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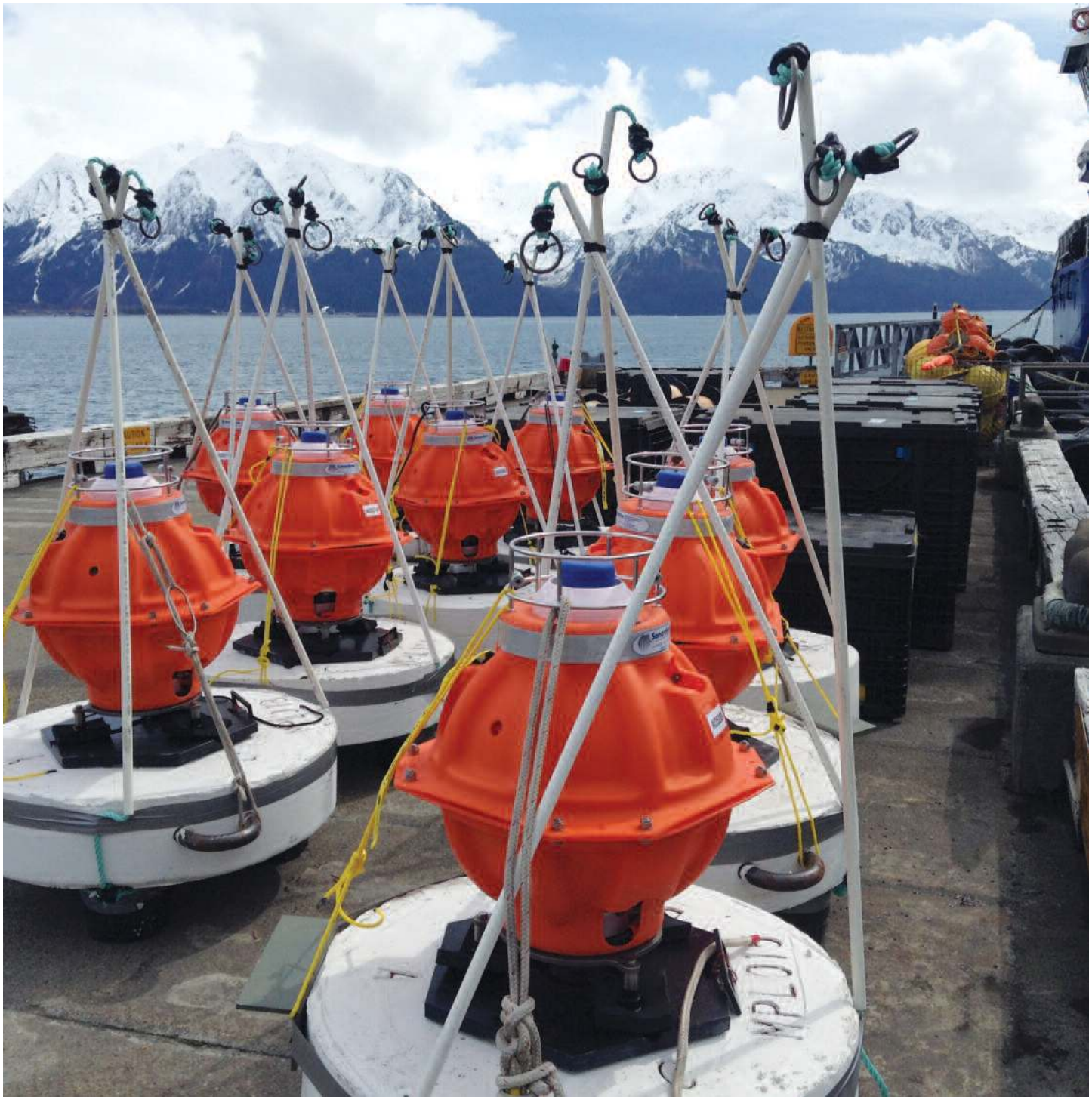
BASELINE. THE CUSTOMER MAGAZINE
FROM SONARDYNE

ISSUE 22



We always enjoy being part of and hearing about the projects our technologies help deliver – especially when they break new ground. We like sharing these stories even more and we have a great crop in this issue.

From plastics to overfishing, the health of our oceans is a national debate in many countries. This spring, the First Descent expedition set out to highlight the challenges faced by the Seychelles, broadcasting live from subsea vessels with our BlueComm free space optical modem. Oliver Steeds, the man behind the project, tells us more from page 12.

Another first is marked by BP's Craig Allinson. He has been behind a project which saw BP carry out its first over-the-horizon unmanned data harvesting operations with an unmanned surface vessel earlier this year. From page 24, he outlines the project and how our Fetch subsea sensor node and our USV-mounted Ranger 2 positioning and telemetry kit helped make the project possible. On both projects, our Applications Group was on hand – either on site or remotely – to make sure everything ran smoothly.

Breaking new ground can also be about meeting existing challenges in a new and more optimal way. From page 18, Tavis Letherby, from CCC (Underwater Engineering) in Dubai, explains how using SPRINT-Nav has helped overcome some of the challenges his team is tackling on a 2,000 km-long pipeline survey project, in shallow, noisy waters where long layback tracking is needed. IKM Subsea's use of SPRINT-Nav on its resident remote operated vehicle system, outlined on page 22, are just the latest examples of how SPRINT-Nav's outstanding performance is helping our customers to achieve more.

Later in the year, there's plenty more coming, not least from the growing fleet of international polar research vessels. Several new builds nearing completion have our Ranger 2 onboard and will be breaking new ground in their respective regions. Our Global Business Manager, Oceanographic, Geraint West, sets out how they benefit from our systems from page 34.

David Brown Editor

Baseline.
The Customer magazine from Sonardyne

Editorial Team
David Brown
Head of Marketing

Elaine Maslin
Senior Content Writer and Editor

Anthony Hammond
Marketing Manager – Digital & Events

Tom Acton
Marketing Executive

Contributors
Jeppe Neilsen, CEO, EIVA; Simon Partridge, Strategy Director, Sonardyne; Oliver Steeds, founder, Nekton Deep Ocean Research Institute; Tavis Letherby, Survey/ROV Manager, CCC (Underwater Engineering); Craig Allinson, Surveyor, BP; Ioseba Tena, Global Business Manager for Defence and Robotics, Sonardyne; Geraint West, Global Business Manager for Ocean Science, Sonardyne.

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Issue #22 Cover
Our long endurance Fetch pressure monitoring and logging technology will be making measurements that provide critical information about earthquake and tsunami hazards offshore Canada. See page 09.
Photo from David Chadwell/ Scripps Institution of Oceanography.

NEWS

Maritime software specialist EIVA joins Sonardyne group

As you will read more about on page 10, we have acquired maritime software and equipment specialist EIVA. It's an exciting move, for us and EIVA, which will remain an independent business and brand.

EIVA has more than 40 years' experience in the development and delivery of software and hardware solutions to offshore and shallow water engineering and survey organisations. They're increasingly supporting customers with their requirements for higher levels of automation and remote and unmanned operations through their NaviSuite software. The company employs more than 75 people with headquarters in Denmark.

EIVA Chief Executive Officer Jeppe Nielsen, who has been CEO since 2011, will remain in post, while our Investment and Integration Director Stephen Fasham will take on the role of Chairman.

Teaming-up with Güralp to advance seabed exploration and research capability

We are pleased to announce that we've signed an agreement to cooperate in the provision of leading-edge multi-disciplinary ocean bottom research technology with UK-based marine seismic monitoring instrumentation and solutions provider Güralp Systems Ltd.

Güralp has more than 30 years' experience in the design and manufacture of broadband seismometers and accelerometers, while our experience in long-endurance seafloor data logging and telemetry is nearing 50 years.

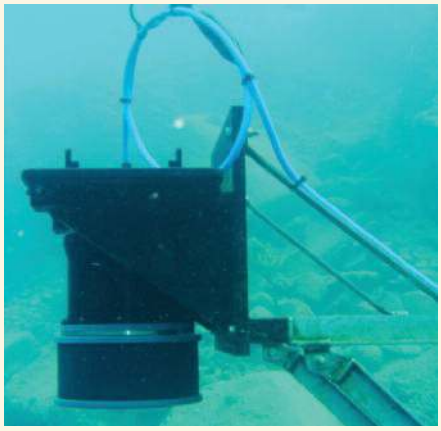
Our new combined offering for seismic data acquisition, seabed deformation monitoring and tsunami detection, underpinned by acoustic positioning and telemetry for remote data access, is expected to deliver significant and cost-effective benefits for geodetic science.

At the heart of the cooperation is Güralp's revolutionary new Aquarius Ocean Bottom Seismometer (OBS) which will come equipped with our 6G Wideband low-medium frequency (LMF) acoustics.

The Aquarius' slim profile design minimises hydrodynamic flow noise, whilst its compact footprint is considered to be the smallest telemetry-enabled OBS on the market. Depending on the system options selected, 12 or 18-month deployments are available.

Inside, it contains a digital feedback tri-axial broadband seismometer, three-axis magnetometer, a micro-electric mechanical system accelerometer, absolute pressure gauge and our 6G custom designed OEM modem. With 6G onboard, Aquarius is now compatible with the Sonardyne Ranger 2 Ultra-Short BaseLine (USBL) tracking systems fitted to a large proportion of the international research vessel fleet. Equally it's data could also be harvested using 6G-equipped unmanned surface vehicles.

Sentinel to protect Eastern European waterside energy facility



Tried, tested and trusted, our Sentinel Intruder Detection Sonar (IDS) is the market leader in underwater threat detection. It's on duty with navies, commercial port authorities, at private waterside residences, and on high value vessels.

One of the latest deployments will see Sentinel protecting the perimeter of critical national energy infrastructure (CNI) in Eastern Europe. There, it will be used to spot unauthorised divers and underwater drones approaching the facility. The installation, at an undisclosed location, is the first phase of a site-wide project led by MARSS Group to enhance security at the facility. This will see Sentinel integrated with their NiDAR long-range air, land and underwater situational awareness system.

Reliably detecting underwater intruders or vehicles in real time at long range is essential, providing time for security personnel to react to waterborne incursions. Vital minutes can make the difference between successful threat interception and divers and vehicles being able to deliver their attack.

Sentinel not only detects, but also tracks and classifies underwater threats at up to 1.5 km range to provide a rapidly deployable perimeter intrusion capability. Its proven ability to discriminate between genuine targets and non-threats, such as large fish in a wide range of operational environments makes it a valuable tool in any waterside security system.

It's suitable for shore-based, portable and vessel-based installation, so whether you're in port or anchored at sea, Sentinel has you covered.

Neptune trades up to Fusion 2

Industry uptake for our all-in-one acoustic and inertial positioning technology platform, Fusion 2, and 6 'plus' (6+) continues to build.

Our latest order is from Australian headquartered subsea services specialist Neptune. After many years of reliable service, the company has traded in its inventory of Compatt 5 seabed transponders. They've been replaced with Compatt 6+ units and ROVNav 6+ Long BaseLine (LBL) vehicle-mounted transceivers, all controlled by Fusion 2 software. The new kit has gone straight to work, assisting rig positioning and field support campaigns in the region.

Fusion 2 offers a seamless environment to support LBL, SPRINT INS (inertial navigation system) and sparse (INS-aided) LBL operations. When used alongside 6+ hardware, it offers the ability to simplify complex projects – all with less subsea and topside hardware.

Docking demo spotlights BlueComm's benefits

In-water demonstrations are the perfect way to show capability, so when an invitation arrived to take part in a resident vehicle dock, data download and recharge display, we were quick to accept.

Led by Saab Seaeye using its Sabertooth autonomous underwater vehicle (AUV) and Norwegian energy company Equinor's open-standard subsea docking station (SDS), the demonstrations were held on Sweden's Lake Vattern.

The BlueComm 200 UV (Ultra-Violet) through-water wireless optical modem fitted to the AUV was used to stream live videos from the vehicle's HD camera to the surface, enabling the pilot to perform the final docking manoeuvres with confidence. BlueComm UV, which is designed to have a high tolerance to ambient light, was successfully demonstrated in challenging conditions with bright midday sunshine. It can also offload large volumes of data – direct to desktops – wirelessly.

Field resident AUVs that can be remotely tasked to perform autonomous surveys and light interventions are a widely held vision of the future. Thanks to hybrid platforms like the Sabertooth, combined with technologies like BlueComm, that future has in reality already arrived.

SPRINT-Nav selected for Oceaneering's subsea resident vehicles

Our hybrid navigation instrument SPRINT-Nav continues to break new ground in the global ocean space – this time as a key enabler for Oceaneering International Inc.'s new Freedom hybrid vehicle and its E-ROV.

Oceaneering's E-ROV has already proven the ability for battery powered remotely operated vehicles (ROVs) working in the oil and gas industry to be piloted from shore, via 4G mobile broadband transmitted from a buoy, independent of support vessels. The company's next-generation resident hybrid ROV Freedom takes the E-ROV concept to another level by targeting long and maintenance-free deployments, both on autonomous missions and with support from shore-based pilots.

The vehicle, which begins operational trials this year, will be based out of docking stations on the seabed, enabling it to recharge and download data. It will operate in tethered and autonomous tetherless modes, performing both autonomous underwater vehicle (AUV) and ROV related tasks, including survey, inspection, torque tool operation and manipulator-relator activities.

SPRINT-Nav is our hybrid inertial navigation instrument that's increasingly being chosen by vehicle manufacturers as a factory fit item. It combines high grade Honeywell-supplied gyros and accelerometers, Syrinx 600 kHz DVL (Doppler velocity log) and a precise pressure sensor in a single, compact unit that can be accommodated by a wide range of vehicle platforms. It's available in depth ratings to 6,000 m and tiered INS performance levels to support simple to complex tasks.

As we reported in Baseline 21, we've recently revised our SPRINT-Nav performance figures to reflect its true capabilities. Suffice to say, dead-reckoning accuracy is a fraction of a metre over many kilometres travelled.

Another vehicle due to be fitted with SPRINT-Nav is Cellula Robotics' Solus-LR long-range unmanned underwater vehicle (UUV). It's being designed for the Canadian defence department to travel up to 2,000 km on multi-month missions. You can read more on page 28.

Coral South and Aasta Hansteen monitoring projects secured

Our teaming agreement with engineering consultancy BMT to supply integrity monitoring solutions to the energy sector is making great progress.

