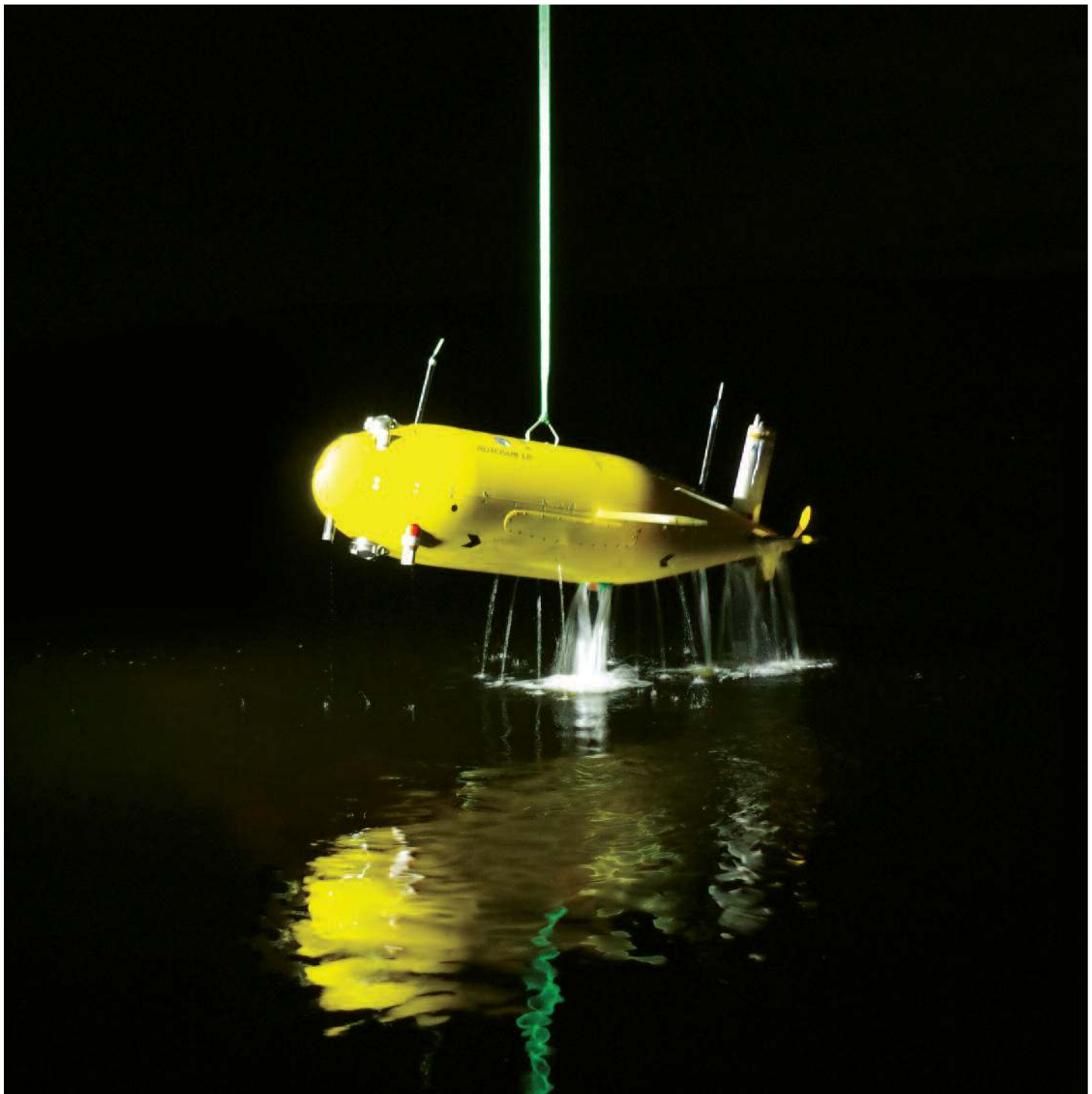


BL

**BASELINE. THE CUSTOMER MAGAZINE
FROM SONARDYNE**

ISSUE 21



Since our last issue, we've been busy delivering the INS release of Fusion 2, our new survey software, and the 6+ hardware that works with it. It's had a fantastic reception and we're already fulfilling orders and supporting operations. By the time you read this, we will have passed the next milestone, releasing LBL functionality. We pick up the story on page 20.

Nothing beats a live, in-water demonstration to back up what we claim something will do. At the end of 2018, in front of around 40 Freemantle-based clients, we put a SPRINT-Nav to the test against local RTK data. The results stunned even us – 0.02% of drift over 20 kilometres – so much so that Rolf Christensen on page 12 explains why we are re-thinking our performance figures. Then, head over to our website to read Graeme Buchanan's blog from Freemantle.

We're often asked to track things in difficult acoustic environments. But a small ROV in a pen containing 200,000 fish? That was a new one – so off went Micro-Ranger 2 to Norway. Did it succeed? Find out the results on page 18.

At a recent conference, oil majors set out their visions for 2025, highlighting leak detection and remote asset monitoring as key challenges. As you'll read inside, these are challenges we are well down the path to helping solve.

You will have noticed that there have been some changes to Baseline Issue 21. Our thinking behind the new look is to make it easier to read, so new fonts have been chosen to improve legibility and by upping the page count, we can now give our content the space it needs.

Baseline's content, however, is one thing that hasn't changed. The magazine will continue to tell the story of our technologies, products and client successes from around the world. We hope you enjoy the new look.

David Brown Editor

Baseline.
The Customer magazine
from Sonardyne

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Issue #21 Cover

The National Oceanography Centre's Autosub Long Range (ALR) was fitted with a SPRINT-Nav and upward facing Syrinx DVL during trials in Loch Ness, as part of our Innovate UK-funded Precise Positioning for Persistent AUVs (P3AUV) project, outlined in our last issue.



PAGE 18. AQUACULTURE
It's Micro-Ranger 2 versus 200,000 fish in testing and trials with SINTEF Ocean in Norway.



PAGE 4. NEWS
Acquisitions, world-wide orders and guiding the way for robots. Get up to date.



PAGE 22. FUSION 2
Easier and faster survey and construction operations with less hardware and fewer interfaces.



PAGE 12. HYBRID NAVIGATION
SPRINT-Nav has set new navigation standards. Find out how.



PAGE 28. OCEAN SCIENCE
Monitoring the restless earth, globally, with our tough, accurate and long-endurance instruments.



NEWS

Chelsea Technologies joins the Sonardyne group of companies



We have acquired Chelsea Technologies, a UK-based maritime and marine science technology specialist.

Chelsea has a broad base in environmental sensing technology, spanning markets in fresh and waste water, oceanography and a wide range of industrial applications. In addition to its optical engineering capability, Chelsea provides underwater acoustic products to both civilian and defence customers.

Acquiring Chelsea is part of our long-term growth strategy, which includes diversification into markets where we see an opportunity to build on our core technology base and expertise in underwater acoustic and optical communications, navigation and autonomous monitoring systems.

The move will strengthen our presence in the maritime, marine and ocean science sectors and create new opportunities in

the water environmental, defence and process control markets. Chelsea will gain access to our considerable research, production, testing, compliance and global distribution capabilities, allowing the company to access international territories more efficiently.

Chelsea is expanding, fuelled by its involvement in the rapidly developing, maritime/green shipping markets, where it has introduced a number of new products, including include FastBallast and Sea Sentry.

These technologies, which are used for ship ballast water compliance testing and ship exhaust gas scrubber wash water monitoring, respectively, are helping maritime operators to meet recently introduced stringent international regulations aimed at reducing the impact of global shipping operations on the environment.

BMT and Sonardyne team-up for integrity monitoring

We have signed a Teaming Agreement with engineering consultancy BMT that will see us jointly providing advanced integrated marine integrity monitoring solutions to the oil and gas industry.

Through the agreement, BMT and ourselves will be able to work collaboratively to provide smarter and more efficient through-life solutions for monitoring and managing critical subsea assets, including drilling and production risers, moorings and wellheads.

By working together, we will combine BMT's monitoring and analysis capabilities with our expertise in autonomous, long-endurance data collection and through-water telemetry. This means clients globally will be able to benefit from a wider range of options to bring more subsea integrity data to their desktops, faster, making it easier for them to make safety critical decisions at the right time.

This new agreement builds on an already strong working relationship between our organisation and BMT and is seen as an opportunity to offer a further step-change in the solutions provided to our customers.

Our two companies are already working on proposals for major operators globally, which would offer significant cost reductions on existing systems, with longer periods between maintenance.

World-wide orders for Ranger 2 and Mini-Ranger 2 USBL systems



Our USBL family remains popular, with orders for Ranger 2 and Mini-Ranger 2 systems from across the globe.

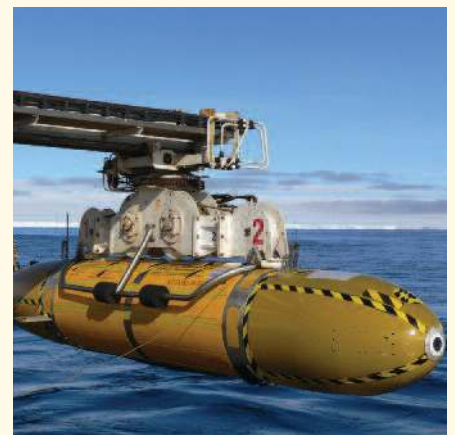
Rolls-Royce's Commercial Marine business has ordered a Ranger 2 USBL acoustic positioning system, including a deployment machine, for the new-build light subsea construction and ROV support vessel *Topaz Tangaroa*. The vessel, which has two integrated work class ROV hangers, is being built for Dubai-based Topaz Energy and Marine.

Thai offshore inspection, repair and maintenance company Beacon Offshore has acquired a Ranger 2 Survey package, with a Dynamic Positioning Transponder 6 (DPT 6) and transceiver deployment system for its latest vessel, the *SC Sirapat*. The Ranger 2 system will be used on the vessel for ROV and diver tracking as part of inspection, repair and maintenance operations on mobile and fixed installations offshore Southeast Asia.

Vietnamese marine services company Greenstar Positioning has acquired two Mini-Ranger 2 USBL underwater positioning systems and a number of Wideband Sub-Mini 6 Plus (WSM 6+) beacons. The equipment will be used to track ROVs and divers on Greenstar's upcoming projects, including the installation and survey of flowlines, pipeline protection mattresses and inspection, repair and maintenance (IRM) work on oil and gas field infrastructure off the coast of Vietnam.

Brazilian underwater engineering company Belov Engenharia acquired a Mini-Ranger 2 USBL system to track its ROVs during IRM work on floating production, storage and offloading vessels and their associated subsea riser and mooring systems offshore Brazil. The equipment will be installed and operated from the dive support vessel *Cidade Ouro Preto*, which operates under a contract with Petrobras.

SPRINT-Nav guides the way for robots

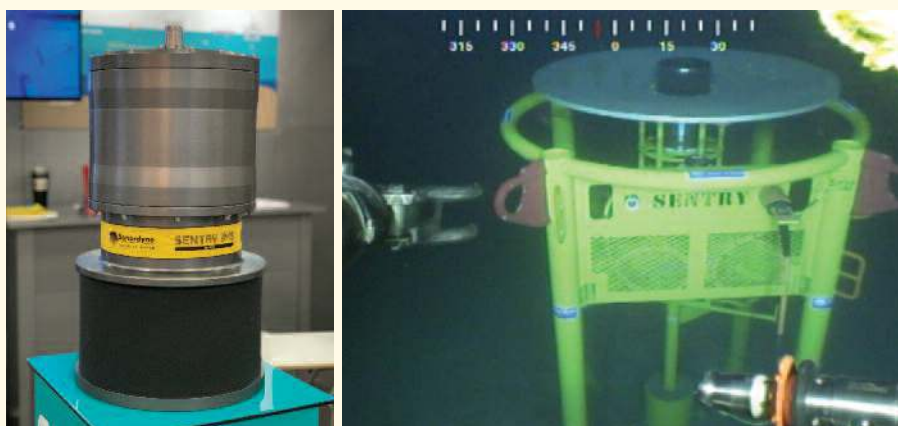


Deliveries of our hybrid navigation instrument SPRINT-Nav continues to accelerate following a string of new orders, one of the most recent being from the UK's National Oceanography Centre (NOC). The NOC has ordered our highest performing SPRINT-Nav 700 for its new AutoSub2KUI, standing for 2,000 metres under ice, where it will operate.

Global heavy lift, pipelay and construction company Allseas ordered SPRINT-Navs for its dynamic positioned trenching support vessel *Calamity Jane*. The SPRINT-Navs will provide precise navigation and positioning during survey and installation operations for the vessel's 4,000 metres depth rated ROV.

International subsea services provider DOF Subsea chose SPRINT-Nav for underwater vehicles on three deepwater construction, inspection, maintenance and repair vessels working in Brazil's pre-salt oil fields.

Sentry goes on leak detection duty in the US Gulf of Mexico



Our Sentry Integrity Monitoring Sonar (IMS) has been deployed by a major US oil company in deep water in the Gulf of Mexico to enhance subsea asset integrity assurance. The system is now on the seabed in more than 2,000 metres (6,500 feet) of water depth to demonstrate its ability to provide real-time subsea leak detection.

Sentry IMS, which can be installed short-term or permanently, is able to detect, classify and localise low volume releases of hydrocarbons from either the seafloor or oil and gas field production infrastructure.

For this project, the Sentry sonar head is mounted on a seafloor lander, connected into an existing power and communication umbilical linked to a floating production facility. During operation, inbuilt intelligence using our algorithms continuously assesses Sentry's sonar data and generates near real-time automatic alerts of any hydrocarbon seeps detected in the water column.

