latest DMU30 device, measuring less than 69mm x 62mm x 66mm. FOG-Grade performance from an all-MEMS inertial measurement unit, on display at Ocean Business
On stand W47 Silicon Sensing will demonstrate its latest all-MEMS inertial measurement unit, DMU30. This delivers the precision inertial performance of a fibre-optic gyro-grade device with the price, reliability, size and weight of a MEMS unit.
DMU30 forms a highly capable inertial core for many motion sensing applications key to the maritime sector, from ROV navigation to platform stabilisation, and surveying and mapping. It is a formidable and affordable choice for the most exacting high-performance inertial measurement requirements, and is already in use in surface and subsurface applications. System integrators using DMU30 will have access to the company's comprehensive evaluation tools and to the close support of their team of inertial system experts. Silicon Sensing's full range of inertial products, including gyros, accelerometers and IMUs.

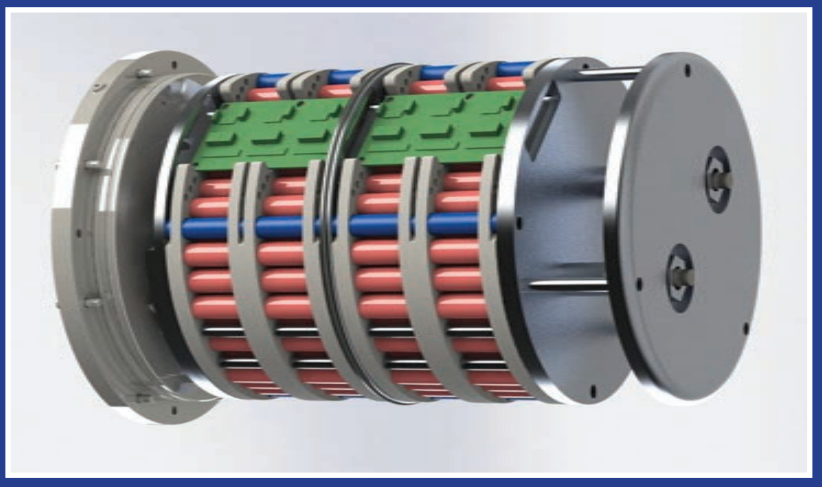
Soundnine Inc. (S9): New Models of Ulti-Buoy
Booth: W-50d

The Ulti-buoy with Cellular or Satellite telemetry, S9 inductive modem technology, and XT/XTP sensors enables reliable, low cost, high-accuracy monitoring in fresh or salt water up 200 meters depth. New hull options range from 30 to 60 cm diameter, allowing a greater range of applications and sensor pay-loads. The buoys are easily deployed/recovered from a small boat, fully submersible to 15 meters, and support up to 20 sensors at user-adjustable depths. XT/XTP sensors can sample up to every ten minutes for three years without service. Third party sensors for Conductivity, DO, and other parameters are also supported. From single or multi-depth water quality monitoring applications to relaying data from bottom mounted instruments via Iridium or Cellular telemetry, Ulti-buoy solutions offer superior value.

SubCtech: Subsea Batteries
Booth: Q2

SubCtech GmbH has expanded its

SubCtech: Subsea Batteries



USS: Accession Class 4.25m USV

Teledyne Marine: SeaRaptor AUV

market position for Subsea Batteries. The company extended its facilities with a new building, in order to handle the growing number globally. This optimizes series production and extends SubCtech R&D, and customers benefit from a faster delivery time and lower costs.

As a maker of high-performance, reliable and safe Li-Ion batteries for subsea Oil+Gas, AUV or ROV, SubCtech presents the latest subsea UPS product line at OB'19. The offshore qualified and proven technology (API17F) is available for a variety of backup and buffer applications, e.g. subsea actuator, All-Electric or control units. Voltages up to 600V and power up to 30kW can be realized.

The UPS systems are highly customizable in order to provide optimal solutions for challenging applications, with highest design and production standards. GoSubsea3000 is SubCtech's vision and brand.

Teledyne Marine

Booth: T5 & U12

Teledyne Marine will be on booths T5 and U12 at Ocean Business, where visitors will discover the largest breadth of technology in the marine industry. This show promises some new surprises, with new product launches spanning the organization's navigation, positioning, tracking, AUV, ROV, ADCP, sonar and camera technologies. Be sure to stop by booth U12 to see the impressive full-scale model of the SeaRaptor AUV, fully equipped with a suite of Teledyne Marine sensor and system technologies.

Learning opportunities will abound, as Teledyne Marine delivers over 20 classroom training sessions, as well as dockside and test tank demonstrations highlighting our vehicle, sonar and acoustic technologies. For those looking to get out on the water, Teledyne will also be conducting demonstrations of their multibeam, hydrographic software, positioning, LIDAR, and underway SV technologies onboard the Falcon Spirit throughout the event. Sign up for boat demos on booth T5.

USS: Accession Class USV

Booth: M2

USS will showcase the new Accession Class 4.25m USV on the quayside at Ocean Business and see a model of the USV on Swathe Services stand M2. A new Unmanned Surface Vessel (USV) with the potential to change the way offshore hydrographic surveys are conducted will launch at Ocean Business in April 2019. Unmanned Survey Solutions (USS) has designed and built the next-generation Accession Class USV for use in nearshore and offshore industries. The design of the Accession Class USV allows the vessel to increase its base design length of 3.5m to a maximum of 5.0m for additional payload equipment and/or power for extended endurance depending on operational requirements. Built by surveyors for surveyors, the vessel offers stable sea

keep conditions, long endurance, high performance and universal payload integration – essential for all survey operations. This Marine-I, part-funded European Regional Development Funded (EDRF) project will integrate Unmanned Airborne Vehicle (UAV) capabilities as well as Geophysical and Hydrographic Payloads. Accession Class USV applications include:

- Offshore Wind Farm seabed mapping using Geophysical and Hydrographic equipment
- Offshore Wind Farm turbine inspections using UAV's launched and recovered from the USV
- Enforcement activities by Inshore Fisheries and Conservation Authorities using combined USV and UAV capabilities
- Environmental mapping of intertidal areas using combined SONAR and laser payloads
- Large harbor and estuary mapping.

RTSYS: AUV NemoSens
Booth B11

RTSYS is a French-based company providing worldwide cost-effective solutions for research institutes and marine energies consulting companies. RTSYS manufactures reliable AUVs and will be presenting its latest portable micro-AUV called NemoSens, along with a new range of underwater recorders offering low-energy consumption for long run use.

OSIL: Autonomous Winch
Booth: C1

Bespoke marine engineering experts Ocean Scientific International Ltd (OSIL) have produced an innovative and compact autonomous profiling winch that will operate unmanned for 30 days. OSIL were approached with a requirement for a 24V waterproof winch system to mount to existing Automated Surface Vehicle systems. The winch will undertake 10 profiles per day, with a 15kg payload, for 30 days continuously. The design was constrained by the size of the available space and a maximum weight restriction, in addition to the payload requirements. The winch has 200m drum capacity using 3mm diameter Dyneema, and is equipped with a level wind to prevent entanglements and ensure the cable spools evenly onto the drum. The winch drum is also fitted with an encoder for pay out readings and an internal brake which operates automatically. OSIL have worked closely with the end client to ensure that the specification is exactly as required.

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