Mooring solutions supplier SOFEC Inc., a MODEC Group company, has awarded a contract to provide a mooring monitoring system (MMS) for the turret mooring system they are building for ENI's new-build floating liquefied natural gas (FLNG) facility. The FLNG vessel, which is being built in South Korea, is destined for the Coral South project in Mozambique, in water depths ranging from 1,500-2,300 m

The combined BMT-Sonardyne bid was considered to offer the most technically competent and robust MMS, offering high data availability, ease of remotely operated vehicle (ROV) installation, robustness and long service intervals. Below the waterline, our SMART (Subsea Monitoring, Analysis and Reporting Technology) will be used to constantly monitor mooring integrity on each of the 20 anchor lines. Daily summary reports and automatic fault detections will be wirelessly communicated to the surface from the SMARTs in real time.

Above the waterline, BMT will supply the station-keeping turret monitoring system and local control panel with touchscreen interface. The control system will also house our topside equipment, to minimise the system's footprint. Additionally, the system will allow SOFEC's client to gain remote data access through BMT's secure cloud-based portal, BMT DEEP.

Meanwhile, in Norway, we worked with BMT to supply a riser monitoring system (RMS) to Subsea 7, for use on Equinor's Aasta Hansteen spar platform in the Norwegian Sea. It's the deepest development on the Norwegian Continential Shelf to date, sitting in 1,300 m water depth, the first spar platform in the country and the first to use steel catenary risers (SCRs).

The RMS incorporates various strain, motion, and position sensors, supported by our underwater acoustic positioning technologies, deployed by ROVs, to monitor the SCR response in the touch down zone and riser interaction with the spar pull tube. Data collected by the RMS is used to validate and bring efficiencies to the spar and SCR design.

Visit **bmt.org** to discover more about BMT's engineering services.

SMARTs aid BOP fatigue monitoring

SMART is one of our most versatile instruments, providing not just wireless monitoring capability, but also analysis, at the sensor site. One of its latest deployments is as part of a Wellhead Fatigue Mitigation System (WFMS) offshore New Zealand.

The complete system, designed by Houston-based Trendsetter Vulcan Offshore (TVO), will allow oil and gas company Tamarind Resources to alleviate wellhead fatigue during drilling on the Tui oil field, in the Taranaki Basin.

TVO's innovative WFMS alleviates the impact of modern, large blowout preventers (BOPs) on legacy wellheads by arresting the motion of the BOP stack via four tethers, which are anchored to the nearby seabed.

In this application, the SMARTs ensure operations are within fatigue safety limits by monitoring movement of the BOP and the bottom of the drilling riser. They then provide in-situ analysis, so that just summary packets of information, such as minimum, maximum and standard deviations for accelerations and rotations in all axes, can then be acoustically transmitted to the rig, via our Dunker 6 transceiver, throughout drilling operations.

Ranger 2 for Brazil's flagship oceanographic research vessel

High precision underwater positioning is critical to gathering meaningful data to support scientific breakthroughs. That's why many national and private oceanographic institutes pick our Ranger 2 Ultra-Short Baseline (USBL) system for installation on their research vessels.

The latest vessel to be equipped with Ranger 2 is Brazil's flagship, the *Alpha Crucis*. The 64 m-long vessel, which is operated by the University of São Paulo, undertakes scientific projects spanning global climate change to biodiversity in Brazilian waters.

The Ranger 2 system will enable the *Alpha Crucis*' 21-strong science team to precisely track their instruments and sensors to beyond 7,000 m, accurately measuring the range and bearing from its surface deployed acoustic transceiver to transponders fitted on each subsea target.

The University of São Paulo has configured its Ranger 2 USBL with our Gyro USBL transceiver, which has a built-in attitude and heading reference sensor (AHRS). It leaves our factory pre-calibrated, eliminating the need for lengthy manoeuvres to be undertaken at sea to determine the alignment of the ship's motion sensors relative to the acoustic transceiver. In practical terms, this means survey operations will be fast and precise, and the available vessel time for science maximised.

The university has also ordered 4,000 m depth rated Wideband Sub-Mini 6 Plus (WSM 6+) transponders to track its in-water equipment, which includes sediment corers, towed cameras, landers and remotely operated vehicles (ROVs).

The *Alpha Crucis* operates from off the coast to the deepest parts of the South Atlantic so it's important it's equipped with the best available technologies to assist its work. The Ranger 2 Gyro USBL combination, deployed using our over-the-side deployment pole, is the perfect option for the vessel – it's quick to install and pre-calibrated. It also gives the university the option to move the complete system to another vessel if the need ever arises.

Supporting future marine robotic engineers

Newcastle University

We're helping to drive marine autonomous systems (MAS) of the future by supporting the next generation of robotics engineers studying at the University of Newcastle, UK.

Following the award of a grant from us, the Newcastle University Sonardyne Robotics and Autonomous Systems Student Laboratory is being kitted out with essential hardware, including vehicle parts, laptops/control stations and a rapid prototype printer. By having a cross-disciplinary, collaborative environment, containing all the tools they need, teams of students, with the supervision of academic members of staff, will be able to take the work they've already started in subsea robotics to a new level, including designing and printing their own custom robotic parts.

The university's Engineering Projects Society has been active in subsea robotics projects for the last three years. Most recently, its competitive arm, the NUROVers team, made it through to the finals of the Marine Advanced Technology Education (MATE) competition in Tennessee, US, winning the 'Guts and Glory' award. One of the Engineering Projects Society's next goals is building an AUV. We wish them luck and look forward to seeing the results!

New Canadian seabed observatory selects Fetch for tectonic plate monitoring

Our long endurance pressure monitoring and logging technology platform, Fetch, has been selected for a major new seabed observatory that will provide critical information about earthquake and tsunami hazards offshore Canada.

The new Northern Cascadia Subduction Zone Observatory (NCSZO) is being constructed offshore Vancouver. At its core there will be a "seafloor GPS" network to monitor long-term vertical displacement of the subducting Juan de Fuca plate and overriding North American tectonic plate. These observations, made using Fetch, will play a critical role in informing assessments of earthquake and tsunami risk to the large populations of the Pacific North-West.

More than 20 Fetch units, with an initial planned deployment of seven years, in depths ranging from 400 to 2,500 m, will form the backbone of the system. Logged data from each unit will be uploaded to the surface up to twice a year using a technique called GPS-Acoustic (GPS-A), something we helped commercialise.

GPS-A uses acoustic positioning techniques, inertial navigation and GPS data to periodically position the Fetch instruments to centimetre-level accuracy, using one of our transceivers mounted on an unmanned surface vessel. These measurements enable the Fetch positions to be related to a corresponding onshore network of geodetic stations operated by Natural Resources Canada (NRCan), allowing the subsea plate motion and onshore plate motion to be correlated for the first time.

A number of Fetch units will also be hard-wired into an existing 900 km-long NEPTUNE cabled observatory to study the potential for continuous measurements. These units will feature our Ambient-Zero-Ambient (AZA) functionality, which enables the instrument's high pressure sensor to be automatically recalibrated in-situ, by periodically measuring the sensor bias against an internal low pressure sensor.

The NCSZO is a truly collaborative project. It's being led by Ocean Networks Canada (ONC) – an initiative of the University of Victoria – with the cooperation of international partners including NRCan scientists at the Pacific Geoscience Centre and Dr. C. David Chadwell from the Scripps Institution of Oceanography.

The project is also supported by Natural Resources Canada, the British Columbia Knowledge Development Fund and the Canada Foundation for Innovation.

"More than 20 Fetch units, with an initial planned deployment of seven years, will form the backbone of the system."

VIEWPOINT

Throughout our history we've been developing new technologies, growing and deepening our capabilities. Acquiring maritime software specialist EIVA adds a new dimension. EIVA CEO Jeppe Nielsen and Sonardyne's Strategy Director Simon Partridge explain how.

BL: Tell us more about the acquisition – why EIVA and why Sonardyne?
Simon Partridge: EIVA, like us, are an independent, commercially successful company. They're in many of the market segments we operate in, and, importantly, adjacent markets. We understand their technology, which has no overlap with our own, and we see the long-term strategic benefits of working together. With EIVA, we're bringing new dimensions and diversification to complement our organic growth.

Jeppe Neilsen: We were looking for the right ownership to give us the opportunity to deliver the potential we see in EIVA, building on the commercial success we have achieved to date. Sonardyne is a perfect fit, culturally, strategically and technically.

BL: Tell us more about EIVA.
JN: EIVA is both a software and mechatronics products provider for a wide range of subsea and offshore segments. Our core product is our NaviSuite software and its goal is to provide automation through the survey data workflow; automating acquisition, processing, and interpretation, utilising the latest computer vision and machine learning technologies such as deep learning.

I joined the company in 2011, as co-investor and CEO, and it's been a continuous journey, growing the company and its products portfolio. The latest addition to the NaviSuite product range is our NaviSuite Mobula, a complete software solution for micro- and mini-ROV steering.

SP: Much of EIVA's software offering is done on a subscription-based model. It's plug-and-play, easy to adopt and use – just like our Fusion 2 LBL and INS software. Much like ourselves, EIVA also has a strong training offering so that clients can really get the best out of their software. EIVA also produces hardware, including its ScanFish remote operated towed vehicles (ROTVs), where we see great synergies with our underwater positioning systems.

BL: How will our customers benefit?
SP: An example is improved software integration. EIVA's NaviSuite software is widely established in the market place and gives our customers an advantage in terms of integration with our hardware. This will mean direct operational benefits and simplification for users.

JN: Being part of the Sonardyne group, means that EIVA can add new capabilities to EIVA products, implement tighter integrated products and new joint offerings. For example, with ScanFish, we can now seamlessly integrate Sonardyne's acoustic positioning and tracking technology, such as the Mini-Ranger 2 Ultra-Short BaseLine (USBL) system, making our systems more powerful and easier to use out of the box. However, EIVA will continue to be sensor agnostic and work with all the high-end sensor providers in our industry, offering the best possible solutions for our customers, whatever equipment spread they may have.

BL: What does acquiring EIVA mean for Sonardyne?
SP: EIVA work in many of the same market segments as us, but they're also in areas where we have room to grow, such as offshore renewables and some areas in the defence space. They are also ahead of us in areas like Deep Learning where we are looking to learn from EIVA. With our global footprint and infrastructure, we'll also be able to help them access more markets.

JN: While continuing EIVA's current strategy, we have in addition started the process of identifying areas of relevant new product extensions, possible joint offerings and where we can utilise Sonardyne's stronger presence in certain

As this recent image from the field shows, EIVA's and our own paths regularly cross within the offshore energy and renewables sectors. Now, as part of the same group of companies, this relationship is set to strengthen and deliver greater synergies.

Much of EIVA's software offering is done on a subscription based model. It's plug and play, easy to adopt and use – just like our Fusion 2 LBL and INS software.

geographies and industry segments. Short term, this has already resulted in us being able to employ EIVA sales staff in locations where EIVA did not have its own presence before.

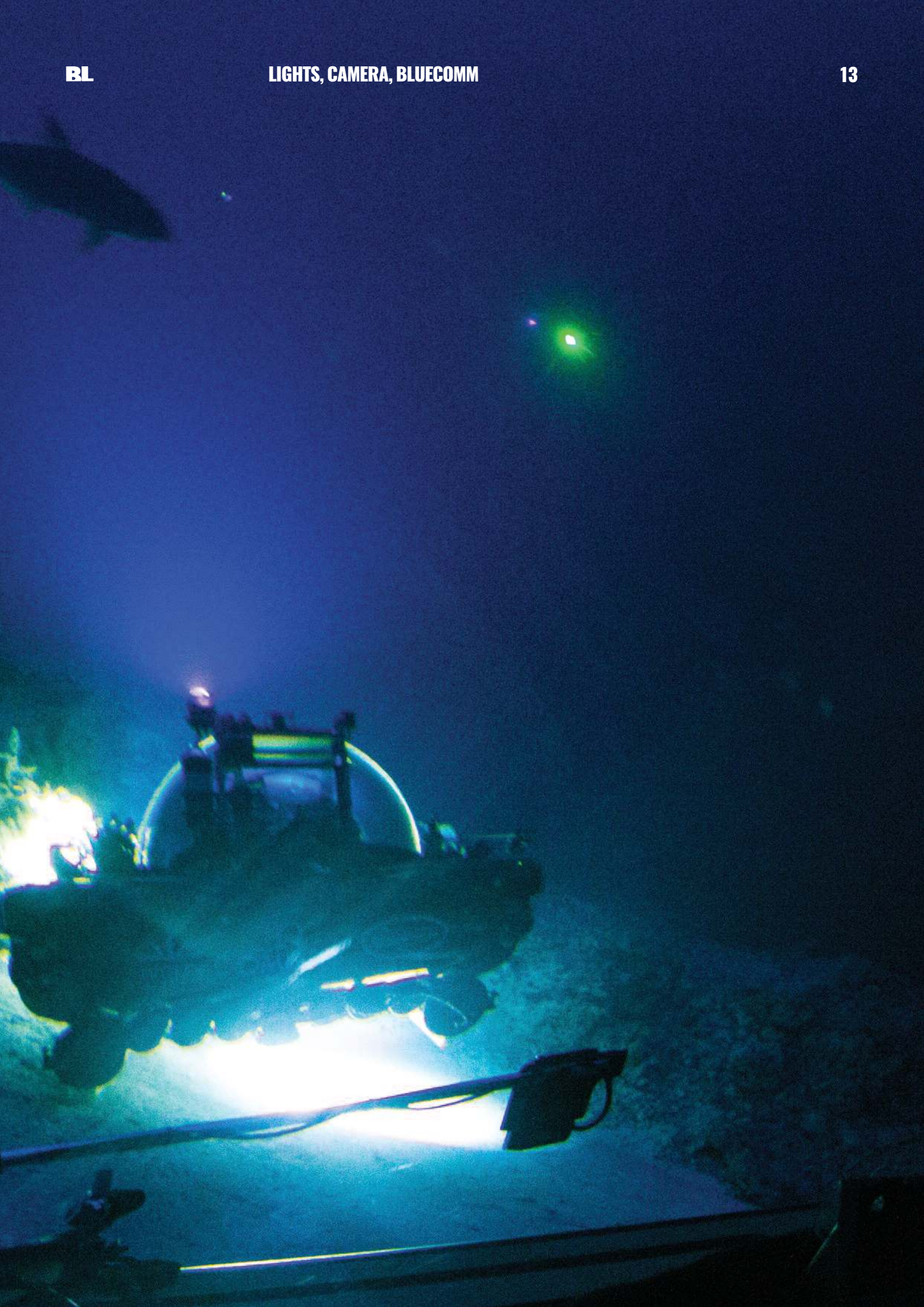
BL: What's next?

SP: For our customers, and EIVA's, day-to-day, it's going to very much be business as usual. Moving on, we look forward to jointly and independently doing what we do best, whether that's our underwater wireless communications, navigation and sonar imaging and detection technologies or EIVA's NaviSuite range of software or its hardware solutions.