As part of the trial deployment, physical simulations of an oil plume in the water were deployed, proving fast and accurate detection and classification of the equivalent release of 100 barrels/day

of oil. Detection was achieved within seconds of the simulated leak occurring. Sentry's capability covers 100 barrels/day mono-phase oil leaks at distances of up to 740 metres (2,427 feet). For mono-phase gas leaks, the system is capable of detecting down to just 1 barrel equivalent/day at 500 metres (1,640 feet) or 100 barrels equivalent/day (as measured at depth) at 1,000 metres (3,280 feet).

This latest deployment follows battery-powered deployments of the Sentry system by other major international and independent operators, in the US Gulf of Mexico and offshore Papua New Guinea. Sentry has also been used in the UK, where it demonstrated its ability to detect carbon dioxide leaks from the seafloor as part of an offshore carbon capture and storage (CCS) demonstration project.

This latest deployment follows use of the Sentry system by other major international and independent operators, in the US Gulf of Mexico and offshore Papua New Guinea."

Naval Surface Warfare Center selects Sonardyne for underwater vehicle testing ground



The US Naval Surface Warfare Center (NSWC), Carderock Division, has chosen our acoustic technology to track underwater vehicles at its South Florida Ocean Measurement Facility (SFOMF).

Carderock Division, in Maryland, is the US Navy's research, engineering, modelling and test centre for surface and undersea technologies. It is the largest, most comprehensive facility of its kind and, thanks to its proximity to the Gulf Stream, is also a demanding open ocean test environment for subsea systems and unmanned underwater vehicles (UUVs) for the navy and wider maritime industry.

To support its work, Carderock Division chose our high accuracy Ranger 2 Ultra Short Baseline (USBL) acoustic tracking system, complete with a Gyro USBL transceiver and Nano and Wideband Sub-Mini 6 Plus (WSM 6+) transponders.

The Ranger 2 system will be mobilised aboard vessels-of-opportunity in order to track the precise underwater position of any subsea system or UUV that comes through the SFOMF for testing. With Ranger 2, systems can be tracked in shallow and deep water, as well as near the surface and over very long ranges. Using Nano and WSM 6+ transponders,

all sizes of vehicles can be accommodated, from man-portable models through to extra-large (XLUUV) designs.

Dan Zatezalo, Technical Sales Manager, at Sonardyne Inc., says, "Ranger 2 with Gyro USBL is a survey grade acoustic positioning system with built-in attitude and heading sensors, which makes moving it from vessel to vessel easy. Used alongside Nano, our smallest ever, rechargeable acoustic transponder, and WSM 6+ transponders, which both support our secure Wideband 2 signal protocols, the NSWC has a high-performance and time-saving system for its operations at Maryland. This sale also further embeds our commercial-off-the-shelf capabilities, field-proven within the US offshore energy and science sectors, into the North American defence market."

The SFOMF has housed an active navy range for more than 50 years. Its main mission is to perform electromagnetic signature tests of navy assets, using multiple fixed, in-water electromagnetic and acoustic measurement sites. The facility also tests and evaluates mine detection, mine countermeasures and mine response; performs acoustic measurements; and acquires radar cross section and infrared signatures.

Bluefin-9 takes to the water with Solstice and AvTrak 6



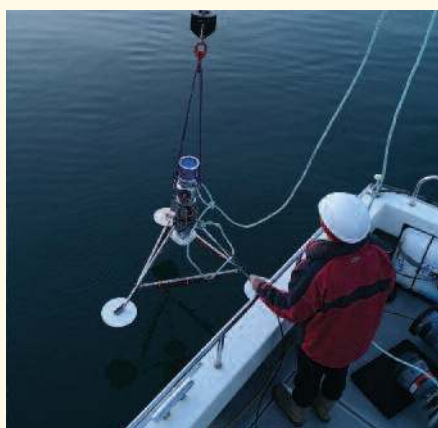
General Dynamics Mission Systems' new highly portable Bluefin-9 autonomous underwater vehicle has been launched, complete with our multi aperture sonar and communication and tracking technology – as factory standard.

Bluefin-9 can be easily deployed and recovered from a rigid hulled inflatable boat without the need for launch and recovery systems.

Once in the water, our Solstice multi aperture sonar makes the Bluefin-9 the most effective mine-hunting and hydrographic AUV of its class. With a 200 metre swath, the range is longer than any other sonar in the two-man portable market. Additionally, the along-track resolution outperforms all competitors, all while consuming very little power.

Our Nano AvTrak 6 OEM provides Bluefin-9 with communications and tracking. Using our 6G acoustics, the Bluefin-9 is able to handle two-way communications with its users, meaning real-time monitoring and control can be achieved with minimal impact on the vehicle's size, weight and power. Using this technology means your AUV can run for longer, improving area coverage rates and mapping more – and more accurately.

Equinor enhances seismic monitoring with PIES



Norway's Equinor is to deploy a cabled Pressure Inverted Echo Sounder (PIES) at its Johan Sverdrup field to help increase the accuracy of time-lapse seismic data.

Equinor plans to use seafloor based seismic cable permanent reservoir monitoring (PRM) technology from first production at the field, to observe what is happening in the reservoir over time to help maximise recovery rates.

Using a PIES will help to reduce uncertainty in the data caused by changing environmental conditions, such as water velocity and tidal height, by directly measuring those changes.

Subsea services contractor Subsea 7 will install the PIES in 120 metres water depth at Johan Sverdrup where it will continuously measure the two-way travel time of sound waves propagated through the water column from the seabed to the sea surface as well as the pressure (depth) at the seabed. This data will then be used to calculate a continuous time history of average water velocity and tidal variation in the water column.

PIES to monitor disruptive current in the US Gulf of Mexico

10yrs

The length of time a larger array will be deployed for following these study results.

A major \$2 million scientific study of disruptive ocean currents in the US Gulf of Mexico is to be aided using our Pressure Inverted Echo Sounders (PIES).

The two-year deployment, led by the University of Rhode Island (URI)'s Graduate School of Oceanography, will monitor the Loop Current System (LCS). The LCS is the dominant ocean circulation feature in the Gulf, influencing all ocean processes there and impacting a wide range of activities, from oil exploration to coastal eco-systems. But, knowledge of its underlying dynamics is limited. URI's initial study aims to improve the understanding and prediction of the LCS, by deploying a seabed network of 25 of its own and our PIES, plus near-bottom current meters, down to 3,500 metres water depth, to monitor the central Gulf's deep waters.

Initial data retrieval is planned for Autumn 2019 via acoustic through-water communications to a surface vessel, with instrument recovery in 2020. The study's results will be used to inform the design of a larger array, to be deployed for 10 years.

PIES works by transmitting an acoustic pulse from an instrument on the seabed upwards. The pulse is reflected off the

water-air boundary at the sea surface and returns back down to the seabed where it is detected by the PIES. This enables an exact measurement of the two way signal travel time to be calculated. At the same instant, an accurate measurement of depth is made using highly precise internal pressure sensors. Combining data from an array of PIES instruments and near bottom current meters with historic water profile data can be used to calculate currents throughout the full water column.

URI's LCS study is being funded by the US National Academies of Sciences, Engineering and Medicine's Gulf Research Programme, which was founded in 2013. The long term objective is to improve forecasts of the LCS in order to increase the safety of operations in the Gulf.

Shell, Sonardyne, Senai Cimatec to design autonomous seismic nodes



Shell Brasil, Petrobras, Brazilian research institute Senai-Cimatec and ourselves have formed a partnership to develop innovative autonomous technology to make the monitoring of Brazil's challenging deepwater pre-salt oil fields more efficient.

We're working on a new 4D seismic monitoring system, based on so-called "On Demand Ocean Bottom Nodes", under a National Agency of Petroleum, Natural Gas and Biofuels (ANP) promoted programme.

The goal is to increase the autonomy of ocean bottom nodes, which will be deployed and remain on the seafloor for up to five years. During that period, no interventions, such as connections for data extraction or replacement of batteries, would be required. The nodes would communicate wirelessly with autonomous underwater vehicles (AUV). These capabilities will help to generate operational efficiencies and eliminate the various existing difficulties in deploying current 4D seismic monitoring technology. The new technology will also allow the reduction of both costs and operational safety risks.

Jorge Lopez, Shell Research and Development Advisor in Brazil, says,

"This is a very promising project, fully aligned with the new reality of the oil and gas industry, which seeks to use new technologies to ensure a safer, more efficient operation that has less impact on the environment. For Shell, Brazil is an important centre for attracting partners and technological development, and we are sure that the partnership with Sonardyne and Senai will be very successful."

Shaun Dunn, our Global Business Manager, Exploration and Surveillance, says, "This project will use our significant expertise in the design of long-endurance battery-powered subsea instrumentation, as well as our wireless through-water acoustic and optical communications technologies. Leveraging these will help to create a unique capability that will greatly enhance the cost effectiveness of on-demand seismic surveys and continuous seafloor deformation monitoring offshore Brazil."

The project is divided into three main phases: development, including design and initial testing of the new node, including communication with the underwater vehicle; manufacturing of a pilot scale system; and deployment of the pilot system for three years in a pre-salt field.



This project will use our significant expertise in the design of long-endurance battery-powered subsea instrumentation, wireless through-water acoustic and optical communications technologies."

VIEWPOINT



Data, its acquisition and processing – at source – is driving today's economies and increasingly making subsea operations safer and more efficient. **Malik Chibah**, Head of Engineering, sets the scene.

Growth in computer processing power and cloud computing capabilities have made the generation of, access to, and analysis of data exponentially easier and faster.

Yet, at the same time, the amount of data being generated is also growing at an unprecedented rate as yet more sensors and devices are built and deployed. While there are applications such as Hadoop open source distributed processing, which enable data processing and storage for big data applications, edge computing, or edge analytics, it is increasingly being used to provide actionable data to operators' fingertips faster.

These are not exclusive systems; they're two ends of a new data ecosystem. At the edge of the system, edge computing uses intelligent devices to log data and communicate between devices (the Internet of Things), while embedded processing (edge analytics) turns that data into immediately useful information, before it's sent on for deeper analysis.

By running data through an analytics algorithm, by setting parameters on what information is worth sending as the data is created, companies can reduce the glut of data that enterprise management systems have to handle, maximizing available wireless bandwidth at their Wifi/IoT enabled facilities. The result? Operators have access to information faster, often in real-time, decreasing latency in the decision-making process.

In the offshore world, where any one platform can have upwards of 50,000 data points, this can make a significant difference. The same can be achieved subsea. Underwater sensors and devices are traditionally harder to install and then access, especially without readily available communication or power links. But, make those systems intelligent, connected and wireless and you have access to information about your system at lower installation costs.

Over the past decades, we have built a powerful combination of intelligent devices, that monitor, log and analyse data at source, alongside subsea communication technologies that deliver that intelligence to the surface.

By embedding processing into our sensors, complete with our robust 6G hardware and Wideband 2 and 3 signal architectures, bandwidth availability is optimised and critical information can be supplied real-time, enabling infrastructure to be better managed, more cost effectively, for longer.

Intelligent devices can send alarms when any operating parameters are breached, they can self-report their status and start to make their own decisions. They also still retain all the raw data they have logged, enabling detailed analysis later. In fact, all our instruments, from Data Loggers to Pressure Inverted Echo Sounders, have Gigabyte-scale data storage, on top of which we can add layers of intelligence as required.

What does this mean in the real world? It means useful information – from

a detection of an oil leak to excessive movement of a subsea pipeline – can be fed autonomously from remote instruments to those who need it.

We can start to reduce the need for manned vessels, enable unmanned over-the-horizon operations and connect onshore devices to what's happening deep subsea. As an example, our Subsea Monitoring, Analysis and Reporting Technology (SMARTs) can integrate with any subsea sensor and perform analytics on the data gathered before sending it to the end user when they want it. Read more on pages 34-37.

Another example is our Sentry Integrity Monitoring Sonar (IMS), which remotely and autonomously detects, classifies and locates seafloor oil and gas leaks, sending alerts to the topside. And our Sentinel sonar autonomously detects threats, such as unfriendly divers or AUVs, and sends a warning and bearing when a threat is detected.

Intelligence doesn't end with individual sensors, however. We're taking it a step further to make LBL faster and more reliable, with fewer transponders and less reliance on communication to the surface, through a combination of our Fusion 2 software, SPRINT INS and SPRINT-Nav hybrid navigation instruments, by calibrating LBL arrays onboard – in the instrument. We've also shown that calibration of an LBL array from a transceiver deployed off an unmanned surface vessel is possible. This is just some of what is already being done. The possibilities are much greater.

By embedding processing into our sensors, complete with our robust 6G hardware and Wideband 2 and 3 signal architectures, bandwidth availability is optimised and critical information can be supplied real-time.

We can bring you access to the information you need about your subsea assets, when and where you need it.





SPRINT-NAV: SETTING NEW STANDARDS

WHEN WE LAUNCHED SPRINT-NAV IN 2015, IT HAD BEEN DESIGNED TO PROVIDE IMPROVED INS PERFORMANCE AS WELL AS EASE OF USE, COMPARED WITH USING STANDALONE INS AND DVL INSTRUMENTS. THE RESULT: SPRINT-NAV SET A NEW STANDARD IN SUBSEA ROV AND AUV NAVIGATION. IT HAS EVEN OUTPERFORMED OUR OWN EXPECTATIONS – SO MUCH THAT WE ARE NOW REVISING OUR SPECIFICATIONS. WE ASKED **ROLF CHRISTENSEN, INS MANAGER**, WHY?



SPRINT-Nav is helping operations across the globe, from the North Sea to Brazil.

BASELINE: WE'RE INTRODUCING REVISED SPECIFICATIONS FOR SPRINT-NAV, WHY NOW?

ROLF CHRISTENSEN: When SPRINT-Nav was introduced, we created something new: an all-in-one subsea navigation instrument for underwater vehicles. It combines our SPRINT INS sensor, Syrinx DVL (Doppler velocity log) and high accuracy intelligent pressure sensor in a single housing that is one of the smallest combined inertial navigation instruments on the market.

It has created a new market. It's in use globally, from the North Sea to Brazil and Australia, on subsea resident vehicles, autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs), for everything from inspection and survey operations, pipelay and construction to ocean science research.

Since the time of launch in 2015, we have built a huge data set, including internal system calibration which we do on each SPRINT-Nav before it goes to our customers, to results from customers, and from direct shootouts against competing solutions. With the results we've seen, we see that our original specifications for SPRINT-Nav were conservative. This instrument is outperforming across the three models we offer and it's time to revise our performance figures to reflect its true capabilities.

The New Numbers

	SPRINT-Nav 300	SPRINT-Nav 500	SPRINT-Nav 700
Typical Survey % Distance Travelled	0.04	0.02	0.01
Distance From Origin (DFO) % Distance Travelled	0.12	0.07	0.05

During the voyage we asked our customers who were onboard to guess what accuracy we would see at the end of voyage. No one came close. The result was a position accuracy of just 3.2 metres out, or 0.02% drift on distance travelled.

SPRINT-Nav is one of the smallest inertial DVL instruments available on the market, delivering unprecedented levels of performance for ROV and AUV guidance and survey.

BL: WHAT IS SPRINT-NAV IDEALLY SUITED FOR?

RC: SPRINT-Nav was developed with survey operations in mind and that's where our SPRINT-Nav 500 model has really been making a difference. It's already being used on work class ROVs in offshore applications from subsea pipeline construction and high accuracy pipeline or cable survey to subsea inspection, repair and maintenance, including laser metrology with ROVs or AUVs, and decommissioning operations. Having more accurate, robust and reliable information about ROV position and attitude gives operators greater confidence in their operations and greatly expands on their capabilities.

It's also ideally suited for the growing numbers of resident vehicles that are being developed (both ROVs and hybrid AUVs), as well as larger ROVs and AUVs.

Recently, subsea services provider DOF Subsea equipped three of its ROVs on Brazil-based offshore construction support vessels with SPRINT-Navs. Meanwhile, global offshore heavy lift, pipelay and construction company Allseas will be using a pair of SPRINT-Navs to support work from its trenching support vessel *Calamity Jane*.

Two in-field ROVs built by Norway-based IKM Technology for IKM Subsea are equipped with SPRINT-Navs and are being used as part of a resident vehicle development programme in Norway for operator Equinor.

SPRINT-Nav is also well suited to ocean science and research. In an Innovate UK-supported project, led by Sonardyne, and working with the National Oceanography Centre (NOC), a SPRINT-Nav is being used to support a lower grade INS sensor to improve AUV navigational accuracy and endurance on long-duration missions. Initial trials of the Precise Positioning for Persistent AUVs (P3AUV) project, using the NOC's Autosub Long Range (ALR), fitted with a SPRINT-Nav, were carried out in Loch Ness, Scotland, late 2018.

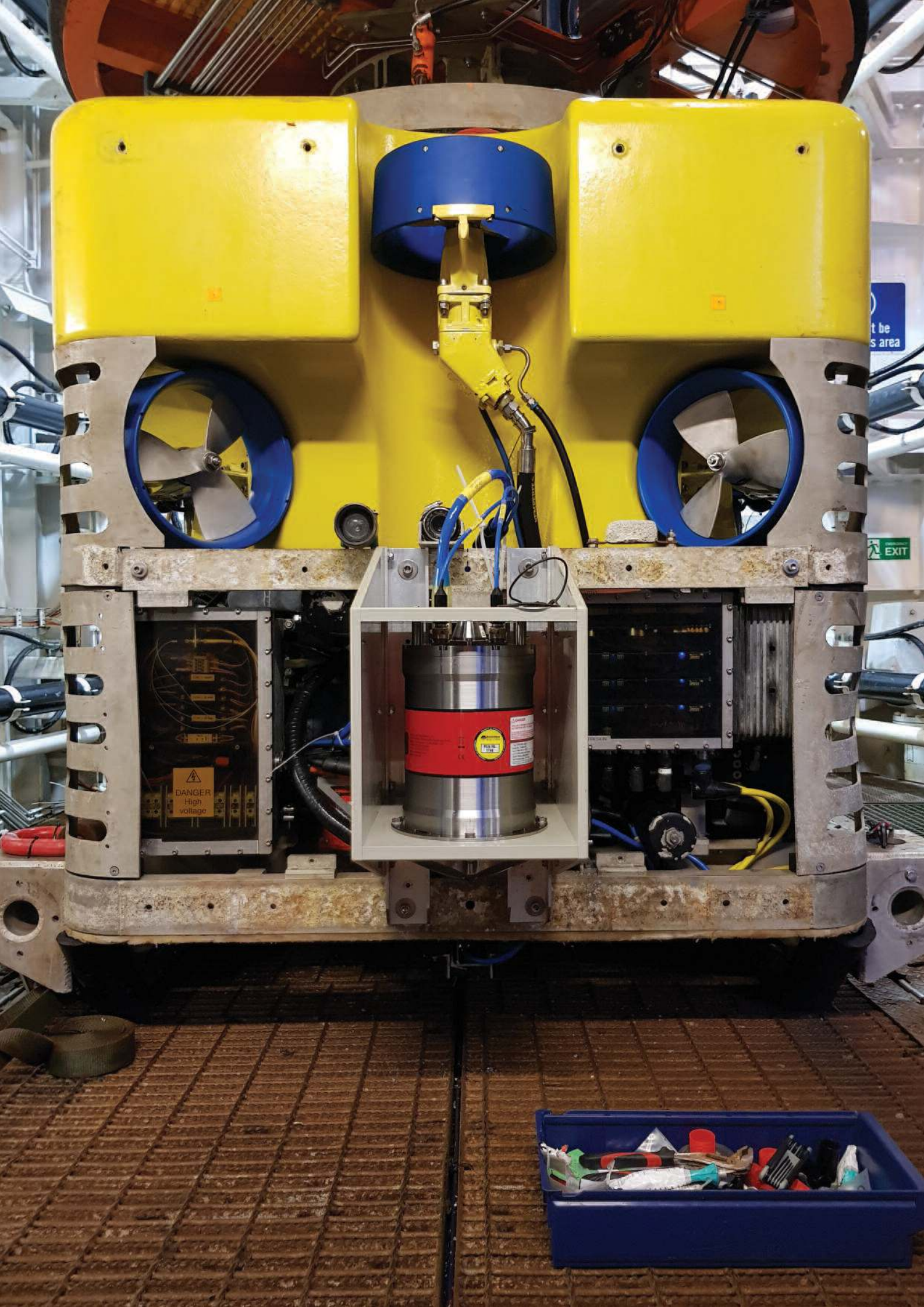
BL: YOU MENTIONED IMPRESSIVE TRIAL RESULTS, TELL US MORE.

RC: Of the many undertaken, there's two that come to mind. In late 2018, during a customer demonstration day for our Fusion 2 software, in Freemantle, Australia, we decided to run an impromptu SPRINT-Nav test. At the end of an unplanned 20 kilometre voyage, out of Success Harbour, we compared our position estimated by our SPRINT-Nav 500, using DVL-aiding alone (i.e. there was no input from GPS, Ultra-Short BaseLine (USBL) or Long BaseLine (LBL) to the local RTK (Real Time Kinematic satellite positioning) position.

According to our previous SPRINT-Nav datasheet, INS drift while running on DVL-aiding alone would be about 0.06%, or 12 metres over a 20 kilometre return journey. During the voyage we asked our customers who were onboard to guess what accuracy we would see at the end of voyage. No one came close. The result was a position accuracy of just 3.2 metres, or 0.02% drift on distance travelled. While such results cannot be guaranteed, as environments change and impact performance, these numbers were far better than any of us expected.

In another trial, we tested how additional acoustic aiding can help the INS constrain its position drift over time. This can be done by deploying seafloor transponders at a known position to provide range aiding to the INS. The acoustic two-way travel time measurements taken from passing next to a transponder on a linear trajectory automatically resets any DVL-INS dead reckoning drift. This means vehicles can operate for longer without reducing their positioning accuracy.

During a customer witnessed demonstration in June 2017, we travelled using a SPRINT-Nav 500 out of our Plymouth test and training facility, passing, after 2 kilometres, a pre-placed transponder at Plymouth Sound breakwater. Then, we passed a second transponder placed a further 5.5 kilometres out into Cawsand Bay. The



DANGER
High voltage

Do not be
in this area

EXIT

SPRINT-Nav LBL-INS positioning, compared to the RTK GPS reference, was within a robust 2 metres at all times and reduced to less than 0.5 metres when passing a transponder. Post-processing using our Janus software reduced this to less than 0.6 metres peak error over the entire run.

Range aided INS performance in the Plymouth Sound is severely compromised by the shallow water and highly complex and variable sound velocity profile. In a typical offshore environment, the realistic transponder maximum ranging distance would be 1-3 kilometres and SPRINT-Nav accuracy relative to a single transponder would be ~0.1% of slant range (1DRMS), i.e. 1 metre at 1 kilometre distance when the vehicle passes a transponder at an optimal angle.

BL: THERE ARE DIFFERENT WAYS OF MEASURING PERFORMANCE, WHAT'S THE DIFFERENCE?

RC: As part of revising our performance specifications we are also introducing two performance terms, so it's easier for our customers to understand what performance they would get in different scenarios.

Distance From Origin (DFO) is the expected accuracy after following a trajectory, as seen in the diagram to the right, top. At the destination the DFO accuracy is the error in % distance travelled compared to the straight-line distance from the origin.

When we talk about Typical Survey, this is the expected accuracy

in a more typical confined area when doing a survey. An example is a site survey, shown in the diagram opposite.

BL: WHAT'S DRIVING SPRINT-NAV'S HIGH PERFORMANCE?

RC: SPRINT-Nav achieves its unprecedented performance through a number of features unique to Sonardyne, all of which are based on our experience and knowledge of how acoustic and inertial measurements complement each other.

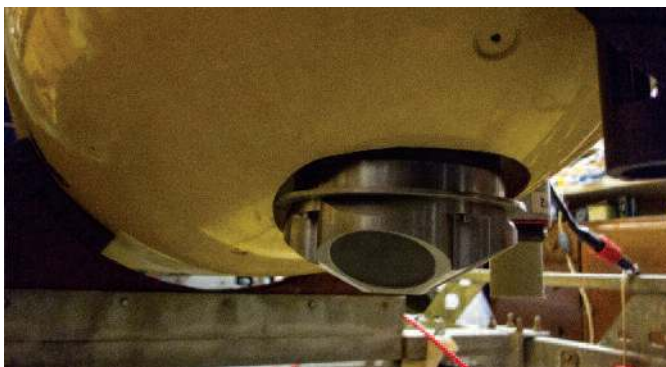
Inside SPRINT-Nav is an inertial motion unit (IMU), designed by Sonardyne and built around carefully selected, highly robust and accurate Honeywell ring laser gyro (RLG) inertial sensors and Honeywell accelerometers. The INS is tightly coupled with a Syrinx DVL, from which the INS takes beam-level data, as well as integrating a high-performance pressure sensor. Tightly integrating raw sensor data from the IMU and DVL at a low-level like this means that higher levels of accuracy and reliability are achieved.

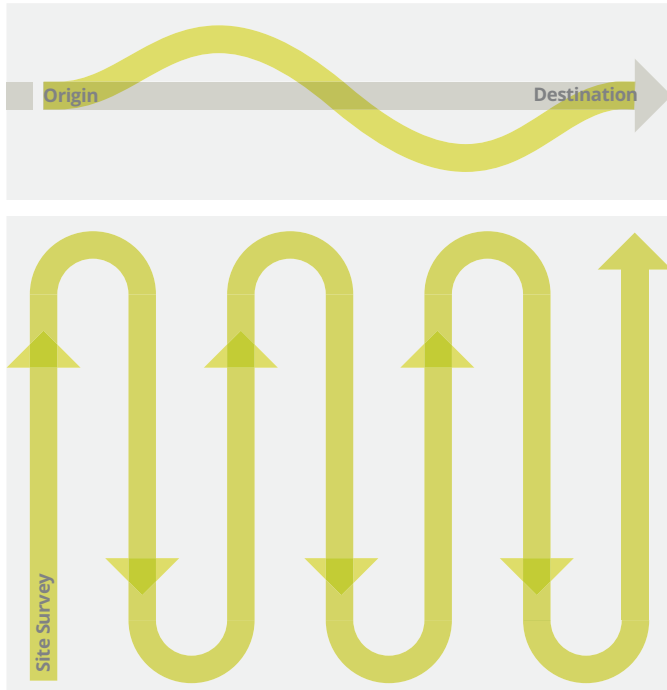
Careful design and strict control of all parts of the SPRINT-Nav is what enables Sonardyne's hybrid navigation instrument to provide unprecedented performance not rivalled by any other solution.

BL: WHAT HAS BEEN THE CUSTOMER RESPONSE, TO DATE?

RC: Our customers, and even ourselves, have been surprised at the high performance the SPRINT-Nav delivers; the dead-reckoning

With SPRINT-Nav on board, any subsea vehicle, from work class ROVs to long-range AUVs, can achieve higher performance.