JN: The entire EIVA team remains onboard and the overall growth strategy with higher investment in products and support capabilities remains. For our customers, the new ownership will therefore result in continuation and acceleration of the product developments and a high level of new products. For joint Sonardyne and EIVA customers, we will be presenting some of these new capabilities at our EIVA Days, in Autumn.

LIGHTS, CAMERA, BLUECOMM

NEKTON DEEP OCEAN RESEARCH INSTITUTE ACHIEVED A SERIES OF WORLD FIRSTS THIS YEAR, BROADCASTING LIVE TO THE WORLD FROM THEIR MANNED SUBMERSIBLES DURING A PIONEERING RESEARCH MISSION IN THE INDIAN OCEAN. OLIVER STEEDS, THE INSTITUTE'S FOUNDER, SETS THE SCENE, INCLUDING THE PIVOTAL ROLE SONARDYNE TECHNOLOGY PLAYED.



"Citizens of the world…. I am 124 m below the surface of the ocean speaking live to you…," explained Danny Faure, President of the Seychelles, during the first live subsea presidential address that was beamed to the world during our First Descent mission.

Historically, the journey up, into outer space, has inspired billions of people around the world with stories that ultimately look to a brighter future. But it's now time we started looking down. We need to capture this same spirit of human endeavour as we journey down into our deep ocean. It's the beating blue heart of our planet. Yet, we don't know how healthy this heart is. With only a fraction of the planet explored, the deep sea has now become our most critical frontier.

But there's hope. While we know the ocean is in crisis, we now have the technology available to us that could help us discover more of our planet in the next 10 years than we have in the last 10,000. As rockets and astronauts inspire us to look skyward, our aquanauts and their submersibles can embody our next giant leap – into the deep. This is one of our key goals for First Descent – a series of missions we, Nekton, are undertaking across the Indian Ocean from 2019 to 2022, which started in the Seychelles this spring. Our primary goal is to accelerate the scientific exploration and conservation of the Indian Ocean, the world's least explored and least protected ocean – aiming to catalyse 30% protection by 2030 to ensure a resilient and prosperous ocean.

Almost no research has been done beneath 30 m (scuba depth) across the Seychelles' vast ocean territory, which covers 1.37 million sq km and includes unique environments like the Aldabra Atoll; the Galapagos of the Indian Ocean. Working with and for the Seychelles government, we set out to help establish a baseline of marine life for these outstanding areas, in a bid to gather the actionable data they need to help protect 30% of their ocean, equivalent in size to twice the entire UK.

ENTER BLUECOMM

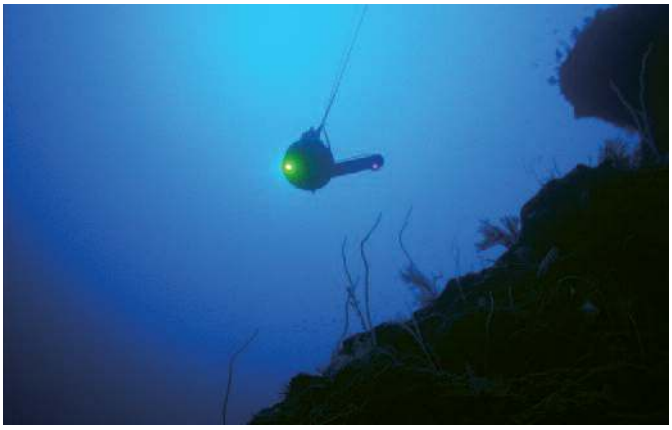
A critical part of what we wanted to try to do was to deliver a step-change in public awareness. Our ambition was to broadcast live from our submersibles in those very areas that we want to protect; to bring the deep ocean into the newsrooms, classrooms, boardrooms and the corridors of power in a profoundly new way. There was just one problem – no one had done this before. Up stepped Sonardyne and their BlueComm technology – into the unknown. Together we were able to make broadcast history.

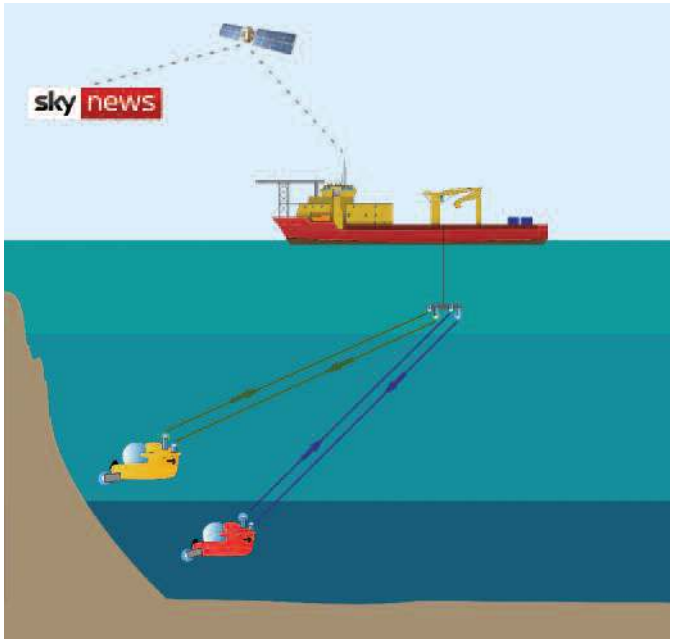
Our mission started in March. Operating from the *Ocean Zephyr* – an offshore supply vessel we adapted for research – we headed into the Indian Ocean with two, two-man submersibles and a suite of subsea research tools. Our subs took our mission scientists and journalists from Sky TV and international news agency Associated Press down into these unique and beautiful ocean environments.

On March 12, during our first week of research, we successfully achieved our first live broadcast from the deep. From China to India, Europe to the US, Brazil to Nigeria – this unique media event captivated audiences globally. Associated Press announced it had achieved "the first multi-camera live signal in full broadcast quality from manned submersibles using optical video transmission techniques, in which the pictures transmit through the waves using the electromagnetic spectrum." We had a world first, enabled by

Clockwise from left: BlueComm mounted on the Kensington Deep submersible; Nekton's Triton sub; a cable deployed BlueComm receiver; Anna Botting, from Sky News, broadcasting live via BlueComm.

"The first multi-camera live signal in full broadcast quality from manned submersibles using optical video transmission techniques, in which the pictures transmit through the waves using the electromagnetic spectrum. We had a world first, enabled by BlueComm."





BlueComm. For this, as a team, we have been shortlisted for the prestigious IBC Technology Innovation Award that celebrates pioneering achievements in broadcasting.

The following week, Sky News presenter Anna Botting broadcast the world's first live news bulletin from 135 m deep, another world first, also using BlueComm. Sky News co-presenter Mark Austin then broadcast from 250 m deep, in the twilight, or mesopelagic, zone of the little explored Aldabra Atoll, which is a deep ocean equivalent to the Galapagos Islands.

Just before the end of the mission was the real highlight. A broadcast with a message for the world. Danny Faure, President of the Seychelles, gave the first subsea Presidential Address - a global call for stronger protection of the ocean – from the ocean's depths, off the coast of Desroches, again transmitted on the back of BlueComm. His broadcast became the trending story of the day globally. Each one of the broadcasts had become global media events. These were extraordinary achievements. We even connected school children from 16 countries across the globe with our scientists while they were working beneath the waves. And it was all made possible by BlueComm.

HOW DOES IT WORK?

So, how does BlueComm transmit video and audio through water? In simple terms, using LEDs that flash on and off so quickly their blue/green/uv light appears constant. The scientific explanation comes from Darryl Newborough, Sonardyne's Technical Director, who helped set up BlueComm on the *Ocean Zephyr* in the Seychelles.

"BlueComm is a free space optical modem that uses high power light emitting diodes (LEDs) rapidly modulated to transmit up to 10 Mbps of data – that's video quality. Typically, our BlueComm units operate in the 450 nm blue light region of the spectrum, because blue is the least absorbed light in water. Depending on the type of BlueComm, these signals are received either by photodiodes (BlueComm 100) or a photomultiplier tube (BlueComm 200), which is more sensitive, allowing ranges of up to 150 m. BlueComm 200 can sustain data rates of up to 10 Mpbs – enough to transfer HD video in real time.

"In shallow waters, where there is ambient light, we also have BlueComm 200 UV. It's similar to the BlueComm 200, but operates with a centre wavelength of 405 nm. Containing ultraviolet (UV) and some visible violet light and with receiver filtering, it has a higher tolerance to visible light, such as a subsea vehicle's own lights or ambient light. Its range is a bit shorter, but it doesn't suffer from artificial light contamination. This means we could operate concurrently while filming video or in the presence of other light sources. It can also operate closer to the surface and suffer less interference from sunlight and it maintains the 10 Mbps update rate.

A SPECTRUM OF COLOURS

"The First Decent mission used our BlueComm 200s. But, Nekton wanted to transmit from both of its two submersibles at the same time. This made life interesting. In addition to making sure the various objects in the water, including a tethered ROV, the two submersibles and the cabled BlueComm depressor didn't get tangled, we needed to make sure that vehicle lighting didn't degrade the BlueComm signal. Then, because two sets of signals were being transmitted – because two submersibles were being used concurrently – we needed to make sure those signals didn't interfere. So, we deployed BlueComms that use green and UV light (one of each on each submersible), so that signals from both could be detected independently, without getting mixed up.

"We also had help from Lumasys, in the US, who we licensed the BlueComm technology from seven years ago, to make sure we didn't get any spectrum interference between the two BlueComm systems in the water as it could impact dual broadcasts. The support from Norm Farr and the team at Lumasys was fantastic. Virtually overnight, they made up and shipped a one-off optical filter to us during mobilisation, so hats off to them for going above and beyond."

THE TIME TO ACT IS NOW

Thanks to today's satellite and internet communications technologies, during live broadcasts, Darryl was able to be based in the UK but

Left to right: How BlueComm worked; BlueComm units mounted and ready for action; the view from the TV control cabin; Oliver Steeds speaks with President Danny Faure.

communicate live with our engineers and the heads of technology for Sky and Associated Press via WhatsApp, while they were also connected via desktop-sharing software. This was all while watching the live broadcasts being beamed to the world. We were truly globally connected.

With BlueComm, we were able to bring some of the least explored, least known areas of the world's ocean to people in the four corners of the world. The images were carried live across the world. In fact, our partners Associated Press, who distributed and tracked the video content we produced, estimate that at least half of the world – 3.5 billion people – saw coverage of our mission in the Seychelles.

We need to inspire people in different ways and pictures and global media events like these helps to ensure that the deep sea is no longer out of sight and out of mind. As Danny Faure, President of the Seychelles, said during his transmission: "We are running out of excuses to not take action and running out of time. The time to act is now." Through the First Descent mission, the impact we're having on the world's ocean is now very much in the public domain. The world is literally now switched on – via BlueComm – to the impact we're having and what we can do about it. Meanwhile, we continue to build our understanding and awareness of our ocean. Our mission in the Indian Ocean has only just started. We have another major expedition early next year and BlueComm will again be at the heart of the action.

Now we just have to figure out how to top what we did in the Seychelles with some new world firsts. A live deep ocean gig with Paul McCartney singing Yellow Submarine? If you know him, please ask him to get in touch! Turns out he was right all along. We all need to live in yellow submarines. The journey continues…. Onwards and downwards. Follow the mission at **nektonmission.org** BL

Watch for yourself to discover how critical BlueComm was to Nekton's First Descent mission.

THE KIT LIST
WHAT'S FEATURED IN THIS STORY

BlueComm 200

What is it?
BlueComm 200 is a free space optical modem that's capable of transmitting up 10 Mbps of your data at ranges up to 150 m.

How does it work?
An array of high power LEDS are rapidly modulated to enable fast, high bandwidth data transfer. A separate photomultiplier tube is used as a receiving element that's sync'd with vehicle lighting to avoid interference.

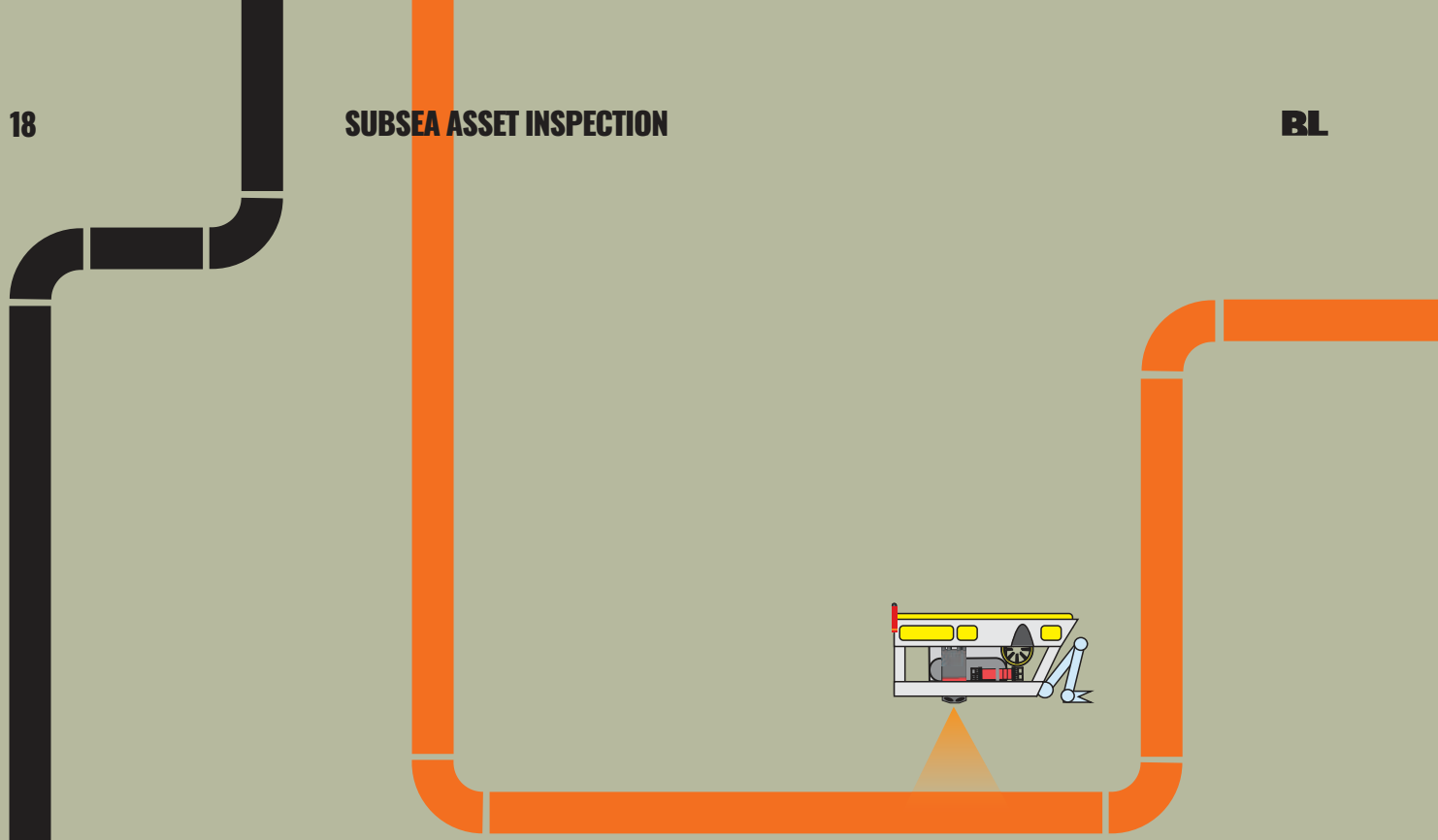
How will it benefit your operation?
It frees you from using expensive, and vulnerable to damage, underwater cables to connect up your underwater instruments. It also means you don't need to recover instruments to access large volumes of data, saving vessel time.