Distance From Origin (DFO)

This is the expected accuracy after following a trajectory (yellow line). At the destination the DFO accuracy is the error in % Distance Travelled (% DT) compared to the straight-line distance (grey line) from the origin.

Typical Survey

This is the expected accuracy which would be observed in a more typical confined area survey application. An example could be a site survey as shown left

performance is simply unmatched in the market. But it's not just its performance. Our customers find it is easier to set up and operate; its integration is simple (one cable and one system to integrate).

It's also fast to initialise, with no need for calibration manoeuvres, before or during a mission. This is due to the fact it runs two algorithms where the INS can instantly initialise from the AHRS. However, fast initialisation is also made possible due to the RLG's very deterministic characteristic, compared with other types of gyros like fibre optic gyros (FOGs).

Our topside software, whether the dedicated SPRINT application or Fusion 2 combined INS and LBL package, is also very user-friendly and a great tool for monitoring system health and trouble-shooting potential issues during mobilisation and operation.

BL: WHY IS THE RLG SO IMPORTANT?

RC: The RLG we use, the GG1320, is used in most commercial aircraft – it's highly robust and has proven reliability and longevity. Our RLG is also resistant to environmental variation, including temperature changes and vibration.

But that's not all. Our RLGs have no initial bias and negligible bias drift over time, meaning that no initial or periodic calibration is required, there's no complex set-up routines or pre-operational manoeuvres needed and there are no regular calibration routines required during the job. The highest performance is available quickly, as soon as you turn the system on. **BL**

THE KIT LIST

WHAT'S FEATURED IN THIS STORY

Type 8262 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?

SPRINT-Nav 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 metres and tiered performance levels to support simple to complex tasks.

How will it benefit your operation?

A combined instrument reduces onboard power consumption and simplifies integration. With SPRINT and Syrinx permanently aligned, there's no need to constantly align the DVL. Operating SPRINT-Nav is simple. Switch the unit on, wait 10 minutes to find North and that's it. All current versions of SPRINT-Nav have been granted "de minimis" status by the US department of commerce which means that the unit will not require a US re-export licence for shipping.



Your guide to our products and specifications

Our handy A5-sized specifications book contains the technical datasheets for over 50 of our products, organised by product type: positioning, imaging, navigation, communications and monitoring. Updated twice a year, you can pick up your copy from one of our offices, trade show stands or user workshops. Alternatively email: marketing@sonarydne.com and we'll post some out to you.

CAN A USBL TRACK THROUGH A CAGE OF 200,000 FISH?

CASE STUDY/ WITH FISH PRODUCTION AND CONSUMPTION INCREASING, OPERATORS OF AQUACULTURE FISHERIES ARE LOOKING TO MARINE ROBOTICS TO HELP OPTIMISE THEIR OPERATIONS. MICRO-RANGER 2, OUR MOST COMPACT USBL SYSTEM, WILL HELP THEM DO JUST THAT.



Aquaculture is an important and growing industry worldwide. It accounts for some 47% – or US\$232 billion worth – of the 171 million tonnes of fish that's commercially caught or farmed per year¹.

Yet, aquaculture operations still face challenges. Fish can escape from pens, leading to reduced output, the potential to threaten local ecosystems, and six figure fines. More often than not, fish escapes are through holes in sea cage nets². Finding these before fish escape is time-consuming work. It's one of many overheads that commercial farm operators have to do – day in, day out – from inspecting the nets for marine growth (which has to be done more frequently in summer) and mooring line inspection to mort (dead fish) removal.

More and more, however, operators and service companies are turning to commercially available micro and mini ROVs to help make these tasks easier and faster, and reduce the need for diver-based intervention and therefore risk to personnel.

Being able to track these ROVs means operations can be further optimised, because operators no longer have to rely on line of sight and anything that they've seen during an inspection can be easily relocated for repair.

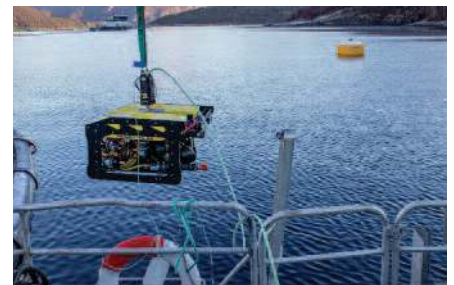
Our Ranger 2 family of Ultra-Short BaseLine (USBL) acoustic positioning systems has been tracking ROVs in the oceans and seas for years. Our broader USBL capabilities go back more than two decades. USBL uses acoustic signals transmitted from a transceiver, usually deployed from a vessel or dock, which emits a signal. Transponders in the water, which detect those signals, then reply. Software calculates in real-time the transponders' positions based on their ranges (acoustic signal travel time) and bearings from the transceiver.

For aquaculture, there has been a question around how easy it would be to track an ROV while it's inside a fish pen that contains upwards of 200,000 fish. As well as the high concentration of biomass, fish have swim bladders containing air, which can impede the acoustic signals.

PUTTING MICRO-RANGER 2 TO THE TEST

Our legacy Scout and our Mini-Ranger 2 USBL systems have been used in aquaculture applications for a number of years and are proven in these environments, thanks to our robust signal technology. Working with

Right: A lightweight aluminium pole proved perfect for deploying the system's USBL transceiver. Details about the adaptor plate you'll need to do the same can be found on our YouTube channel. Below: With its Nano transponder fitted, the Argus Mini ROV is deployed for the first of several tracking runs. *Photos courtesy of SINTEF Ocean.*



Norwegian research organisation SINTEF Ocean, we put our latest and most compact USBL system, Micro-Ranger 2, to the test in and around a fish cage containing up to 200,000 fish.

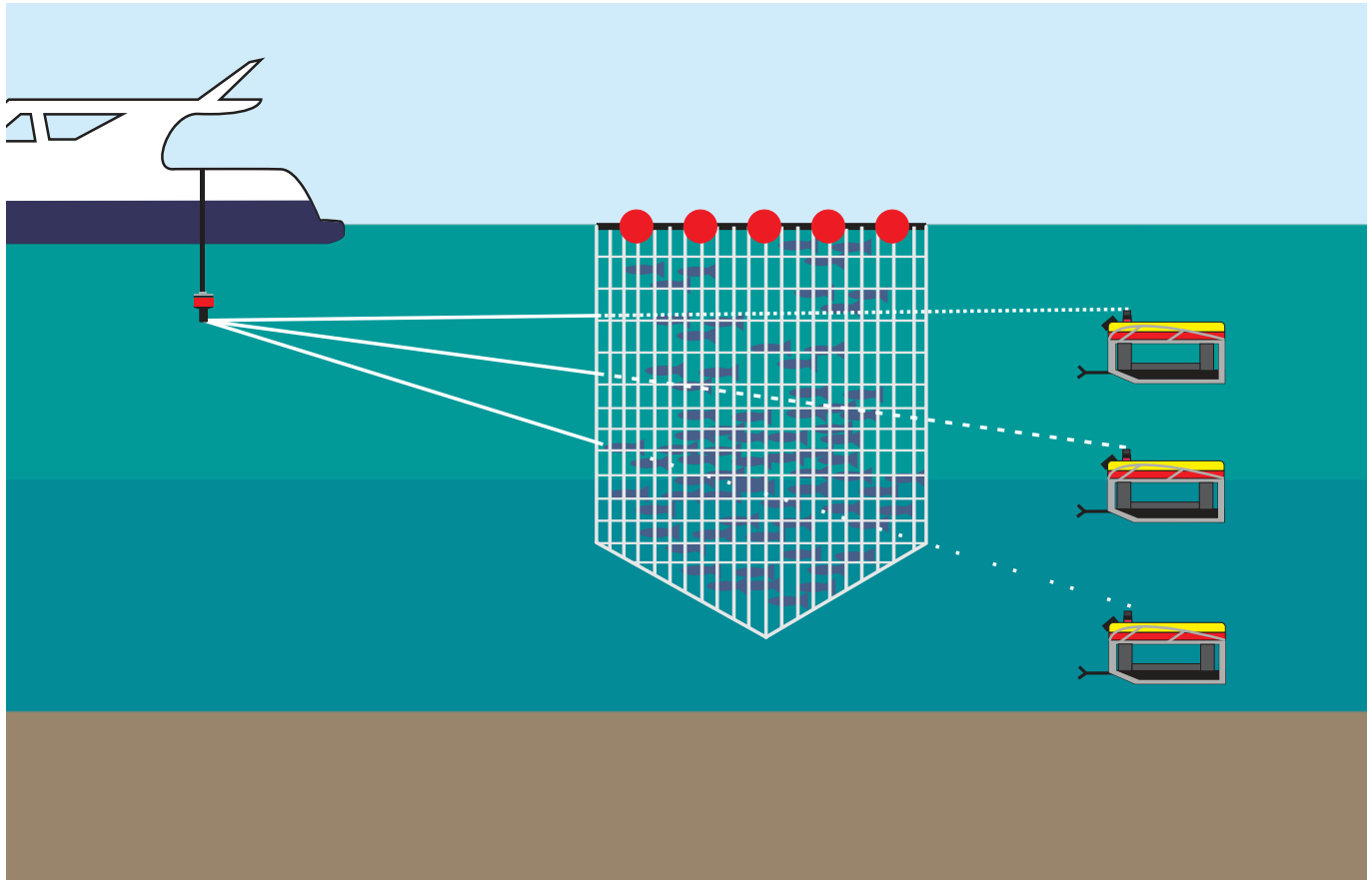
A demonstration was arranged at the Korsneset SINTEF ACE site near Trondheim in Norway. Over a day, we put a Micro-Ranger 2 system through its paces in a series of tests designed to assess the effectiveness and reliability of tracking the Argus Mini ROV that's used at the farm.

We were based on, and deployed the ROV from, a support vessel moored alongside the fish's cage. A Micro-Ranger Transceiver (MRT) was mounted from a rigid pole at about 1 metre below the hull of the vessel and a Nano transponder – our smallest ever rechargeable acoustic transponder – was attached to the front of the ROV.

CLEAR WATER TESTS

First, we ran a baseline assessment in clear water, continuously tracking the ROV in the water, close to shore. As expected, the Micro-Ranger 2 performed well, reporting consistent and accurate positions during the test period.

The next test was designed to assess the ability of the Micro-Ranger 2 to guide the ROV to items of interest at waypoints on the seafloor. Again, Micro-Ranger 2 performed



well and we easily relocated the items highlighted – including a bolt and an interesting rock formation.

CAGE TESTS

Now that we knew the system's performance in open water, we moved on to two sets of tests where the ROV was positioned at 180° and 90° behind and to the side of the 30 metre-diameter cage, in relation to the vessel and the MRT, to provide the most challenging geometry,

At each position, the ROV held station at four set depths – 3 metres, 7 metres, 9 metres and 13 metres – to assess the USBL system's tracking performance. The biomass density in the cage, between the vessel and the ROV, increased with depth, with the maximum density at 13 metres (at 3 metres, a fine nylon net was present for sea lice mitigation).

At both locations (i.e. 180° and 90° from the vessel), the Micro-Ranger 2 tracked the ROV effectively from 3 metres down to 9 metres, including at 2.3 metres, where the depth differential between the Nano and the MRT was only 1.3 metres over a horizontal distance of 30 metres, i.e. high elevation.

In the final test, the ROV was deployed inside the cage and, again, the positioning ability was tested at 13 metres depth. Once again, the Micro-Ranger 2 system was able to track the ROV successfully.

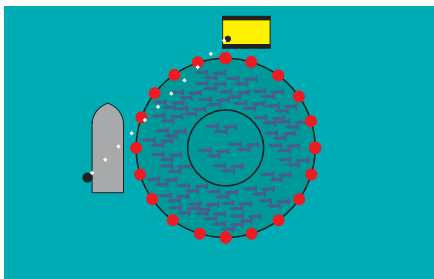
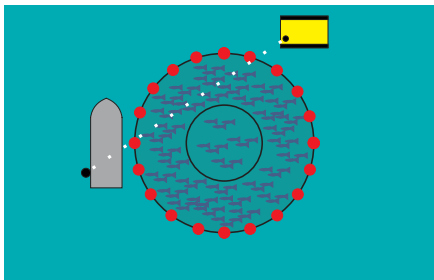
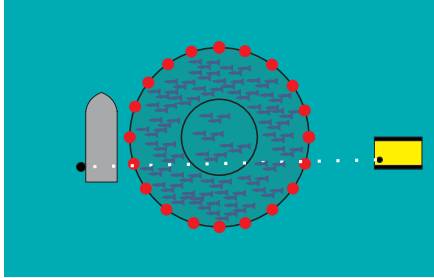
When tracking through the densest area of the biomass, positioning the ROV further from the net reduced the shadowing effect of the fish and so the frequency of positioning updates increased.

UNDERSTANDING THE RESULTS

Our Micro-Ranger 2 USBL system succeeded where other USBL systems have not due to the robust signal architecture in our Wideband 2 acoustics. Using Wideband 2 advanced digital signals, combined with the acoustic coverage capabilities and sensitivity of the MRT, provides successful positioning, despite the refraction and absorption along the acoustic path.

In the areas of high fish density, the frequency of the position updates decreased, as the ability to find acoustic paths through the biomass was reduced. However, when the acoustic signals were detected, the positions reported were consistent, giving confidence

USBL performance was tested at different depths, including 3, 7, 9 and 13 metres.



Above: Tracking was also tested at multiple angles through the cage. Below: A complete Micro-Ranger 2 USBL setup; user-supplied laptop, ESH interface unit, cable-connected MRT and Nano target-mounted transponder.

that position repeatability was not impacted. In this acoustically challenging environment, our Micro-Ranger 2 system outperformed expectations and clearly demonstrated the ability to track an ROV in a fish farm environment. The use of the Wideband 2 signal technology permitted consistent positioning of the ROV in a variety of tests, including within the cage itself.