BlueComm 200 UV

What is it?
BlueComm 200 UV provides the same 1-10 Mbps optical communications link as BlueComm 200, just in a slightly different way so it's less susceptible to ambient light. This reduces range to around 75 m – but that's still far enough for a passing AUV to establish a reliable link.

How does it work?
BlueComm 200 UV has minimal susceptibility to artificial light, i.e. LED vehicle lighting ($\lambda > 430$nm) and reduced susceptibility to solar radiation, which means it can be fitted to your ROV, manned submersible to resident AUV, and near to the sea surface.

How will it benefit your operation?
Like the Nekton mission, with BlueComm 200 UV at work, your underwater operations can continue around the clock – day or night. Plus there's less chance of the communications uplink/ downlink being affected by your own vehicle, or those operating around you.



LONG EXCURSION HIGH ELEVATION TRACKING – NOT A PROBLEM, EVEN IN BUSY WATERS

ROV PIPELINE INSPECTIONS IN SHALLOW WATER – WITH LONG EXCURSIONS AND HIGH ELEVATION TRACKING REQUIREMENTS – CAN POSE MAJOR CHALLENGES FOR EVEN THE BEST USBL SYSTEMS. WITH SPRINT-NAV IN THE MIX, IT'S NO LONGER AN ISSUE, AS TAVIS LETHERBY, SURVEY/ROV MANAGER AT CCC (UNDERWATER ENGINEERING), EXPLAINS.

Today's digital data acquisition capabilities and global positioning systems have made offshore inspection operations easier and more accurate. With Global Navigation Satellite Systems (GNSS) or Differential GPS (DGPS), we can achieve 20 cm accuracy. The data gathered is also more easily accessible for operators and then easier to analyse.

But, if you don't have good subsea positioning accuracy, you will not have a good baseline or repeatability, in order to compare new survey data with old. In the past, baseline data could be three metres out and that was acceptable. Now, we expect less than half a metre and we want repeatability.

The key is getting positioning repeatability and the accuracy errors down; having a solid baseline and knowing future surveys will accurately match it. Underwater positioning is not always that easy, with some environments being more challenging than others. Recently, CCC was engaged for a project offshore the United Arab Emirates, conducting subsea pipeline external inspections with challenging subsea environments for survey technology.

A 2,000 KM MISSION

It's a periodic integrity survey of an operator's pipeline network, some of it dating back to the 1960s and 1970s. The subsea inspection campaign amounts to approximately 2,000 km of accumulative inspection distance, covering 316 pipelines, over various offshore fields. The project is being completed in two campaigns. The first ran from August 2018 to April 2019, and covered 1,500 km of pipeline (214 pipelines). The second will cover the remaining 102 pipelines, and is expected to start in August this year. The platform used to undertake the subsea external inspection was the CCC owned and operated Saab Seaeye Leopard 1706 remotely operated vehicle (ROV). Fitted with three HD cameras, Valeport bathy suite, mini SVP, CP, UT, laser

line generator, MCS PRC system and two Kongsberg M3 profiling sonars, that's tracked by a Sonardyne Mini-Ranger 2 Ultra-Short BaseLine (USBL) system from our CCC *Maritime 2* multi-purpose dive support vessel.

The scale of the inspection campaign was not the main concern for the project. Our main challenge was that these pipelines are situated in waters as shallow as 5.5 m and not more than 30 m. When conducting operations in shallow water, you inevitably put a lot of man-made noise into the water – engine noise, ROV noise, etc. There are also surface reflections and high signal to noise, all of which has the potential to reduce the accuracy of subsea positioning when using a USBL system. So we needed to supplement the conventional means for subsea pipeline inspection positioning.

We're a long-term customer of Sonardyne and we like to standardise, so we have Ranger 2 Pro USBL systems on all our vessels. We're also very happy with our 6G and 6+ equipment. But, because of the shallow water, we decided to use a Mini-Ranger 2, which has a beam plot that suits these needs, and WSM 6+ (Wideband Sub-Mini 6 Plus) beacons, which are proven to be reliable when operated in shallow water.

But, we still had to deal with noise in the water, which could impact our USBL effectiveness, and an additional challenge – long ROV excursions. For safety reasons, our vessels are not allowed within 50-70 m of platforms in this area, sometimes further, which of course is normal. This means that, sometimes, the ROV has to navigate upwards of 70-100 m away from the vessel (and therefore also the USBL transceiver) to the riser base, in order to do the full pipeline inspection.

In the past, when we have done such long excursions, the subsea position of the ROV has become unreliable or erratic. You're working in 12 m water depth and the vessel has 4 m of draft, so there's only maybe 8 m between the keel and the seabed. The ROV is 1.2 m high and sitting over a 14 inch pipeline, so it's actually 2 m off the seabed. That means there's only 6 m between the base of the transceiver head and the top of the beacon. In addition to being at a high elevation,

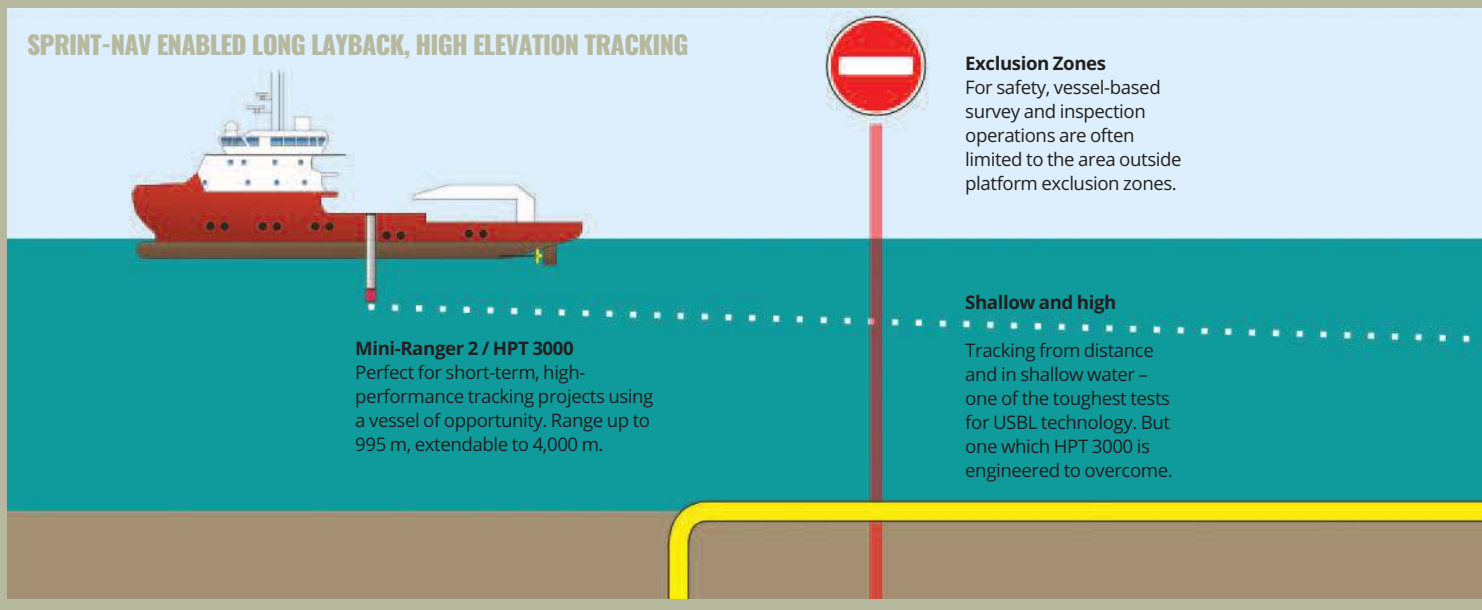
they're at a long excursion, at 70 m, well outside the optimal boresight of the vessel's acoustic transceiver.

While Mini-Ranger 2 is great for high elevation tracking – it's tracked divers in 14 m water depth out to 200 m before – the noise in the water where we're working is still an issue, which usually means having to do a lot of post processing. Even then, when we've done it before, you can still be out by a few metres.

For this project, we decided to optimise our USBL by adding an ROV-mounted gyro and motion sensors, to help improve our position with pitch, roll, attitude and heading, when the USBL started to jitter. But, because they're not fully integrated, it didn't really do what we wanted.

SPRINT-NAV CHANGES THE GAME

Then, we found out about SPRINT-Nav. SPRINT-Nav is an all-in-one navigational instrument, which combines a SPRINT INS sensor, Syrinx 600 kHz DVL (Doppler velocity log) and a high accuracy intelligent pressure sensor in a single unit. SPRINT-Nav tightly integrates all the raw sensor data, including individual DVL beams, to provide its high performance. We'd not tried it before but one of its advantages is that, with bottom lock enabled, if you lose your USBL it



doesn't matter. It will preserve the integrity of your positioning solution until your next acoustic fix comes in. This had a great advantage for us in achieving subsea positioning repeatability and reliability.

With SPRINT-Nav 500 fitted to our Leopard, we've completely changed the game on this project and indeed all our future shallow water inspections. We have the best of both worlds – USBL and a high-performance INS. You feed SPRINT-Nav the USBL position from Mini-Ranger 2 and it outputs a corrected position, based on the information from its INS and the DVL. So now, when the ROV goes on an excursion away from the vessel, it doesn't matter. If the USBL tracking drops out or if it starts jittering, SPRINT-Nav still knows where it is. Our survey and data acquisition team on board the vessel were amazed; straight out of the box, SPRINT-Nav keeps our ROV on course.

So we now have excellent positioning and repeatability, which is critical for quality inspection projects. Our survey accuracy is below half a metre, mainly because of SPRINT-Nav. We have full confidence in the start and end position and, furthermore, we don't even require any post-processing.

The client is very happy – so we are. They now have a new baseline survey that all their future inspections can be compared against. BL

Above left: With so much infrastructure to inspect, survey operations continued around the clock. Here CCC's Sea Leopard is deployed over the side of CCC's *Maritime 2* multi-purpose support vessel on the project.

THE KIT LIST
WHAT'S FEATURED IN THIS STORY

SPRINT-Nav

What is it?
An all-in-one subsea hybrid acoustic and inertial navigation system for your ROV or AUV, providing class-leading performance as good as a fraction of a metre over many kilometres travelled.

How does it work?
It houses an IMU, an AHRS computer, an INS navigation computer, a DVL and a high-accuracy pressure sensor. It's available in depth ratings to 6,000 m and tiered performance levels.

How will it benefit your operation?
It's one of the smallest inertial DVL instruments available on the market so is easy to fit. Low power consumption, simple integration and supports both LBL and USBL survey operations.

Mini-Ranger 2 USBL System

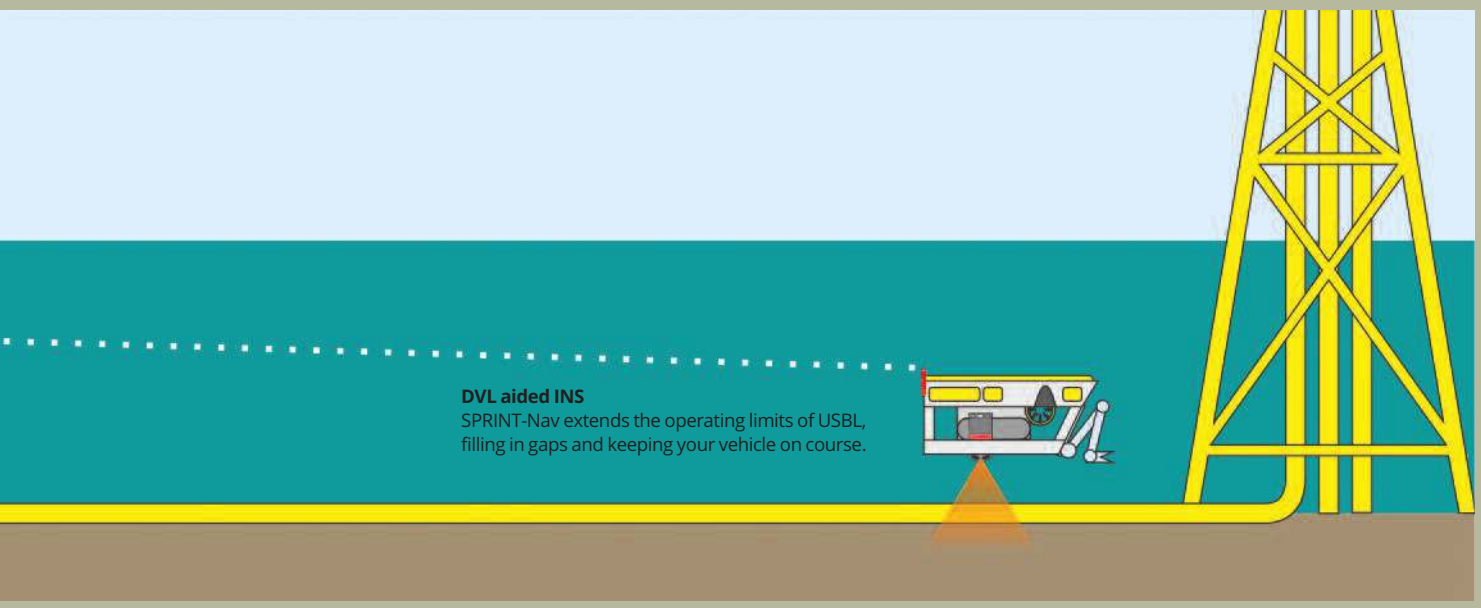
See page 29

Wideband Sub-Mini 6 Plus (WSM 6+)

What is it?
A small, rugged and versatile USBL transponder with responder mode for fast updates.

How does it work?
Supports two-way Wideband signals which offers superior ranging precision.

How will it benefit your operation?
It's available in 1,000 m and 4,000 m, is easy to fit, configure and is widely available from equipment rental pools.



AS WELL AS KEEPING SHALLOW-WATER PIPELINE INSPECTION OPERATIONS ON TRACK IN THE MIDDLE EAST, SPRINT-NAV IS PART OF THE MOVE TO RESIDENT ROV SYSTEMS IN THE NORWEGIAN NORTH SEA. WE RECENTLY VISITED IKM SUBSEA TO FIND OUT MORE.

ROV IN RI

IKM Subsea has been taking a step-wise approach to resident subsea systems. After building their first all-electric remotely operated vehicles (ROVs) in 2015, the company has gone on to introduce a subsea garage system from which their latest vehicles can operate.

Having vehicles based subsea has a number of benefits that more and more operators are seeing. As resident systems, deployed permanently, or semi-permanently subsea, vehicles can be on site, ready for action, 24/7, supported from onshore – reducing cost and increasing safety, operability, and productivity.

IKM Subsea's resident ROV (R-ROV) concept is based on the firm's 3,000 m-rated Merlin UCV ROV, which operates on a 1 km excursion capable tether management system (TMS) from a subsea "E-cage" (or garage). The E-cage is in turn wired to a host platform. Since late 2018, one of these systems has been operating on the seabed at operator Equinor's Snorre B facility, offshore Norway. It's available on demand, piloted from offshore and onshore (via a fibre optic link to the beach), on three-month long deployments. Between deployments, it's lifted to the surface, using the host facility's crane, for maintenance.

Enabling a subsea resident vehicle poses a number of challenges, from remote control functionality to reducing maintenance requirements. "A key requirement has also been station keeping, to help with certain tasks, when you need the ROV to be stationary," says Ments Tore Møller, IKM Subsea's Engineering Manager, "and as a backup mode of operation, if communication is lost. It's also useful for path-follow mode, when the ROV can navigate itself."

EASY TO FIT, FAST TO INITIALISE

For these capabilities, IKM Subsea looked to SPRINT-Nav. As we explained earlier in Baseline (see page 21), SPRINT-Nav is our compact hybrid navigation instrument built around highly robust and accurate Honeywell ring laser gyro (RLG) inertial sensors, in an inertial measurement unit (IMU), tightly coupled with our Syrinx Doppler velocity log (DVL), and a high-precision pressure sensor. Tightly integrating raw data from these sensors at a low level means higher accuracy and reliability is achieved: ROVs can calculate their position for longer with less drift.

SPRINT-Nav is also fast to initialise, with no need for calibration manoeuvres before getting to work. This is because it runs two algorithms so that the inertial navigation system (INS) can instantly initialise from the attitude, heading reference system (AHRS) in the IMU. It is also due to the RLG's very deterministic characteristics, compared with other types of gyros.

All of these characteristics make it a very popular instrument for resident ROVs that can be quickly called on to operate, without waiting on weather or spending time getting to the work site.

SUBSEA TRANSFORMATION

This transformation in the ROV world is just starting. There is more that could be done. Some are looking to remove the tether, because survey work today is limited by the length of the tether from a fixed point. Møller believes there will be a need for different vehicles to do different things.

Without a tether, and aided by SPRINT-Nav, a vehicle can travel further, between wired nodes where it could recharge or transfer data. Compatts on the subsea cage would mean that the ROV's return to its standby position could be automated, supported by anti-collision systems. Our BlueComm free space optical modem, providing live video transmission through the water, also enables live remote controlled operations. Another option is deploying a cage with battery packs, so that the ROV is independent of both a support vessel and wired infrastructure, communicating with onshore via a surface buoy and 4G cellular networks, says Møller.

IKM Subsea is also looking at digital twins of the subsea world. SPRINT-Nav would provide positioning alongside a 3D sonar, which could recreate the subsea environment. If communications or the sonar drops out, SPRINT-Nav can continue calculating where the ROV is. A digital twin would also make simulating procedures and training easier and more realistic and reduce time on the real system, says Møller. Next steps include more automation.

With interest in seabed deployed systems increasing, more of these systems are appearing in the market. Their capabilities and concepts of operation will evolve and differ, but they can all rely on our navigation and communications technologies. BL

ESIDENCE

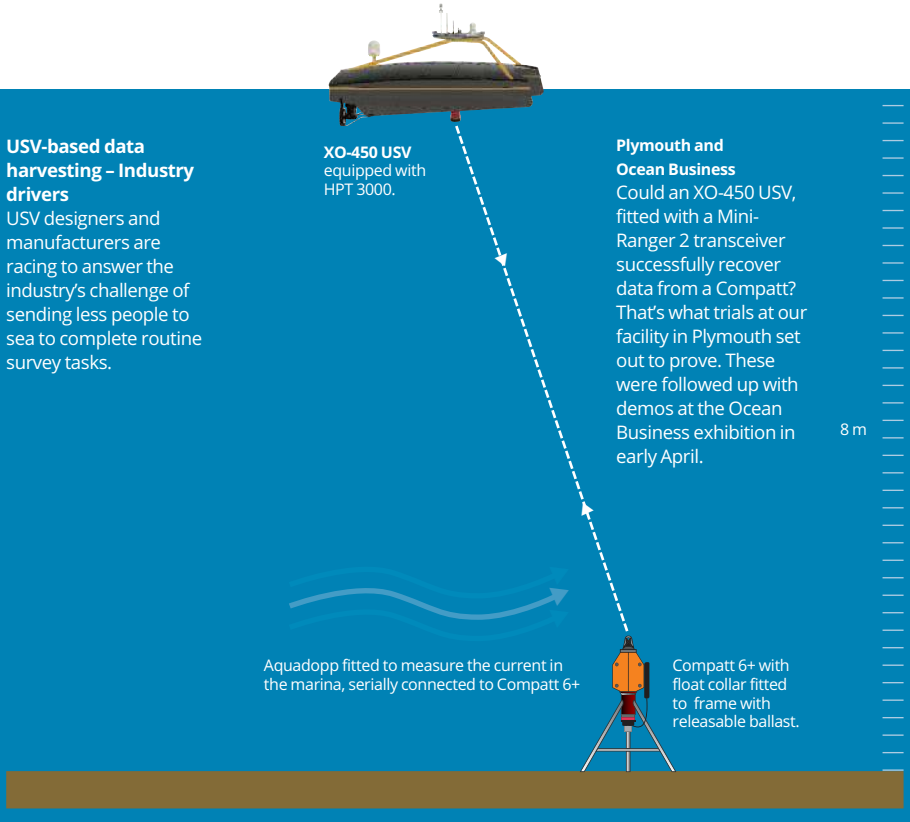
IKM Subsea's resident ROV (R-ROV) concept is based on the firm's Merlin UCV ROV, which operates on a 1 km excursion tether from a subsea garage, with power and comms coming from a host platform. SPRINT-Nav will perform a number of roles include station keeping.

DATA HARVESTING –

BP'S FIRST FORAY INTO UNMANNED, OVER-THE-HORIZON OPERATIONS, USING SONARDYNE TECHNOLOGY AND AN XOCEAN USV, IS HELPING TO GATHER STRATEGIC SEABED DATA. IT'S ALSO A KEY STEP IN THE JOURNEY TOWARDS A MORE MARINE AUTONOMOUS SYSTEMS LED FUTURE. CRAIG ALLINSON, SURVEY AND POSITIONING LEAD, BP NORTH SEA, EXPLAINS.

Sonardyne, Plymouth

USV-based data harvesting – Industry drivers
USV designers and manufacturers are racing to answer the industry's challenge of sending less people to sea to complete routine survey tasks.



Throughout the life of oil and gas fields, reservoir management strategies can change and, when they do, we need data to verify what impact we're having. For the Machar field in the North Sea, we changed our reservoir water injection strategy and we wanted subsea data monitoring and harvesting capabilities to monitor its impact.

Machar is a subsea development which ties into the ETAP (Eastern Trough Area Project) hub, about 120 miles east of Aberdeen in the UK North Sea. Water injection has been used for pressure support in the reservoir until last year, when the strategy changed. We stopped the water injection and the subsequent drop in the reservoir pressure then helps to release saturated gas, which then helps to mobilise oil in the reservoir as the gas moves through the formation, thus boosting production. With this drop in the reservoir pressure, it is expected that we will see a small amount of seabed deformation.

We wanted an efficient way to keep a close eye on any seabed deformation in the Machar field. Having considered unmanned operations for some time, we decided, in a first for BP, to use seafloor sensors, from Sonardyne, combined with an unmanned surface vessel (USV), which was then operated over the horizon, to harvest the data from seafloor sensors.

AN OVER-THE-HORIZON FIRST

We chose XOCEAN's XO-450 USV, fitted with a Sonardyne HPT 3000 Mini-Ranger 2 Ultra-Short BaseLine (USBL) system. The Mini-Ranger 2 has modem functionality, so it can communicate with and retrieve data from the Fetch subsea sensor logging nodes, also from Sonardyne, that were chosen for our seabed monitoring.

The XO-450 is an International Marine Organisation compliant, 4.5 m-long USV with a hybrid power system, including a diesel

OVER THE HORIZON

Ocean Business, Southampton

600 road miles

At the show, then on the road
Despite being on show at Ocean Business, when the call came from BP, the team mobilised the XO-450 in just a couple of hours, ready for its long drive north to Peterhead.

generator and solar panels, powering lithium-ion batteries to drive the electric thrusters and all instrumentation. The vessel has an 18-day endurance and a communications and surveillance suite, that includes dual redundant satellite communications systems, cameras (including thermal imaging), antennae and navigation lights.

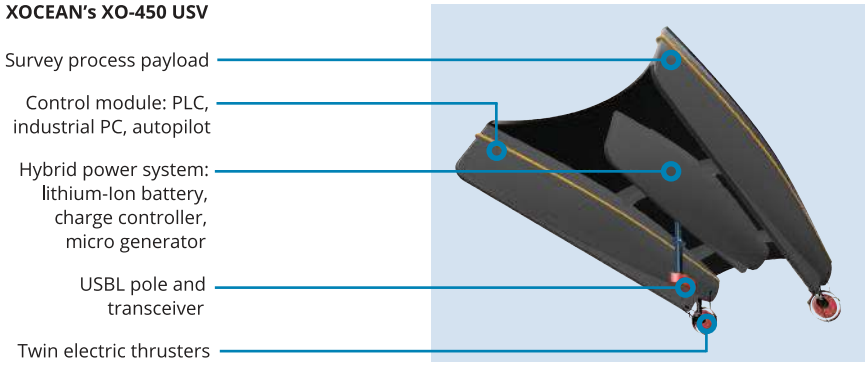
It's able to communicate real-time with XOCEAN's onshore control room, where pilots are based 24/7, enabling remote, over-the-horizon control. The pilots have a full view of all the systems and can take control at any time. So we can use the vessel almost anywhere. With it, we can go out in to the North Sea and harvest data without sending people offshore and therefore removing risk.

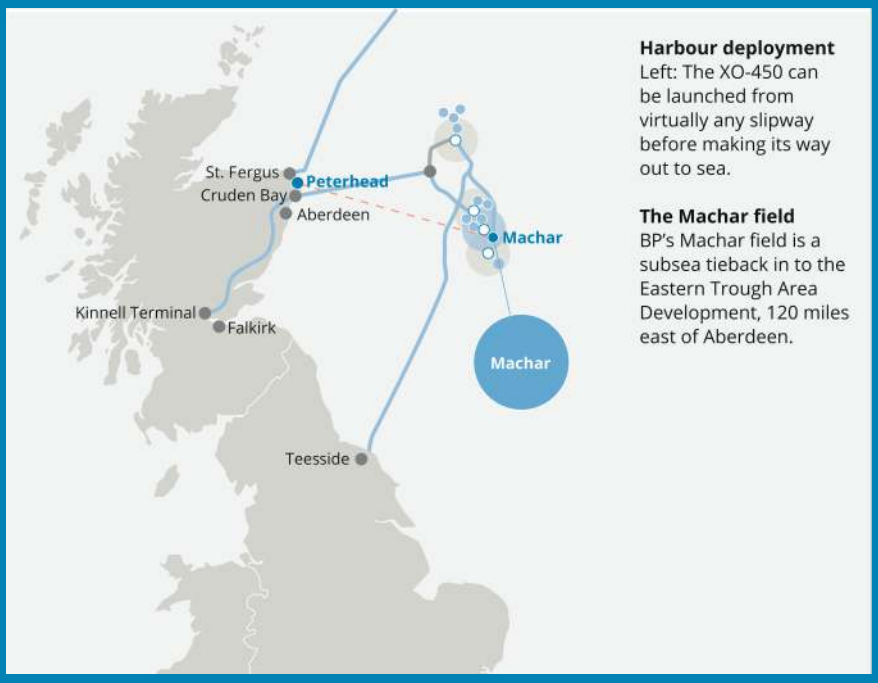
"We decided, in a first for BP, to use seafloor sensors combined with an unmanned surface vessel (USV)."

LOW-POWER, LONG-LIFE SENSORS

Sonardyne's Fetch are low-power, long-life sensors used to measure seabed deformation. This means they can continuously monitor and log the seabed depth where they are deployed, so when we retrieve their data we're able to calculate any seabed movement, over a period of up to 10 years.

We installed four Fetches over the Machar field in November 2018. After a few months, we wanted to go out and harvest the data they had collected during that time. It was a





quick and easy process. In early April, the XO-450was brought by trailer to Peterhead, Scotland, where it was launched from a slipway. The USV used waypoints to safely transit 120miles out to Machar, avoiding other marine traffic and installations along the 40hour transit.