Commercial operators and service companies have additional options to pick from in our USBL technology pool. In addition to using our Nano transponder, for small ROVs where weight and power needs to be kept to a minimum, operators can select our WSM 6+, offering longer battery life but also the opportunity to run on responder mode. Responder mode is where you use the ROV tether for the interrogation signal to the WSM 6+, instead of an acoustic signal, which means only the return acoustic signal will have to travel through the fish pen, further increasing position reliability and repeatability. WSM 6+ can also be trickle charged while on the ROV and not transmitting, extending the length of time they can be deployed. [BL](#)

¹ Figures from the United Nation's Food and Agriculture Organisation, The State of World Fisheries and Aquaculture, 2018.

² Two out of three escapes are due to holes in sea cage nets, according to research commissioned by The Research Council of Norway.

Micro-Ranger 2 succeeded where other USBL systems have not due to the robust signal architecture in our Wideband 2 acoustics and the acoustic coverage capabilities and sensitivity of our MRT.



THE KIT LIST

WHAT'S FEATURED IN THIS STORY

Micro-Ranger 2 USBL System



What is it?

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

How does it work?

It measures the range and bearing from a surface transceiver to transponders on underwater targets.

How will it benefit your operation?

It's portable, quick to setup and easy to use, even if you've never used USBL technology before. Deploy it and track.

Type 8243 MRT Transceiver



What is it?

Micro-Ranger Transceiver (MRT) is an extremely small and light USBL transceiver that can track underwater targets to 995 metres.

How does it work?

MRT uses a multi-element array to provide omni-directional tracking coverage, all the way to the surface.

How will it benefit your operation?

MRT can be fitted to the side of a boat, pontoon, or USV. Built-in diagnostics optimise performance.

Type 8262 Nano Transponder



What is it?

A 6G-enabled USBL transponder that weighs in at just over 200 grams and 150 mm long; perfect for fitting to divers and micro vehicles.

How will it benefit your operation?

Nano is built using our Wideband signal technology, ensuring fast, reliable communications.

How will it benefit your operation?

Nanos are low-cost meaning you can fit them to anything you want to track underwater.



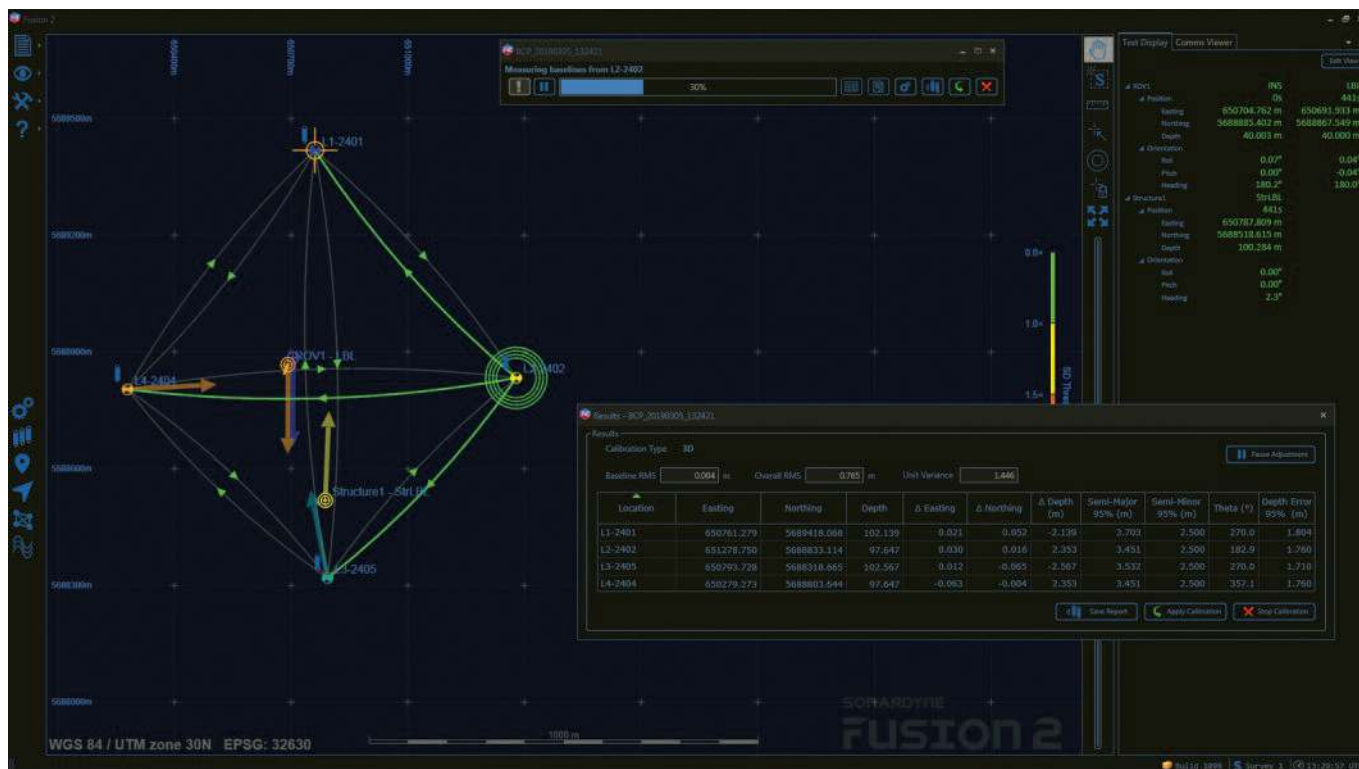
A TRUE FUSION

IN NOVEMBER, WE BROUGHT FUSION 2 INS TO THE WORLD, A NEW SOFTWARE SETUP THAT LETS YOU DO SPARSE LBL AIDED INS, INCLUDING REAL-TIME SLAM CALIBRATION, ALL FROM ONE SYSTEM. NOW, WE'VE UNLEASHED THE FULL POWER OF FUSION 2: A SYSTEM THAT CAN DO ALL OF THE ABOVE, PLUS YOUR FULL LBL ARRAY OPERATIONS.

Our Fusion 2 first release focused on INS operations and created a package that's less complicated, more capable, more productive and more intuitive to use. It eliminated the complex interfacing otherwise required for Sparse LBL aided INS operations and introduced real-time SLAM calibration capability for Sparse LBL. It made setup easier and faster with a simplified user interface (UI) and more intuitive workflows, all delivered through powerful customisation options. The reception to it has been great, as you will read later on.

Now, Fusion 2 LBL is living up to its name by being a true fusion of navigation systems. By fusing traditional LBL with state-of-the-art SPRINT inertial navigation systems (INS), new operational efficiencies are possible. It enables Full LBL to be deployed in areas requiring the highest navigational accuracy, as well as the ability to seamlessly switch to Sparse LBL aided SPRINT INS, to reduce how many transponders you need, where the project requirements allow. It can even run standard UBSL position-aided INS, with zero LBL requirement, for areas where accuracy is less critical – all from one operator station, without the need to start or stop tracking.

As we set out in Baseline 20, Fusion 2 works on our new digital signal processing protocol, Wideband 3, which is already up and running in our trusted 6G platforms, Compatt 6+ and ROVNav 6+



LBL array calibration in Fusion 2 is now simpler, faster and easier to get right first time.

and is available as an upgrade to existing 6G equipment. Wideband 3 delivers a major step-up in your positioning update rates; we're talking 1Hz LBL update rates. Not only that, Wideband 3 allows you to get sensor data at the same time as navigation ranging data, which means you can get real-time navigation and sensor data, at the same time, without the need to pause tracking. Because Wideband 3 provides Fusion 2 with ranges and sensor data in real time, Fusion 2 is able to update its position continuously.

There's more. In the full Fusion 2 LBL release you can manage your Compatt transponder inventory and locations in one place, enabling quick and easy review and audit. Compatt configuration can be uploaded from Fusion 2 direct from your iWand, which can then be used to transfer the setup straight into the Compatts before they are deployed. You can also dynamically select and change seabed acoustic references during navigation and we have introduced the concept of having separate Compatt transponder and locations tables, to better match the reality of most offshore survey operations.

An array of locations can be calibrated and stored and Compatt transponders can be changed out without the need to reconfigure positions. With calculations now done using Earth-centred Earth-fixed (ECEF) coordinates, grid scale factors are also not an issue. It's all simpler, faster and easier.

WHAT DOES IT MEAN FOR YOUR OPERATIONS?

Simon Waterfield, Survey Support Group Manager, talked us through some typical scenarios – and how they will now be different:

LBL array calibration

“For LBL array baseline calibration, we've simplified what was a fairly manual process by taking out an entire step and enabling users to spot any errors earlier.

“LBL array calibration involves designing and then setting out an array according to that plan. Previously, the operator would add the Compatts they want to use into the system, select them for the array and then input their locations, according to the array plan. At this point, the system didn't know how each Compatt is set up, what sensors it had or its status – and it would not know this until the Compatts were deployed and the calibration routine, via a Wizard, had begun. Calculation of the transponder positions didn't start until all the acoustic ranges had been collected, which meant the user couldn't check for any errors until post processing calculations were complete. If there were any errors, the whole process would have to be run again.

“Fusion 2 simplifies this process. Compatts can be added into the system and their status, settings, sensor information, etc., can be simply and quickly added, while they're still on deck, wirelessly, using our iWand. The iWand can also be used make changes to Compatt settings while they're on deck: just change the settings in Fusion 2, import them wirelessly into the iWand and then into the Compatt.

Compatt array locations can then be added by importing CSV files. This means you don't have to manually add locations, which avoids mistakes. Then, after you have deployed your Compatts, you can just use a selection tool to select the Compatts you want to

calibrate and, because the system is pre-populated, it picks the simplest workflow for you.

“Now, instead of waiting for all of the ranges to come in before calculating positions, Fusion 2 starts solving the array adjustment as soon as it gets the first range. As the ranges come in, the user can check for outliers and monitor in real time a least squares convergence of the LBL array, so problems can be addressed earlier. For an extra layer of quality assurance, post processing is still possible. This all makes calibration easier and saves you time. You can focus on QC’ing the data as it’s collected, ensuring you get the right result the first time around.”

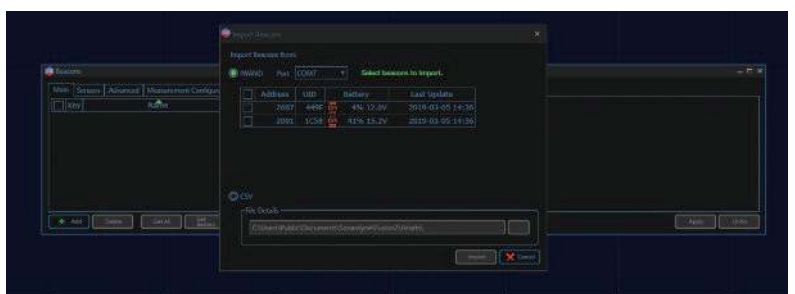
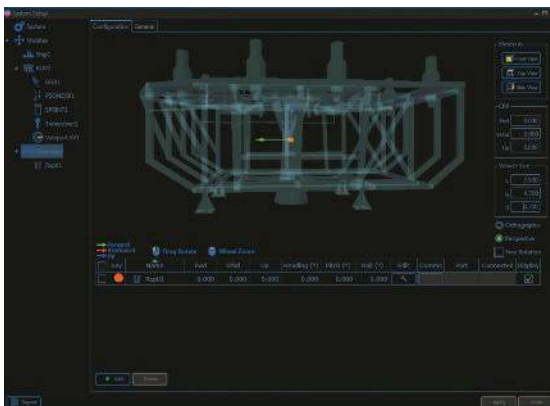
Structure tracking with LBL

“Using our Wideband 3 new generation protocols, which combine telemetry and ranging, structure tracking can be done with far greater confidence, easier and faster. With our new 6+ hardware, ROVNav 6+ and Compatt 6+, Wideband 3 opens up new capabilities. We’ve also streamlined the process.

“Previously, an ROV fitted with a ROVNav 6+ transceiver within an LBL array would send out a command to the LBL transponders, asking for ranges. Then it would wait while it received all of the ranges, before sending the data into Fusion to calculate its position. Now, as soon as the first range arrives, ROVNav 6+ sends it straight to Fusion 2, which starts calculating immediately and continuously as further ranges arrive. This means you know where your ROV is faster.

By fusing traditional LBL with state-of-the-art SPRINT inertial navigation systems (INS), new operational efficiencies are possible.

Below, clockwise from top left: How it was in the past – two screens to operate your INS and LBL. Now it's just one; import your transponder settings on deck wirelessly with our iWand; import into and out of Fusion 2 with iWand is simple; structure tracking system set-up is clear and easy in one flexible interface.



“To track a structure, perhaps a manifold being lowered to the seafloor, a mobile Compatt would be fastened to the structure. Previously, the mobile Compatt on the structure would be acoustically interrogated from a ROVNav transceiver and instructed to then interrogate the LBL array it was in. It would then wait until it had collected all the array ranges, before sending them back to the ROVNav to be sent topside to the Fusion software to calculate its position. Most contractors involved in lowering structures to the seafloor will also want the heading, pitch and roll of their structure, so they will use a Gyro Compatt. But, to get the Gyro Compatt sensor data, ranging would have to be paused, sensor data sent, then ranging resumed, creating gaps in the tracking. While they’re small gaps, they’re still gaps and this meant tracking update rates would typically be once every 10 seconds.