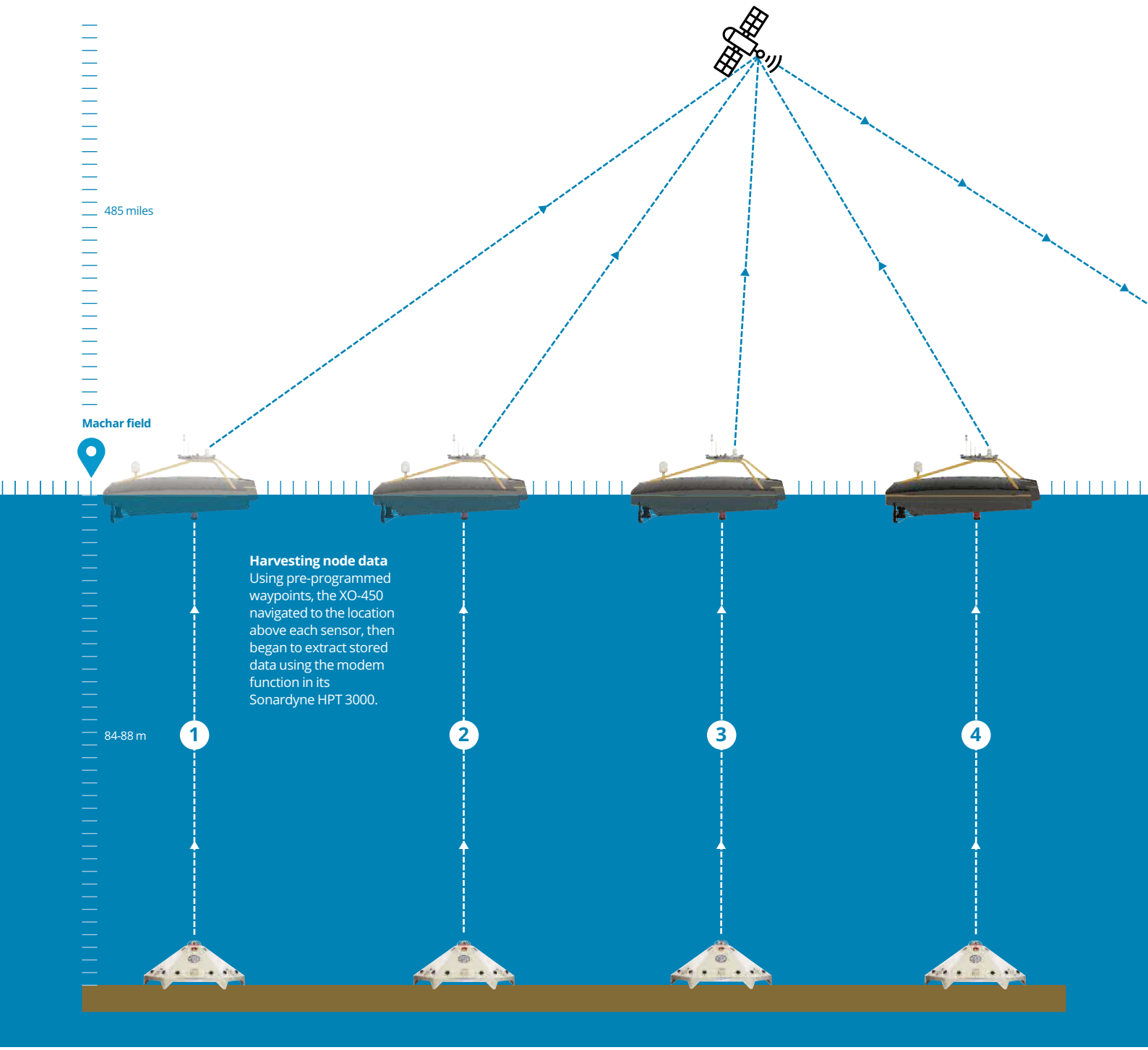
During the entire transit we were able to view real-time images from the USV, we could monitor it and other nearby vessels on AIS (Automatic Information System) and the onshore pilots were ready to steer around any obstacles, if necessary.

Once on site, one by one, we located and then started communicating with the Fetch sensors, first to check their health and then to download their data. While the USV held its position, auto-piloting in a 25-30m radius, the Mini-Ranger 2HPT 3000did its work, gathering about 750pages of data fromeach sensor. Even with the vessel travelling at 4 knots, the noise from its thrusters didn't disturb the data download.

DATA TO SHORE –REAL TIME

After each download, the USV's satellite communications sent the data to shore, where we were able to confirm, in real time, that we had the data we needed before moving on to the next Fetch seabed unit. I even got a copy of the data in my inbox 15 minutes after the download had completed. Throughout these operations Sonardyne specialists were on hand (remotely) with full access to the real-time data to ensure the harvesting was successful and completed efficiently. When the operation was complete, the vessel transited safely back to Peterhead for demobilisation.

No project is that smooth of course. We had to wait for a suitable 5-day working weather window for the operation and, after waiting three weeks, the weather improved – during Ocean Business in Southampton where XOCEAN had its XO-450on show.



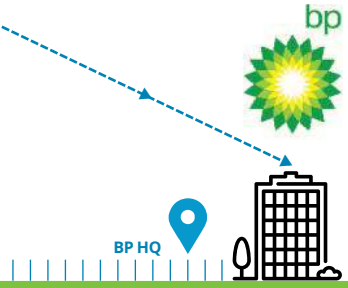
With only a few hours notice, XOCEAN were able to drive the vessel up to Peterhead for mobilisation, all within 24 hours.

Once offshore, there was a light well intervention (LWI) vessel operating close to one of our sensors, which meant we had to negotiate going into their 500 m exclusion zone and then perform simultaneous operations (SIMOPS).

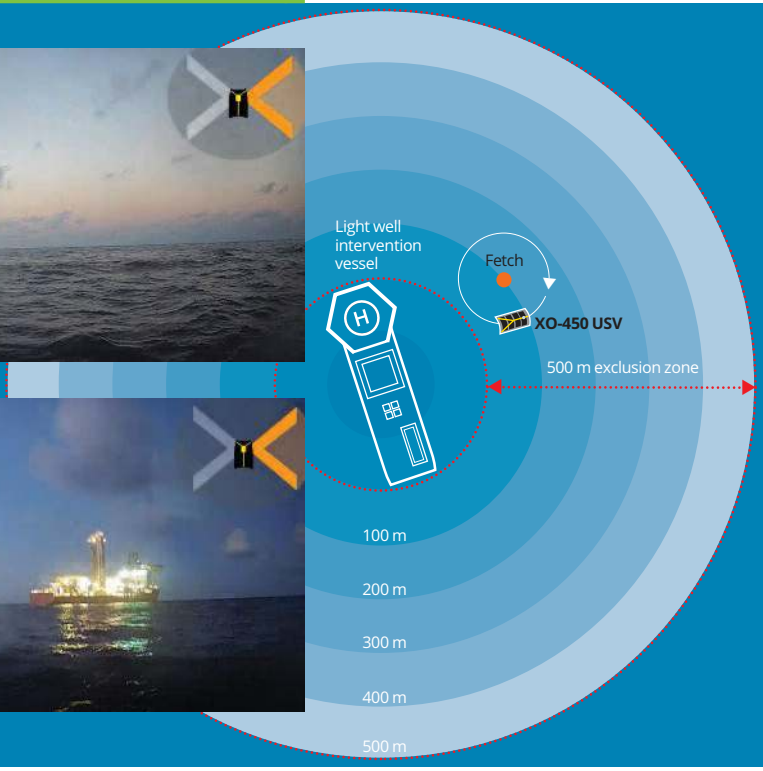
There was also a concern that the acoustics being used by the LWI vessel and ours – which were using the same frequency – could interfere with each other. So, we took a risk-based approach and started our data collection campaign from the Fetch furthest from the LWI vessel, keeping in continuous contact with its crew. There was no interference at the first two Fetch units, so we moved to the third.

"Unmanned ops with a small vessel enable us to achieve a significant reduction in carbon emissions eliminating the need for humans offshore for this type of work."

At the third sensor some issues unrelated to the SIMOPs were encountered. We decided to move to the final sensor during daylight hours, closest to the LWI vessel, and got within 100 m of it to successfully harvest the data without any problems; a SIMOPS success. Had we not been using the USV we would not have been able to get as close to the fetch unit, because it was within the LWI vessel's 500 m zone, and data harvesting of this unit may not have been possible.



"After each download, the USV's satellite communications sent the data to shore, where we were able to confirm, in real time, that we had the data we needed before moving on to the next Fetch."



Entering new territory
Left: Using a USV meant simultaneous operations planning with a light well intervention vessel in order to reach one of the sensor locations.

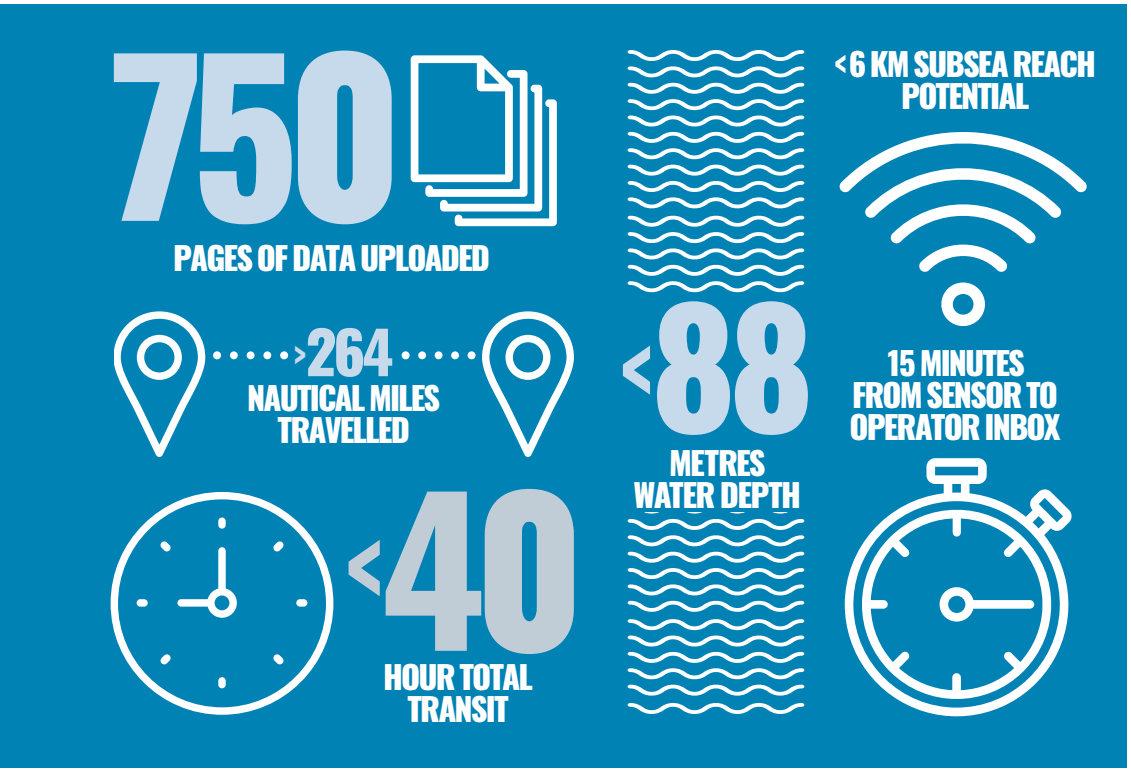
LIVE SENSOR CONFIGURATION

Then, we went back to sensor 3, with the help of Sonardyne staff, we found that the modem had been incorrectly configured. All that had to be done was a remote re-configuration and we were able to fully retrieve that data set. It was a simple solution and showed the value of having a Sonardyne technician with direct remote access to the real-time data. Without that, we wouldn't have been able to retrieve the data.

REDUCING RISK AND MISSIONS

A key reason for us going down this route, for using a USV over-the-horizon, was to eliminate health, safety and environmental (HSE) risk. Unmanned operations with a small vessel enable us to do that. They achieve a significant reduction in carbon emissions – compared with a manned vessel – and total elimination of the need for humans offshore for this type of work. We also get a significant cost saving, compared with using a conventional vessel.

BP have been pleased with the result of this operation and we have proven the concept of data harvesting with USVs. We now have our data from the first harvest, on which Sonardyne has done a detailed analysis and processing, and the results are currently being assessed. The Fetch units are continuing to monitor the seabed at Machar. Their power levels mean they will be able to keep working for 10 years, which will enable us to continue monitoring the seabed, harvesting data twice a year, using the USV, for some years to come. BL



UNMANNED MONITORING FOR ANY DATA GATHERING APPLICATION

Using unmanned systems to gather data from the deep opens the door to far greater and easier visibility of our underwater systems.

Whether it's through unmanned surface vehicles (USVs), Wave Gliders or autonomous underwater vehicles (AUVs), we've been driving progress in this area.

Combining our subsea instrumentation and sensing platforms with our underwater acoustic positioning and communications technologies creates the perfect package that can be modified to your needs, from short to long-term monitoring and data collection down to 3,000 m water depth.

We can measure centimetre-level decadal geological events, periodic high-frequency pipeline vibration and even help monitor oil and gas reservoirs.

What's more, with Mini-Ranger 2 onboard any USV could be used to position and communicate with underwater vehicles, offering an alternative when, for example, long lay back positioning operations close to or within exclusion zones is necessary.

THE KIT LIST
WHAT'S FEATURED IN THIS STORY

Mini-Ranger 2 USBL System

What is it?
Mini-Ranger 2 is part of our sixth-generation (6G) USBL underwater positioning and data telemetry system family. Its standard operating range is to 995 m and it can track up to 10 subsea targets at very fast update rates.

How does it work?
With modem capability, using our Wideband 2 broadband signal architecture, and our HPT 3000 transceiver, we can harvest high bandwidth data.

How will it benefit your operation?
Because the communications are all Ethernet based, these systems are easy to connect to a topside computer (via an Ethernet Serial Hub).

Fetch

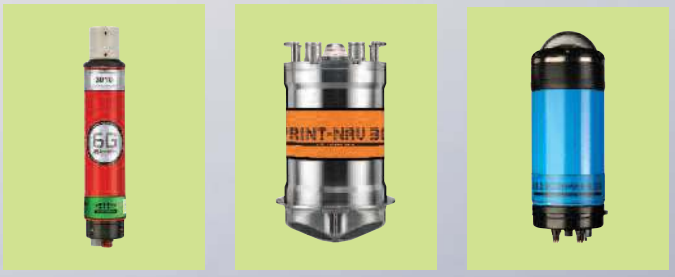
What is it?
Fetch is our ultra-low power subsea sensor logging node. It can be deployed for up to 10 years in water depths down to 6,000 m. Standard sensors include high accuracy pressure, temperature and sound velocity as well as inclination.

Fetch is also configurable to a wide array of other sensors, as required, while sampling rates can be configured before deployment, as well as after, via its integrated acoustic modem. The Fetch modem can also deliver data recovery at 9,000 bits per second, to reduce time on site.

How does it work?
Using its onboard sensors, Fetch continuously monitors and logs the seabed depth where they're deployed. When the data is retrieved we can then calculate any seabed movement.

How will it benefit your operation?
Fetch can be deployed in different ways including free fall and inside anti-trawl frames (pictured), are easy to recover and are popular for long-term environmental monitoring.

A NEW GENERATION OF UNMANNED UNDERWATER VEHICLES ABLE TO RELIABLY TRAVEL LONG DISTANCES, BETWEEN PORTS, IS EMERGING – WITH THE SUPPORT OF SONARDYNE ACOUSTIC AND OPTICAL SYSTEMS. IOSEBA TENA, GLOBAL BUSINESS MANAGER FOR DEFENCE AND ROBOTICS, TAKES A LOOK AT ONE.



DEEP, COVERT

The concept of a long-endurance unmanned underwater vehicle (UUV) able to travel long distances and quietly and covertly hover in strategic locations is a desired and useful capability in today's world.

In the defence sector, it would enable increased and extended military surveillance and support anti-submarine warfare operations. In the commercial world, an underwater vehicle that can travel from port, carry out a full route survey and then return home again – without intervention – would eliminate the need for costly and risky launch and recovery operations at sea using ships. With help from our underwater acoustic and optical positioning and communications systems, steps towards realising this capability are now being taken by Canadian underwater systems specialist Cellula Robotics.

Under a programme for the Canadian Department of National Defence's (DND) science and technology organisation, Defence Research and Development Canada (DRDC), Cellula has designed and built an 8.5 m-long, 1 m-diameter, 3,000 m depth rated vehicle that's able to carry-out multi-month underwater surveillance over a 2,000 km range. It's called the Solus-LR (Long Range).

, LONG RANGE

Solus-LR ● 2,000 km submerged mission range ● Patented suction anchor, enables extended period low-power station-keeping ● 8.5 m-long and 1 m-diameter 3,000 m-rated ● 3,700 kg in air ● 0.7 – 2 m/s cruising speed ● High pressure hydrogen and oxygen fuel cell delivering 250 kWh of usable energy ● **SPRINT-Nav 300** for long endurance DVL-aided inertial navigation, upgradeable performance if required ● **AvTrak 6** supporting USBL tracking, LBL transponder ranging and acoustic telemetry ● **BlueComm 200** for high-speed underwater data transfer ● Surface communications, including long range Wi-Fi, iridium and GPS localisation ● Forward looking obstacle avoidance multibeam ● Forward control planes, for low altitude manoeuvrability.

A UNIQUE CONFIGURATION

The UUV, which is due to begin sea trials this October, brings together a unique payload configuration including an innovative onboard power system and an integrated navigation and communications suite, in order to meet the DRDC's All Domain Situational Awareness (ADSA) Science & Technology (S&T) Program objectives, which include enhancing domain awareness of air, maritime surface and sub-surface approaches to Canada, in particular those in the Arctic.

To start with, long-endurance mission capability is being enabled by a newly designed high pressure hydrogen and oxygen fuel cell, delivering 250 kWh of usable energy. Its other secret weapon is a specially designed suction anchoring system, which, deployed via the UUV's underhull cargo doors, allows the vehicle to tether itself to the seabed in a low-power loiter mode, quietly and covertly listening for a range of targets.

Underpinning its guidance and communications – the backbone of any long-duration underwater vehicle – is a suite of our trusted 6G positioning and communications acoustics and high speed optical modems. Critically, to aid the Solus-LR on its multi-month missions, Cellula has integrated our SPRINT-Nav hybrid (Doppler and inertial) navigation instrument. SPRINT-Nav is already proving its worth on deep water autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs) globally, as you can read elsewhere in this issue and this is just the latest testament to the performance it offers.

SPRINT-Navs' high performance is crucial to enabling prolonged autonomy over long ranges. By limiting error growth through dead-reckoning, SPRINT-Nav enables underwater vehicles to travel for longer without surface support. The alternative – i.e. poor navigation performance – would limit the autonomy of the vehicle and therefore its effectiveness.

For Cellula, SPRINT-Nav offers not only a high performance, operationally proven instrument, but also one which is easy to upgrade, thanks to the availability of different grades of Honeywell-engineered ring laser gyros (RLGs) to support different mission performance levels – all packaged in the same form factor.

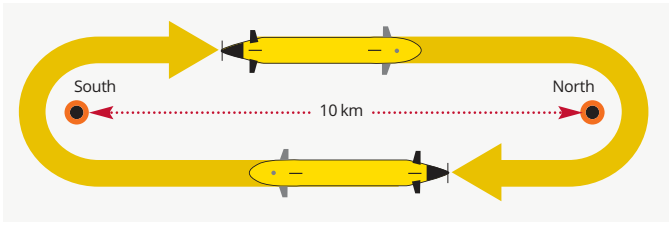
ENDURANCE TRIALS

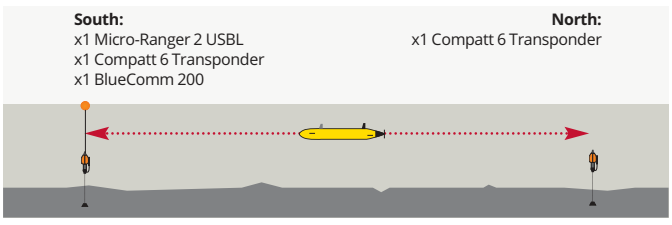
Sea trials start in Indian Arm fjord, near Vancouver, British Columbia this autumn – just 18 months after the project was kicked off. The trial itself will be equally ambitious – requiring Cellula's Solus-LR to run 10 km laps of a range in the fjord, without surface support for around a month.

Integrating trusted, commercial-off-the-shelf technologies (COTS) like our acoustic, inertial and free-space optical sensors into underwater capability programmes – especially naval ones – has considerable appeal. It reduces cost, reduces risk and, crucially, means that the time needed for new platforms to enter service can be measured in months, not years.

The trial will be supported with Compatt 6 seabed transponders, BlueComm 200 optical modems and our Micro-Ranger 2 Ultra-Short BaseLine (USBL) acoustic tracking system with bolt-on Robotics Pack. This will be used for tracking, telemetry and control, supported by an AvTrak 6 Omni combined transponder, transceiver and telemetry instrument, integrated into Cellula's UUV.

"At the north end of the range, a Compatt 6 will be deployed and





surveyed to provide a navigation update to the SPRINT-Nav," says Cellula's Business Development Manager, Adrian Woodroffe. "Meanwhile, the south marker will have a Micro-Ranger 2 installed on a surface buoy for acoustic telemetry and position updates and Sonardyne's BlueComm omni-directional subsea optical modem installed on a seafloor lander connected to the buoy. The surface buoy will have a cellular data link providing a communication link back to our office.

"During the demonstration mission, Solus-LR will operate submerged and truly autonomously without a chase boat. Solus-LR will check in with us approximately every six hours as it passes the south marker, with low bandwidth status updates via an acoustic link using the AvTrak 6 on the AUV and the Micro-Ranger 2 on the buoy. Here, it can also receive mission updates and transfer large log files using the high bandwidth BlueComm link. At the North end of the range, the SPRINT-Nav will autonomously use the seafloor Compatt 6 to reduce the INS drift and correct any accumulated position error since the last update."

APPLICATION ENGINEERING SUPPORT

Throughout, our application engineering team will be on hand, ready to help. So, Cellula is not only supported by the full range of instruments it needs for the Solus-LR – all from under one roof – but also the engineering support it needs to get the best value from its instruments and us.

We look forward to supporting the trials and seeing the Solus-LR take the next step. The result could offer new capabilities for defence, survey and monitoring applications, all Sonardyne supported. BL

"Underpinning its communications and guidance is a suite of our trusted 6G positioning and communications acoustics and high speed optical modems."

Opposite page, from top: For around one month this autumn, the Solus-LR will repeatedly loop a 10 km underwater circuit in Canada's Indian Arm fjord. Compatt 6s will mark each end of the course, and be used by the Solus-LR to range-aid its onboard navigation system. Left: The Solus-LR, in-build ahead of its trials in Indian Arm fjord. Photo from Cellula.

THE KIT LIST
WHAT'S FEATURED IN THIS STORY

AvTrak 6

What is it?
One of the most versatile instruments you can fit to your AUV. It allows you to track a vehicle, position-aid its onboard navigation system and send and receive data packets.

How does it work?
It combines the functions of a USBL transponder, LBL transceiver and modem in one unit. Available in OEM form factor for small vehicles.

How will it benefit your operation?
With AvTrak 6, AUVs can alter mission plans, provide health status updates and even share mission goals with other AUVs and underwater platforms operating nearby.

BlueComm 100 and 200

See page 17

Micro-Ranger 2 USBL System

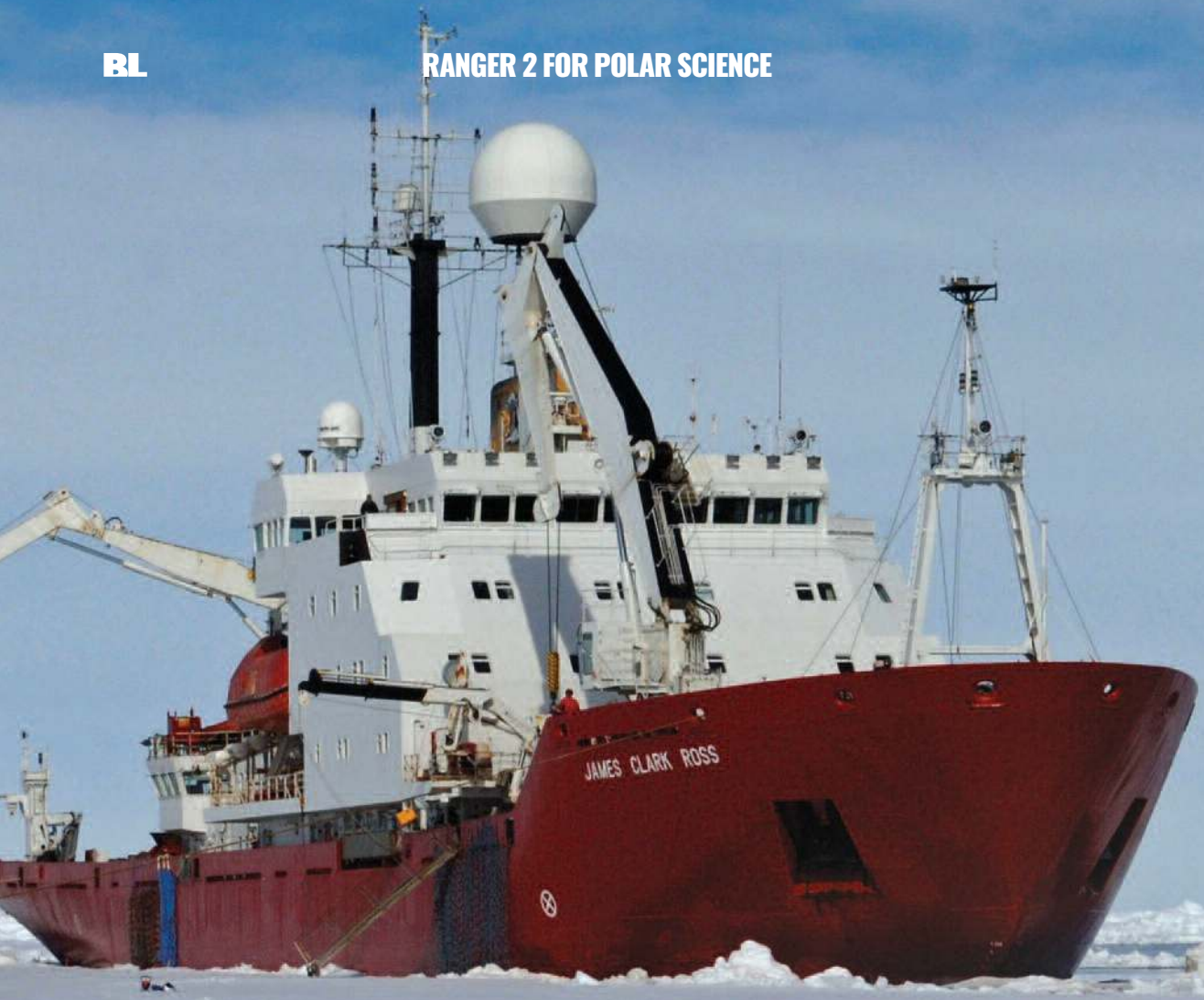
See page 37

SPRINT-Nav

See page 21

RANGER 2 OPENS THE WINDOW FOR POLAR SCIENCE

WHEN YOU'RE WORKING IN EXTREME ENVIRONMENTS, WHERE OPERATIONAL WINDOWS ARE MEASURED IN WEEKS NOT MONTHS, HAVING THE RIGHT KIT ON BOARD COUNTS. GERAINT WEST, GLOBAL BUSINESS MANAGER – OCEANOGRAPHIC, LOOKS AT THE CHALLENGES OF REMOTE SCIENCE AND DISCOVERS HOW THE LATEST GENERATION OF POLAR RESEARCH VESSELS IS LEAVING SHIPYARDS EQUIPPED FOR SUCCESS.



The polar regions are among the most challenging environments to operate in, with extremes of weather and long, complex, costly logistics trains. Their critical influence on global processes, including climate, bio-geochemical cycles and sea-levels, means they're also among the most scientifically important areas on earth.

That's why a small number of specialised polar research vessels (RVs), hosting an increasing number of autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs), are dedicated to research in these regions.

But, while the underwater robotic assets hosted by RVs are beginning to reshape the way polar research is done, 24-hour darkness, dangerously low temperatures and ice thickness, still make winter-time RV operations all but impossible. That means maximising the effectiveness of operations – when Arctic or Antarctic seas are accessible – is key.

These are considerations going into the latest breed of specialist polar RV designs, including the British Antarctic Survey's (BAS) new vessel, the RRS *Sir David Attenborough*, and the Polar Research Institute of China's (PRIC) *Xue Long 2* (*Snow Dragon 2*). Although these two flagship vessels are from yards separated by 5,700 miles - Cammell Laird's yard in Birkenhead, UK, and Shanghai's Jiangnan Shipyard – they share many similar features.

Both vessels, which are in excess of 120 m long, will transport cargo and scientists to Antarctic bases – up to 90 onboard the RRS *Sir David Attenborough* and up to 60 on the *Xue Long 2*. Both will be fitted out with an impressive range of scientific equipment and vehicles, much of which has to be deployed outboard of the vessel to gather a range of important marine chemistry, ecology, geology, geophysics and sea ice dynamics data. This equipment is deployed with complex heavy

handling systems over the stern and side, as well as through a moon pool, an increasingly common feature in polar RVs. And, significantly for us, both vessels will be equipped with Ranger 2 USBL tracking technology.