“Now, thanks to Wideband 3, just like how the calculation of the ROV’s position starts as soon as ranges begin coming in, the same happens with structure tracking. But, the ROVNav 6+ doesn’t have to wait until the Compatt sends it measurements. Because of 6+ and Wideband 3, it’s able to ‘listen’ to and gather the ranges itself and send them on for continued position calculation updates. It will also receive the ranges gathered by a Gyro Compatt 6+, along with the sensor data combined, and the tracking will not have to stop in order to receive the gyro sensor data thanks to Wideband 3. Now structure tracking with sensor data can run at sub 2 second update rates.”

MORE TO COME

There is still more we’re working on. In future releases, we’re looking to automate more processes and workflows and enable smarter integration with survey systems as well as more remote capability. We’re also continuing to work with leading suppliers of survey navigation systems to provide slicker integration so that as with position data, associated position quality information will also be transferred to survey navigation packages. In future releases, multi-user functionality will come as standard for Fusion 2 LBL operations, so you will have even more potential for increased efficiency. **BL**



FUSION 2— THE WORLD TOUR

THROUGHOUT AUTUMN AND WINTER 2018, WE TOOK FUSION 2 INS ON A WORLD TOUR, STARTING IN ABERDEEN, THEN HEADING TO BAKU IN AZERBAIJAN, HOUSTON IN THE US, PERTH IN AUSTRALIA, AND SINGAPORE, BEFORE ENDING IN BRAZIL. IF YOU MISSED OUT FIRST TIME, OR WANT TO LEARN MORE ABOUT FUSION 2 INS OR THE FULL LBL RELEASE, GET IN TOUCH. MEANWHILE, HERE ARE SOME OF OUR HIGHLIGHTS.

Despite unseasonably cold and rough weather out on Lake Conroe, just north of Houston, our demonstration was a success. While for ourselves and our customers, the rolling of our demo boat was not ideal, the conditions were perfect for demonstrating the robustness of the acoustics (DVL and acoustic LBL ranging).

We performed two SLAM array calibrations in real time, using different sail patterns, to show the flexibility of the real-time SLAM procedure. Once the array was calibrated, we compared the resulting Sparse LBL aided INS position to RTK-GPS (our “truth”) and consistently achieved agreement to within a few centimetres.

One survey firm told us that Sparse LBL helped them save US\$800,000 on a single project last year, so they were excited to see an array SLAM calibrated in real time, first hand, as this will lead to further savings. In the Gulf of Mexico, where operations are in ever deeper waters, which means it takes longer to install an array, SLAM calibrated Sparse LBL arrays will be of great benefit to surveyors and customers.

Onshore, we also demonstrated the ability to remotely connect in to Fusion 2 from the beach, where navigation data can be viewed and some control over Fusion 2 is possible. As explained elsewhere, the remote control is scalable, depending on client requirements. As it’s not always possible to get specialists onboard, re-moving the requirement for INS post-processing for array calibration was seen as a positive move. Remote access would also further help companies optimise their manning requirements.



Top to bottom: Fusion 2 INS went on a world tour; including a BBQ in Aberdeen; trials in Freemantle, Perth and Lake Conroe, Houston; sales, including to STR.

THE KIT LIST

WHAT'S FEATURED IN THIS STORY

Type 8300 Compatt 6+



What is it?

Compatt 6+ is the new industry standard, Wideband 3-enabled Long BaseLine (LBL) transponder for high-precision survey and construction.

How does it work?

Compatible with Fusion 2, fully backwards compatible with Wideband 2, for use with Fusion 1, and HPR400 compatible for box-in operations.

Type 8310 ROVNav 6+



What is it?

ROVNav 6+ is our 6G Wideband 3 ranging Long BaseLine (LBL) ROV Transceiver and telemetry transceiver, specifically designed for installation on work class ROVs.

How does it work?

Fully compatible USBL responder or transponder, compatible with Wideband 3 for use with Fusion 2, whilst also being fully backwards compatible with Wideband 2, for use with Fusion 1.

How will it benefit your operation?

Comes with new connectors, to increase reliability, a new remote transducer and new cabling.

Type 8315 iWand



What is it?

iWand is our wireless transponder test and configuration tool.

How does it work?

Small, rugged and splash proof, iWand is ideal for setting up equipment in the workshop, on the back deck of a ship, or on ROVs and subsea structures before they are deployed.

How will it benefit your operation?

Works with all our 6G and 6+ product range.





MONITORING THE RESTLESS EARTH – UNDERWATER

ON LAND, MAJOR EVENTS LIKE LANDSLIDES AND EARTHQUAKES ARE EASILY MEASURED WITH SATELLITE IMAGERY, WHILE PRECISE MEASUREMENT OF MUCH SLOWER TECTONIC PLATE MOVEMENTS USING SPACE GEODESY TECHNIQUES HAVE BECOME ROUTINE. UNFORTUNATELY, NEITHER TECHNIQUE WORKS UNDERWATER, WHICH MEANS SUCH MEASUREMENTS HAVE STOPPED AT THE WATER'S EDGE – UNTIL NOW. GERAINT WEST, GLOBAL BUSINESS MANAGER FOR OCEAN SCIENCE, EXPLAINS WHY.



Whether it's a fast-moving landslide or tectonic plate movement on a geological timescale, the reality is that, in one way or another, much of the earth's surface is in motion. On land, surveyors and scientists now take the ability to measure centimetre (or even millimetre) displacements of the earth's surface using a variety of space-based technologies, including GPS, very long base interferometry and satellite laser ranging, for granted. Unfortunately all of these techniques employ wavelengths that are unable to penetrate through water. This means that there have been major gaps in the understanding of deformation mechanisms at the seabed.

Based on technologies originally developed for the oil and gas industry to measure seabed subsidence (see BaseLine 17), we have been working with diverse commercial and academic partners to develop new techniques and technologies to directly measure the movement of the seabed, even when it's under many kilometres of seawater. The result is that our versatile ranging technology is now being used in a wide variety of projects that are improving the understanding of seabed processes, from short and violent high velocity events to very slow tectonic plate movement.

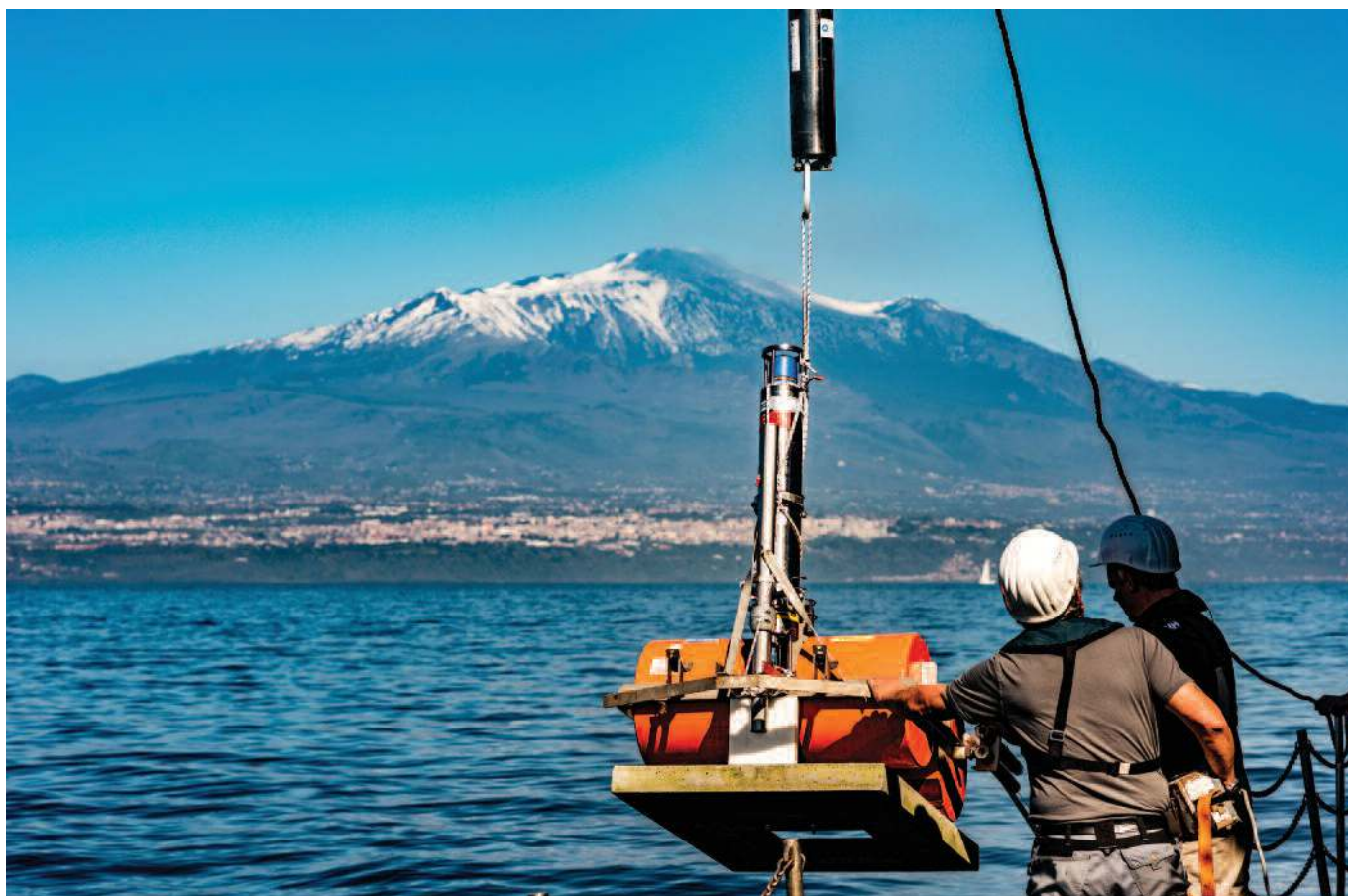
At the heart of these studies is our Autonomous Monitoring Transponder (AMT) and its long-endurance relative, the Fetch subsea sensor logging node. Derived from our 6G Compatt transponder, these instruments are designed to acoustically measure the two-way transmission time between pairs of instruments, as well as make high-precision pressure measurements at the ocean bottom,

to ascertain depth. Additional sensors, including for temperature and inclination, complement these to make highly capable scientific data gathering instruments.

Furthermore, our integrated Wideband 2 high speed telemetry enables both offloading of data from the seabed instruments at rates between 100 – 9,000 bps to a variety of surface dunker systems and their remote (re-)configuration from the surface. The latest versions of our Fetch instrument have sufficient battery capacity for in-situ operation in excess of 10 years, resulting in a tool that provides both the sensitivity and long-duration performance required for seabed applications, even in extreme depths.

UNDERWATER 'AVALANCHES' – MEASURING OCEANIC TURBIDITY CURRENTS

Used as a standalone instrument, between October 2015 and April 2017, an AMT was deployed in one of the most challenging environments that our technology has ever been subjected to. Led by the Monterey Bay Aquarium Research Institute (MBARI), the Coordinated Canyons Experiment's (CCE) ambitious objective was to make the most detailed direct observation of oceanic turbidity currents yet undertaken. These 'avalanche'-like events are responsible for carrying vast amounts of sediment (including globally significant volumes of organic carbon) into the deep ocean, while carving out submarine canyons that are similar in proportion to the Grand Canyon. Turbidity currents are unpredictable and powerful, with frontal velocities of up to 19 metres per second. At this rate, they have



Fetch, ready to be deployed anywhere in the world.



“For years we have seen instruments on the bottom move in unexpected ways, and we suspected that the seafloor might be moving. Now we have real data that show when, where, and how this happens.”

Previous page and left: Putting sensors to work measuring major underwater events; the research vessel *Poseidon* working close to Mount Etna and researchers deploying a Sonardyne AMT attached to an Ocean Bottom seismometer. Photos by Felix Gross, from GEOMAR Helmholtz Centre for Ocean Research Kiel.

the potential to destroy pipelines and communications cables. This makes them extremely challenging to measure, which means scientists have been unsure of their basic characteristics and, in particular, whether they are entirely composed of suspended sediment (i.e. dilute) or driven by a dense basal flow of sediment.

The CCE deployed more than 50 instruments in the Monterey Canyon, including an AMT mounted on top of an 800 kilogram, 2.5 metre-high tripod frame. During the CCE, this frame was moved down canyon by the turbid flow six times: on one occasion it was moved 2.4 kilometres down the canyon and half buried in the seabed in just one day, while on another it was moved 0.9 kilometres and left buried on its side beneath a 2 metre-thick sediment layer. The events that caused these movements all originated in less than 300 metre water depth and then travelled up to 50 kilometres down canyon, past the deepest instruments in 1,850 metres water depth.

The fact that the AMT moved at broadly similar speeds to other instruments that were also carried downstream is a strong indicator that these were all rafted in a moving mass of water-saturated sediment, often up to 15 metres-thick, rather than being dragged by a dilute flow. Charlie Paull, MBARI marine geologist and first author of the recent *Nature Communications* paper describing the experiment said that, “for years we have seen instruments on the bottom move in unexpected ways, and we suspected that the seafloor might be moving. Now we have real data that shows when, where, and how this happens.”

MEASURING LANDSLIDES ON MOUNT ETNA

Networks of AMTs can be used to monitor deformation of plate boundaries using direct ranging measurements. Derived from Long BaseLine (LBL) techniques, this involves acoustically measuring the change over time of the relative horizontal displacement between pairs of AMTs, while integrated high-resolution pressure sensors measure the change in their relative vertical displacement. This technique results in millimetric measurement of relative movement at a high temporal resolution, providing detailed information about



Above, left: Instruments used to measure underwater avalanches have to be able to live through major displacements. Above right: Plate tectonic measurement has been boosted by GPS-A techniques.

seabed deformation over a local area.

Using this technique, GEOMAR measured underwater slippage of the southeast flank of Europe's most active volcano, Mount Etna, for the first time. Satellite observations have previously shown that the volcano's flank is slowly sliding seawards. But, until a network of AMTs was deployed beneath the waves, it was impossible to confirm if and how the submerged segment was moving. GEOMAR's array comprised a network of five AMTs placed astride of the fault in about 1,200 metres water depth; three on the presumed unstable flank and two on the adjacent stable slope. Measurements logged during a 15-month period confirmed that the entire flank of the volcano is in gravity-driven motion. In one event, the slope slipped about 4 centimetres in just eight days. The consequences are potentially dramatic.

"The entire slope is in motion due to gravity. It is therefore quite possible that it could collapse catastrophically, which could trigger a tsunami in the entire Mediterranean," says Prof. Heidrun Kopp, co-author of a paper on the project. While there is still more work to be done towards fully understanding the processes at work on coastal volcano flanks, Dr. Morelia Urlaub, another study co-author, is excited about the potential to greatly improve understanding of these processes; "Our investigation shows that the sound-based geodetic monitoring network can be a tremendous help in this respect."

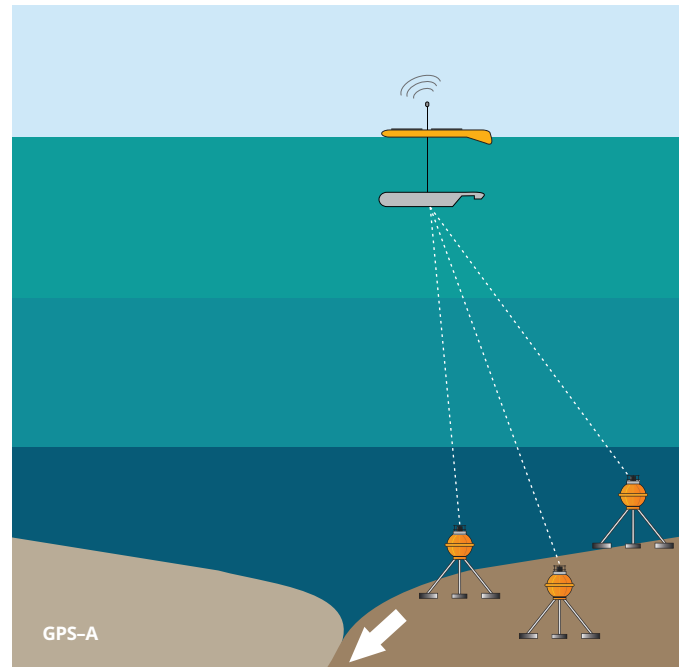


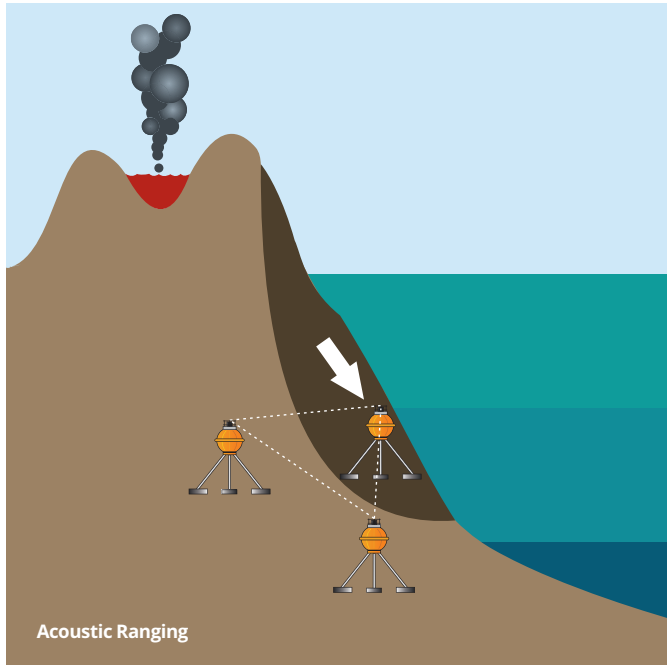
PLATE TECTONIC MOTION MEASUREMENT

While direct ranging produces detailed relative measurements, measuring the movement of a submerged oceanic tectonic plate that is colliding with a continental plate requires absolute positioning within a world reference frame. The techniques for doing this on land are quite mature; underwater observations rely on an emerging technique called GPS-Acoustic (GPS-A).

GPS-A combines GPS and acoustic measurements. First, the acoustic transducer on a surface platform is positioned with highly accurate kinematic GPS and an attitude sensor. Next, simultaneous acoustic ranging from the surface transducer positions a seabed transponder. By undertaking averaged observations over several days, it's possible to achieve world geodetic frame positioning to centimetre-level. Repeating these observations yields absolute measurement of change in seabed position.

GPS-A was developed by Scripps Institution of Oceanography in the 1980s, with the first site established offshore Vancouver Island in the mid-1990s. However, these were costly endeavours due to their dependence on ships or buoys as a surface platform. Since 2013, we have provided commercial off-the-shelf technology to underpin Scripps' GPS-A work, including development of a modular payload for Liquid Robotics' Wave Glider unmanned surface vessel (USV), which has enabled the ability to perform observations much more economically.

GPS-A is the basis for the new North Cascadia Subduction Zone Observatory (NCZSO), which will comprise seven GPS-A sites deployed in 400–2,500 metres water depth offshore Vancouver Island, each comprising three Fetch instruments. An additional three units, equipped with our new in-situ pressure sensor calibration system, known as Ambient Zero Ambient (AZA), are also being connected to Ocean Networks Canada's (ONC) cabled NEPTUNE array, an 800 kilometre-long loop that covers the coastal zone, the northern part of the Cascadia Subduction Zone (CSZ), Cascadia Basin and the Endeavour Segment of the Juan de Fuca (JdF) Ridge with a network



Fetch units were able to help measure underwater landslides on the submerged flank of Italy's Mount Etna – the most active volcano in Europe.

of seismometers and bottom pressure recorders (BPR).

The NCSZO GPS-A stations will be critical to resolving the ambiguity between two separate models that have been developed for Cascadia. In one, the JdF oceanic plate is subducted very slowly beneath the North American continental plate, releasing strain as it creeps along with minimal seismic activity. In the other, the two are locked together, causing a dangerous build-up of strain, which could ultimately be released in what Pacific Northwesterners refer to as the “Big One.” The NCSZO is led by Ocean Networks Canada (ONC) – an initiative of the University of Victoria—and is made possible through cooperation of international partners that include Natural Resources Canada (NRCan) scientists at the Pacific Geoscience Centre and David Chadwell from the Scripps Institution of Oceanography.

Lying just 50 km offshore, the CSZ poses a considerable earthquake and tsunami threat to a series of major cities on the Pacific Northwest region of America, from Portland, in the south, to Vancouver, in the north. Scientists therefore have high expectations of the NCSZO, which will be deployed later in 2019, for an initial planned duration of seven years.

In ONC Senior Staff Scientist, Science Services Martin Heesemann's words, “data provided by the NCSZO are certain to enable major breakthroughs in the scientific assessment of earthquake and tsunami risks related to the CSZ.”

SUSTAINED PRESENCE IN DYNAMIC ENVIRONMENTS

The emergence of technology able to investigate such varied seabed processes is timely. Previous studies have been limited to capturing snapshots of the processes at work, often with spatial and/or temporal constraints, leading to incomplete, flawed or ambiguous conclusions. These new capabilities offer a new era of sustained seabed observation with the ability to measure events at high spatial and temporal resolution over decades. Exploration of these capabilities is still nascent, but, with a strong synergy between earth scientists and Sonardyne, there is more to come. **BL**

THE KIT LIST

WHAT'S FEATURED IN THIS STORY

Type 8305 AMT



What is it?

A long-endurance monitoring transponder capable of recording hundreds of thousands of stable, highly precise geodetic observations.

How does it work?

AMTs run a fully automated logging regime, gathering acoustic travel time (range) between neighbouring units, pressure, sound velocity, temperature and tilt data at intervals defined by the user. Its integrated modem enables data to be extracted wirelessly, on demand.

How will it benefit your operation?

AMTs wirelessly bring you the data you need on demand, when you need it, over deployments up to five years.

Type 8306 Fetch



What is it?

Has many of the same features as an AMT but thanks to its glass sphere housing, it can be equipped with a high capacity primary lithium battery pack to support deployments up to 10 years.

How does it work?

The ultra-low power platform only powers up sensors when required and logs and timestamps the data to an internal SD memory card. Fetch can also be fitted with up to three high precision internal pressure sensors, with scope for other internal and external sensors, as required.

What you need to know

How will it benefit your operation? Fetch supports the most demanding long-term seabed geodesy projects and can be GPS-A positioned using a USV.

CASE STUDY/ SELECTING A SMART SOLUTION FOR DEEPWATER PIPELINE INTEGRITY MONITORING. BY CHRISTOPHER BOLER, PROJECT MANAGER, SUBSEA PROJECTS GROUP, OCEANEERING AND STEPHEN AULD, GLOBAL BUSINESS MANAGER, SONARDYNE



"5Hz frequency movement detected, duration 50 seconds."

Thousands of kilometres of pipeline, flowline, and interconnecting spool pieces are installed on the world's sea and ocean floors. They create vast networks which bring hydrocarbons from beneath the ocean floor up to production facilities before they make their way to refineries. Their design can be complex, having to account for a huge array of variables, from water depth to expected flow composition and behaviour.

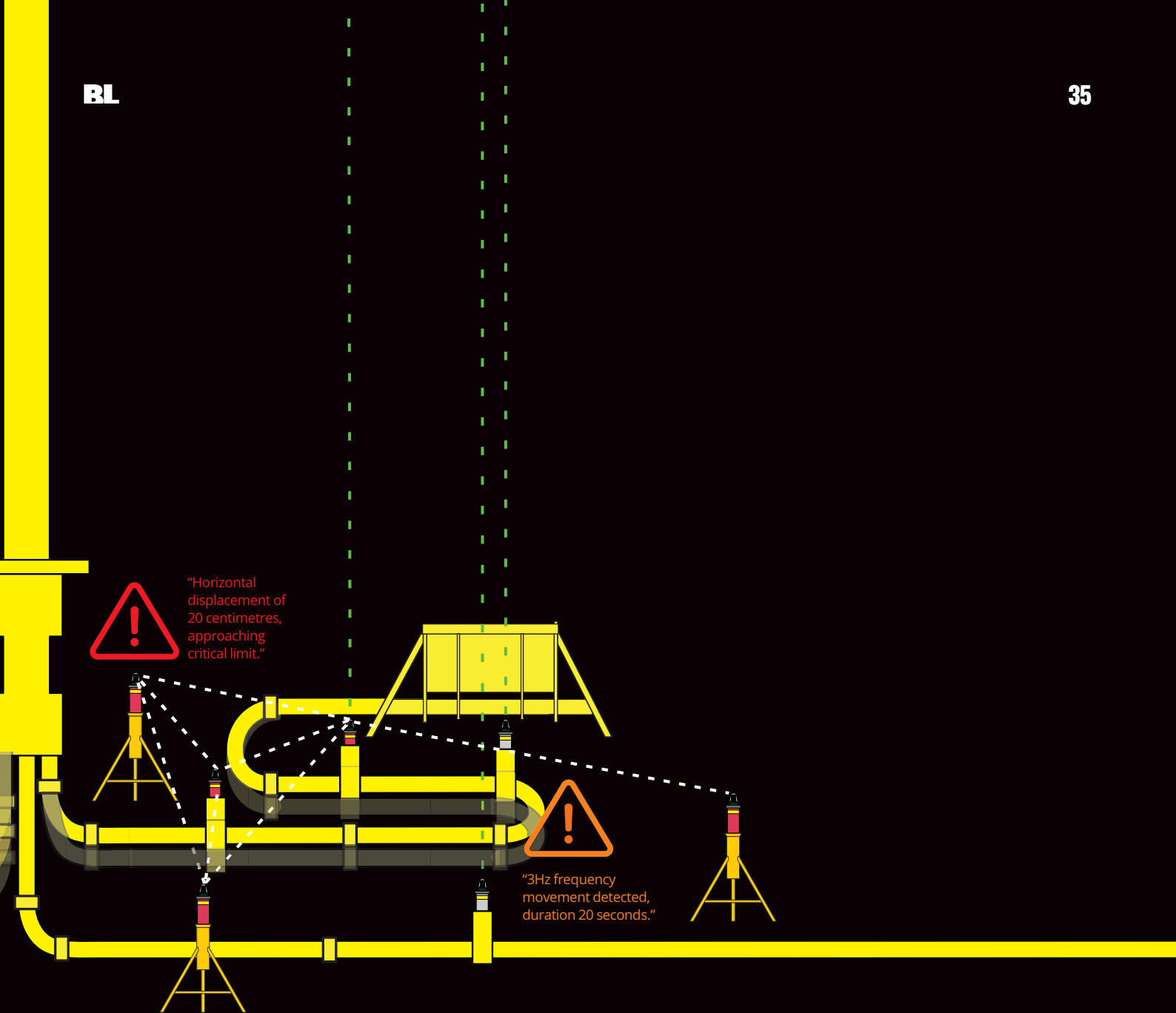
Sometimes, it's not always possible to

account for all of the variables that an oilfield infrastructure is subjected to. This can lead to issues, such as external vortex induced vibration (VIV) or internal flow induced vibration (FIV), which, in certain circumstances, can be caused by slugging. Slugging is caused by variable or irregular flow of gas and fluids through risers, pipelines, flowlines or spool pieces. It can cause problems for process equipment, impact production efficiency and, critically, accelerate pipeline

fatigue and therefore impact design life. It can even cause pipelines to be displaced or entrenched or erode the supports they stand on.