SHALLOW, DEEP, NOISY

We've now more than 25 years' experience building USBL systems for vessels of all shapes, sizes and roles. But we're particularly proud of the track record Ranger 2 has earned within the international science community. There, it's seen as the performance standard for tracking vehicles and platforms from vessels, as well as a dynamic positioning (DP) system reference. In fact, it's already fitted to a number of polar research vessels including BAS' the RRS *James Clark Ross*, and the Korea Polar Research Institute's RV *Araon* (*All Sea*), as well as other ice strengthened vessels.

RVs by their nature work in many different environments; shallow, deep, noisy. So, USBLs need to be equally versatile – Ranger 2 is. It's built on our Wideband 2 acoustic signal technology and 6G (sixth generation) hardware platform, enabling simultaneous and precise tracking of multiple AUVs, ROVs, towed platforms and sea-floor landers to slant ranges in excess of 7 km or 11 km with our LMF version.

Wideband 2 and 6G are key to a host of flexible options, meaning that Ranger 2 is a tool-kit that can be used in a wide range of scientific applications. At a basic level, platform and vehicle positioning are supported by a wide offering of acoustic transponder options, ranging from the Wideband Sub-Mini 6+ (WSM 6+), a versatile, 4,000 m-rated USBL transponder that is easy to install, to AvTrak 6, which combines the functions of transponder, transceiver and telemetry link in one low power unit for the optimum AUV solution. Using our Sonardyne Messaging Service (SMS), AvTrak 6 enables two-way transmission of vehicle configuration or status messages, as well as position updates from surface.

That's just the beginning though. HPT, the system's vessel-mounted transceiver, is a highly effective modem that supports seven user telemetry rates between 100 – 9,000 bps. This means Ranger 2 can track your sensor packages, but also receive the data they are gathering. Something the science community has been asking for is for Ranger 2 to be able to command Sonardyne acoustic releases. That request has now been addressed with our new RT 6 family of releases. Read more about these in our Tech section on page 38.

PROTECTION FROM ICE

Mounting and deployment arrangements for your HPT is always critical for optimal performance. For a polar RV, this has particular significance. Building on our experience, with literally hundreds of installations to date, our deployment systems incorporate a number of modifications and adaptions to mitigate against the harsh environmental conditions of the polar regions. These include use of appropriate materials and installation arrangements that maintain the watertight integrity of your double hull.

In addition, the system fitted to these vessels has an option to lower the pole so that the face of the transceiver is flush with the ship's hull. This does compromise performance to an extent, dependent on the ship's self-noise and dynamics, but it also protects the transceiver if ice is likely to be encountered under the hull, such as when actively breaking ice. In open waters, optimal performance is achieved with the pole extended to around 2 m below the hull.

Ranger 2 is built on our Wideband 2 acoustic signal technology and 6G hardware platform, enabling simultaneous and precise tracking of multiple AUVs, ROVs, towed platforms and sea-floor landers out to 11 km.

As I've mentioned, these ships are also home to an expanding fleet of autonomous and robotic systems. The RRS *Sir David Attenborough* will host a range of vehicles from the UK's National Marine Equipment Pool, operated by the National Oceanography Centre (NOC). These include the Isis ROV and the Autosub family of vehicles, which includes the now famous Boaty McBoatface Autosub Long Range (ALR) AUV. Indeed, Isis and the Autosub are no strangers to the polar regions, having been deployed from the RRS *James Clark Ross*.

As we reported in Baseline 21, the newest member of the Autosub family, the 2,000 m depth rated under-ice Autosub (called Autosub-2KUI, or A2KUI for short), is being equipped with our SPRINT-Nav 700 hybrid navigation instrument. SPRINT-Nav will give A2KUI a positional accuracy of 0.01% of distance travelled in a typical survey scenario, giving it the positional capability to operate under the ice far beyond the range of the RRS *Sir David Attenborough*'s Ranger 2 system.

TRACKING ASSETS ON THE GO

Of course not all work is carried out from an RV. In many instances, scientists set up camp on the ice, but, even here, USBL can play its part. BAS has recently confirmed its acquisition of one of our Micro-Ranger 2 USBL systems with our Nano beacons for tracking their divers and small vehicles. It's a neat addition to the Ranger 2 family which has now grown to three models.

Because the Micro-Ranger 2 system uses the same software as a 'standard' Ranger 2, BAS scientists can start operating it with no additional training. Its compact size also means it's great for use from small boats and quaysides, so it's ideal for the ice-covered waters around BAS' Rothera Research Station on the Antarctic Peninsula. There, it will not only enable geolocation of scientific seabed samples, but also underpin the safety of BAS' divers in these hazardous environments.

These latest deployments are the latest in our increasing track record in providing underwater positioning and communications technology that enables polar operators to work with confidence, safety and maximum efficiency in ice covered waters. A further tool to support safe operation of RVs in poorly charted ice-covered waters is our Navigation and Obstacle Avoidance Sonar (NOAS), but that's another story which we'll cover in a future edition of Baseline. BL

Right, from top: RRS *Sir David Attenborough* under construction at Cammell Laird, June 2019; When used off the vessel, USBL systems still have a part to play, tracking small ROVs and divers, as well as commanding acoustic releases.

Ranger 2 USBL System

What is it?
If you need to track a towfish, DP your vessel, search the seabed or navigate an AUV, then you need Ranger 2 Ultra-Short Baseline (USBL).

How does it work?
An acoustic transceiver on the surface calculates the range (distance) and bearing (direction) to transponders fitted to underwater targets. Positions are displayed in a radar-style display out to 11 km.

How will it benefit your operation?
With greater positioning accuracy of sensors, equipment packages and subsea vehicles, data gathering for oceanographic research and scientific studies is faster and more meaningful.

Micro-Ranger 2 USBL System

What is it?
Micro-Ranger 2 is our smallest underwater target tracking system. It's ideal for locating small remotely operated vehicles, drones and divers.

How does it work?
In exactly the same way as our standard Ranger 2 system, but with a surface transceiver which uses a unique design of transmit and receive elements.

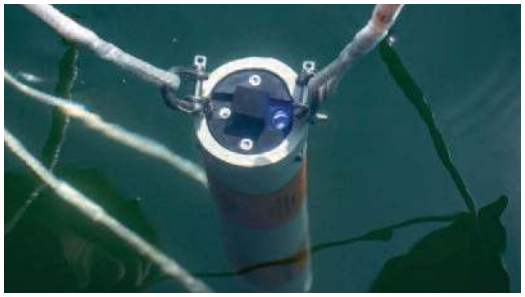
How will it benefit your operation?
It's portable, quick to set up and easy to use, even if you've never used USBL technology before. Deploy it and track.

RT6 1000 and 3000

See page 38

TECH

SPOTLIGHT: OUR SUBSEA TECHNOLOGY ESSENTIALS FOR YOUR OPERATIONS



RELEASE TRANSPONDER 6
ONE FAMILY, MANY USES

If you're deploying science equipment to gather data over several years, or lowering equipment to the seabed, an acoustic release transponder is an essential piece of kit.

They've been a mainstay of our product line for many years so we understand the must-have features you're looking for; reliability, long lasting, the ability to cope with different water depths and ease of use. Unsurprisingly then, these are all the benefits we've built into the Release Transponder 6 (RT 6) units now being delivered to customers.

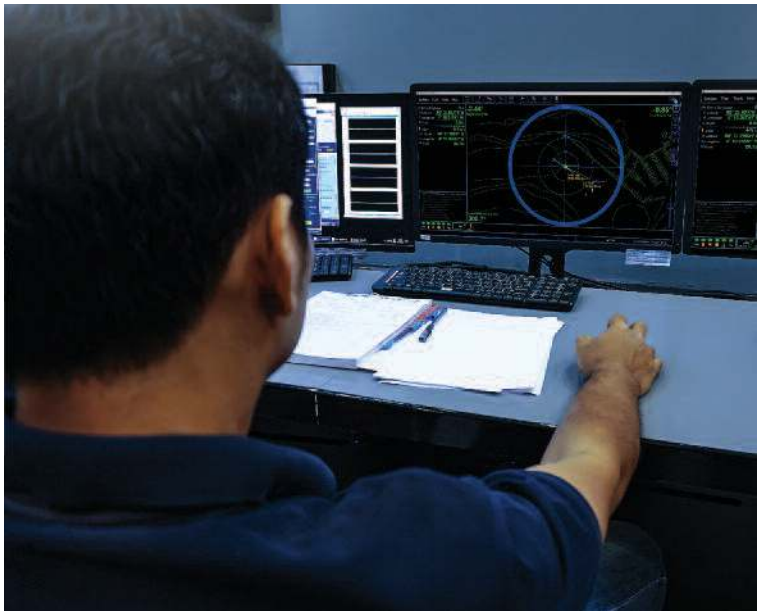
RT 6-1000

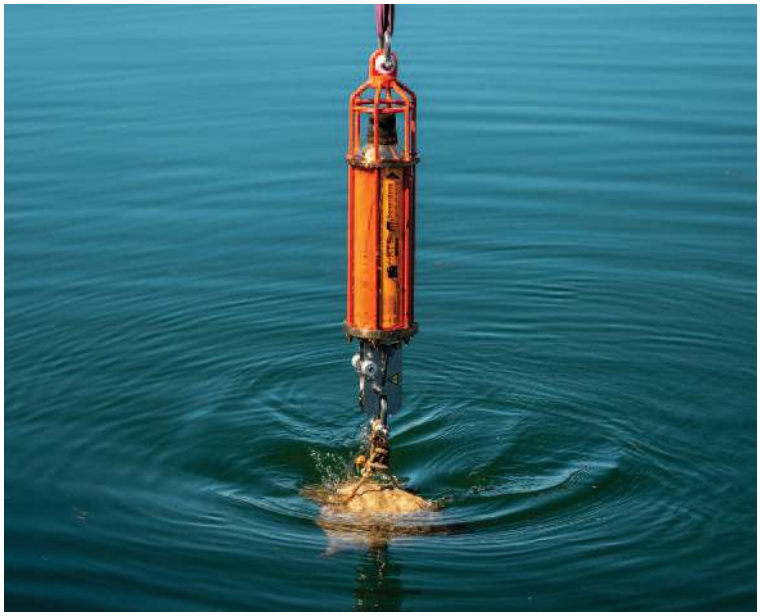
A standout feature of the medium frequency (MF) RT 6-1000 is, as its model number implies, a depth rating of 1,000 m. That's twice as deep as many of the other entry-level releases on the market. At 15 months, alkaline battery life is equally impressive, and when it's time to recover it to the surface – and the valuable equipment it's attached to – it's screw-off release mechanism won't let you down. It's the same one as used on our popular high frequency LRT.

And talking of the surface, just like the rest of our RT 6 family, the RT 6-1000 is compatible with our Micro, Mini and Ranger 2 USBL tracking systems. So you can now deploy, track, locate and activate your mooring all with one piece of topside equipment.

No topside; no problem

If you don't have a Ranger 2 system to hand, no problem – we've other topside options available. Firstly, we've engineered the RT 6-1000 to be setup and controlled via our free Android app. All you need is a near field communication (NFC) enabled device and a second RT 6-1000 which stays with you on the surface to handle sending acoustic commands and receiving replies. For small boat operations, what could be simpler? If you'd rather not go Android, you'll soon be able to order a ruggedised over-the-side dunker that's connected via a serial cable to our deck test unit, iWand, which you may already have onboard. You'll just need the latest firmware. A separate, industrial-grade NFC antenna is also available meaning you can configure your RT6-1000s in the workshop with a PC and our 6G Terminal software utility.





RT 6-3000
RT 6-3000 covers all of your deep water equipment mooring and structure lowering needs down to 3,000 m. It can be left in situ for up to three years on alkaline batteries. Its working load limit of 1,275 kg based on a 4:1 breaking load – expandable with one of our compatible load amplification frames. It works on MF frequency so it can be controlled using your Ranger 2 system, or else with the iWand and dunker combination mentioned earlier.

RT 6-6000
Going up (or rather down) another level is RT 6-6000. It offers you the same load and long-endurance capability as the RT 6-3000 but with the freedom to go to 6,000 m. It's also able to be operated by Ranger 2 – but in this case the LMF system which is often specified by the deep ocean research community. If you don't have a Ranger 2 LMF system, you have the same dunker option as you do for the RT 6-3000, albeit an LMF dunker-iWand combination.

As standard, all RT 6 units come with an inclinometer and you can check their release status using the acoustic set-up you've chosen for deployment and recovery. What's more, they have battery disconnect, which means your battery isn't wasting power while your unit is on the shelf – so you get the best out of your battery.

YouTube

See how easy it is to deploy your RT 6 1000, watch our video.

LODESTAR-NAV
ALL-IN-ONE FACTORY FIT SOLUTION

If you're a vehicle manufacturer looking for a navigation solution to factory fit, our acoustic-inertial products provide the highest performance available in the industry and reduces integration and operational complexity. For ROV control and guidance the Lodestar-Nav is a highly suitable solution combing a high accuracy attitude heading reference system (AHRS), Syrinx Doppler velocity log (DVL) and survey grade pressure sensor. Availability in three performance grades (300, 500, 700), in an identical form factor, means you can easily swap between performance grades without additional integration work required.

It comes pre-calibrated, providing your platform with a turnkey solution that's accurate, robust and reliable in even the most challenging environments. For survey applications where true inertial output is required, Lodestar-Nav can be remotely upgraded in the field to a SPRINT-Nav to provide exactly that.

COMPATT 6+ DOCK AND LATCH
LOW COST LBL DEPLOYMENT

Recently, we've been working with Forssea Robotics to fit and test their underwater quick latching system to our Compatt 6+ transponders. The collaboration means that their Atoll light-size autonomous docking vehicles can now deploy and recover this market-leading LBL transponder from vessels of opportunity or USVs. This method, pioneered by Forssea, is expected to enable operators to drastically reduce costs on both their development projects and life-of-field operations by using smaller, cheaper vessels.

The attachment replaces the Compatt's existing transducer guard, allowing it to be latched on to, flown to the seabed and placed into an LBL frame; a sequence all performed autonomously based on Atoll's embedded control algorithms. For more information, visit **forssea-robotics.fr**

ENGINEERED BY NATURE

Sharks are some of the most fascinating animals in the seas. Streamlined and efficient, sharks have been honing their features for over 400 million years. 500+ species, many of them occupying vital roles within the ecosystem, all of them invaluable pieces in nature's jigsaw. Overfishing is pushing too many shark and ray species to the brink. Change is urgently needed to transform fisheries and protect vulnerable species.

As a Corporate Patron **Sonardyne** is committed to helping the Shark Trust take on the challenge of safeguarding the future of sharks through positive change.

Find out how you or your business can get involved and help to create a better future for our oceans.

www.sharktrust.org

SHARK TRUST

CORPORATE PATRON