When FIV occurs, pipeline engineers need all the information they can get about just how much this is happening and to what degree, so they can re-calculate the remaining fatigue life of the infrastructure and decide on any remediation requirements. Unfortunately, monitoring exactly what is happening – what forces the pipelines, flowlines or spool

DATA FROM



pieces are being subjected to – can be very challenging, especially in deep water.

Global subsea engineering company Oceaneering International Inc. was asked to solve this exact problem by an operator who had a number of spool pieces deployed in more than 1,000 metres of water, running between riser bases and flowline termination assemblies. They were being subjected to sudden and frequent movements caused by slugging.

These movements had already resulted in new spool piece supports having to be installed. Now, the operator's engineers wanted to both assess the resilience of the new supports and learn more about the vibration the spool pieces were encountering. The challenge was that no motion monitoring sensors had been fitted prior to commissioning. The solution would need to provide accurate and accessible data using a solution that was not cost-prohibitive to install and

operate. Oceaneering's solution was an innovative, wireless approach, using our SMART sensor – Subsea Monitoring, Analysis, and Reporting Technology.

TAKING THE SMART OPTION

SMART sensors are, well, smart sensors. They contain low-power MEMs-based (micro-electric mechanical systems) inertial measurement units (IMUs), subsea processing power and integrated acoustic modem capabilities.

AT THE DEEP

Following installation and confirmation that all the SMARTs and AMTs were working and a post-installation survey, the autonomous and intelligent instruments were simply able to be left to do their work.

Installed on bespoke clamps, designed and built by Oceaneering, our AMTs and SMARTs need no intervention during long-term deployments.



This means they can autonomously measure, log and process high-frequency pipeline or spool piece acceleration and angular rate motion over pre-programmed intervals.

Importantly, SMARTs, which can be integrated with many different subsea sensors to suit a wide variety of applications, process data at source, then send small statistical summary packets of data – based on parameters set by the user – through the water column to a surface transceiver. This reduces the need to send time-series, or raw data up to the surface for analysis, prolonging battery life, maximizing bandwidth availability and providing useful information to engineers faster. It's edge analytics and subsea communication technology in one battery-powered autonomous compact unit, able to work on extended deployments down to 7,000 metres water depth.

But, back to the project. The operator wanted to monitor high and low-frequency

motion on the spool pieces. For the high-frequency motion, SMARTs were installed on each spool piece at a location between the riser and flowline termination assemblies. To monitor lower frequency movement on one of the spool pieces, another of our technologies was used: Autonomous Monitoring Transponders (AMTs).

AMTs are transponders used for long-term survey and monitoring tasks where instruments are needed to acquire acoustic ranges and sensor data without surface control. They time-stamp the data and log it internally, to be retrieved as and when it's needed at the surface. By creating a Long BaseLine (LBL) array of "static" AMTs, to which "mobile" AMTs installed on a spool piece and fitted with sound velocity sensors can range, highly precise measurements of any horizontal movement of that spool piece can be monitored and logged. By fitting the mobile AMTs with Digiquartz pressure trans-

ducers, vertical motion could also be tracked.

MOBILISATION

Before installing the SMARTs and AMTs, Oceaneering surveyed the seabed location, which supported the LBL array design and SMART and mobile AMT positioning. Oceaneering designed and built ROV-installable spool monitoring clamps, so that the SMARTs and AMTs could be easily attached to the spool pieces. For the LBL array, four AMTs were placed in tripod stands at pre-defined locations for optimal ranging.

Following installation, confirmation that all the SMARTs and AMTs were working and a post-installation survey, the autonomous and intelligent instruments were then just left to do their work. A huge benefit of both instruments' design is that they can be left unattended for three years thanks to their internally monitored lithium primary cells.

Anyone with these instruments in their

THE KIT LIST

WHAT'S FEATURED IN THIS STORY

Type 8316 SMART



What is it?

SMART (Subsea Monitoring, Analysis and Reporting Technology) brings together low power electronics, long duration data logging, subsea data processing and acoustic telemetry into a single, easily deployed instrument.

How does it work?

Each SMART has digital and analogue inputs able to connect to multiple data sources; a low-power data logger; and raw data onboard processing.

How will it benefit your operation?

SMARTs have six degrees of motion monitoring capability; the ability to interface with a wide range of internal and external sensors and other data sources and can then use standard or bespoke data analysis algorithms to provide the data that you need, when you want it.

Type 8309 Dunker 6



What is it?

A combined LBL and telemetry 6G transceiver, designed for over-the-side vessel deployment.

How does it work?

It has high power output and our Wideband 2 signal processing, that offers improved operating range and acoustic performance for the most challenging conditions.

How will it benefit your operation?

It will reliably gather command and recover data from your subsea 6G instruments.

field has a choice in how they collect the data they generate. If it's close to a topside facility, they can deploy our Dunker 6 transceiver permanently, via a deployment pole, or temporarily over-the-side, via a winch or A-frame. If the subsea infrastructure is quite remote, they could periodically send a support vessel or an unmanned autonomous surface vessel with a Dunker 6 to harvest the data. For this project, while the site was deep, it was close enough to the customer's production facility for Oceaneering to be able to temporarily deploy a Dunker 6 from it, using the onboard crane, as and when data collection was required.

Since commissioning in the summer of 2018, continuous SMART monitoring of the spools, at four-minute intervals has taken place. Packets of data from both SMART and AMT devices, including raw runtime data, have routinely been sent to the surface. Once received, it has been analysed and used in the

predictive modelling, enabling the operator to calculate the accumulated fatigue and remaining operational design life of these assets. Gaining access to the spools' motion characteristics has been invaluable to the operator. It's data they would have struggled to access through other means, economically. It has led to a deeper understanding of each spool's motion frequency, rotation angles and cycle times. Where previously the operator had concerns about the remaining operational life of the spools, they now know that the operational life is within the limits of the productive life of the field.

This is a great result for the operator, but also for Oceaneering and Sonardyne, by working together to find a cost-effective and viable solution.

By combining our expertise and flexible instruments as an integrated solution, the supply chain is able to tackle operators' deepest challenges, quite literally. **BL**



TECH

**SPOTLIGHT:
OUR SUBSEA
TECHNOLOGY
ESSENTIALS
FOR YOUR
OPERATIONS**



MICRO, MINI AND STANDARD TRACK DOWN OUR RANGER 2 USBLs

Track a towfish, position an ROV, DP your vessel, search the seabed or command a swarm of AUVs. When you need to invest in Ultra-Short BaseLine (USBL) acoustic technology to support your underwater operations, the Ranger 2 family has the performance you need, at the investment level you can afford to get the project completed faster and more efficiently than any other system on the market. But which one is right for you; Mini, Micro or Standard?

Micro-Ranger 2

Portable and quick to get up and running, Micro-Ranger 2 is perfect for simple USBL tasks such as tracking some divers, an ROV or micro AUV. But simple doesn't mean compromising. It's built using our 6G and Wideband technology platform, meaning dependability in shallow water and fast position

updates. Expect a system slant range accuracy of 5% and ranges out to 995 metres.

Mini-Ranger 2

When you need to track targets further, simultaneously, and with survey-quality precision, Mini-Ranger 2 delivers on both performance and price. The topside is the same as supplied with Micro; software that's easy to learn and operate and a combined power and communications hub. This connects to HPT 3000; a transceiver optimised for precisely tracking targets near the surface and up to 4,000 metres away. Ethernet communications and an internal pitch and roll sensor means installation is simple. Out of the box, system slant range accuracy is 1.3%.

Ranger 2

It's anything but standard, in fact Ranger 2 is the standard by which all USBLs should be measured against. Installed on a global fleet of vessels, operating in all water

depths and market sectors from energy to defence, the system works with any make of dynamic positioning system, tracks targets to 12,000 metres and supports vessel-based inertial navigation for critical station keeping. As your needs grow, software feature packs extend capability even further, such as the robotics pack which enables command and control of AUVs. An optimised Ranger 2 installation can deliver system slant range accuracy of 0.04%.

KEY:

- 1** HPT 3000 Transceiver
- 2** RT 6-6000 Release Transponder
- 3** Wideband Sub-Mini 6+ Transponder/ Responder
- 4** HPT 5000 Transceiver
- 5** Nano Transponder
- 6** Micro-Ranger 2 Transceiver
- 7** Ethernet Serial Hub
- 8** Gyro iUSBL Transceiver

RT 6-6000HD 2.5 TONNE-RATED, 6G-ENABLED ACOUSTIC RELEASE

Our 6G-enabled family of acoustic release transponders will soon be joined by the RT 6-6000HD. It's depth rated to 6,000 metres, has a Working Load Limit of 2.5 tonnes, Breaking Load greater than 10 tonnes and battery life of 4 years – and of course a highly reliable release mechanism. Use it to deploy and recover instrument moorings and equipment from research ships and survey vessels equipped with our Ranger 2 LMF USBL systems, or via a standalone over-the-side dunker. The highly secure Wideband 2 signal protocols used to command and track the RT 6-6000HD prevent accidental activation. Contact your local office for more details about our RT 6 product family.

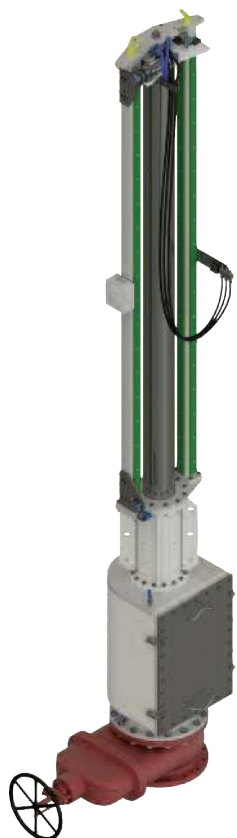


DEPLOYMENT MACHINE A MORE ECONOMICAL OPTION

Ultra-Short BaseLine (USBL) system performance can be seriously degraded by poor transceiver mounting and deployment. Our new Type 8223 offshore support vessel (OSV) Through-Hull Transceiver Deployment Machine has been specifically designed to meet OSV and smaller vessel requirements, without compromising sensor operational performance.

It maintains the rigidity needed for deepwater USBL operations, but at a lower cost, thanks to a smaller diameter and shorter pole, which will meet the needs for most ROV operations where vessel speed will not be more than 10 knots. The reduced length pole still achieves the required drop below the hull (1.5 metres) to ensure the digital wideband signals are not affected by the hull structure.

By reducing the pole diameter and length, the entire system is smaller and lower power hydraulics are needed. So you get the same system performance for less.



BLUECOMM 200 UV ULTRAVIOLET IS THE NEW BLUE

BlueComm 200 UV is a new variant of our BlueComm subsea free space optical modem range, offering fast and high data-rate subsea communication capability.

BlueComm is a free space optical modem for wireless data transfer subsea supporting data harvesting and tetherless control of underwater vehicles. It makes possible, multiple high definition streams simultaneously, with negligible latency at rates 2,000 times faster than acoustics.

With data transfer rates of 1-10 Mbps at up to 75 metre range, BlueComm 200 UV has minimal susceptibility to artificial light, i.e. LED lighting ($\lambda > 430\text{nm}$) and reduced susceptibility to solar radiation, which means it can operate near to underwater vehicles with lights and near to the sea surface.

BlueComm UV has the same interface and form factor as BlueComm 200 and can be used in conjunction with BlueComm GR (Green $\lambda = 532\text{nm}$) to avoid signal interference when using more than one BlueComm pair within operating range.



SYRINX DVL LIGHTER, SMALLER, EASIER TO MOUNT

Our Syrinx DVL has had a make-over. It's now lighter and shorter and comes with an integrated mounting plate, making it easier to fit. We've also updated the connectors to SubConn, a more common interface, to make cable spares and interchangeability easier.

What are the numbers? The 6,000 metre rated version, including mounting plate, is now 204mm-tall and weighs in at 14.5 kilogram, compared with 213.3mm and 15.5 kilogram in the past. The 4,000 metre-rated Syrinx is now 189mm tall and

weighs in at 12 kilogram, compared with 201mm and 12.5 kilogram in the past (including mount plate). Inside, they're still the same highly capable and versatile 600 kHz DVLs, for surface and subsea vehicles. Syrinx DVL combines the high altitude performance of a 300 kHz DVL with the high resolution of 1200 kHz DVLs in a single, easy to install navigation instrument with easy to individually replace transducers.

Use Syrinx for ROV station keeping, integration with our SPRINT INS, for unmatched DVL aided navigation, down to 4,000 metres as standard, with 6,000 metre and OEM models available.





What do all these robotic vehicles have in common? They go to work with Sonardyne technology onboard

From micro to work class ROVs. From low logistic to field resident AUVs. And from self-powered to wave-powered autonomous surface vessels. Whatever unmanned platform your operations rely on, extend their capability and add value to the services you offer by equipping them with Sonardyne. Our family of integrated communication, navigation, imaging and positioning technologies can be adapted to meet any mission in any water depth, from remotely servicing offshore fields and harvesting data from science landers, to searching and classifying seabed targets and commanding swarms of underwater drones. We support you every step of the way during integration, reducing risk and ensuring your robots get to work faster. To discover more, search **Sonardyne Marine Robotics**

**POSITIONING
NAVIGATION
COMMUNICATION
MONITORING
IMAGING**