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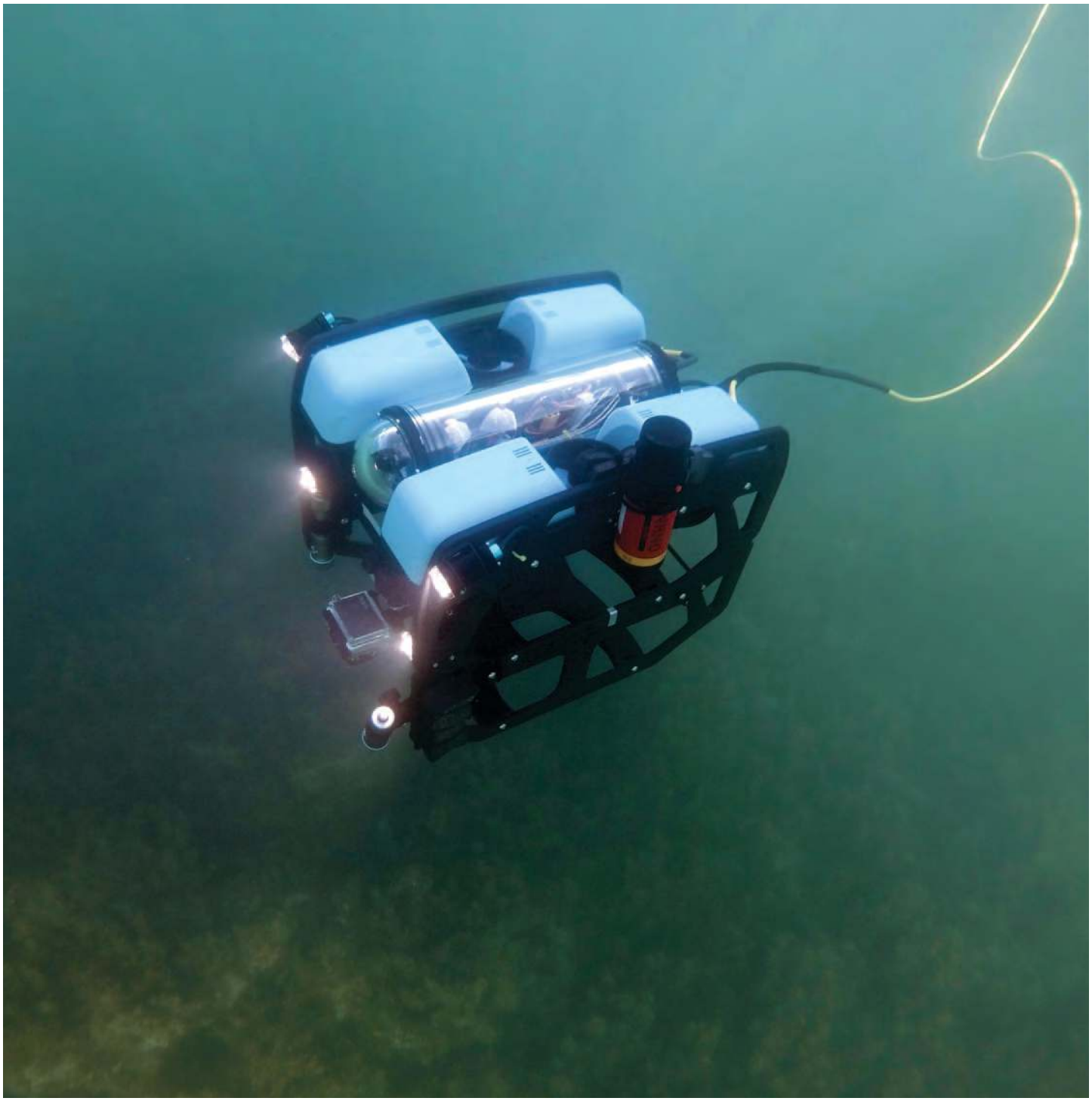
BASELINE. THE CUSTOMER MAGAZINE
FROM SONARDYNE

ISSUE 23



The expansion of what's possible in our oceans and waters continues at pace. Using combinations of remote sensing, manned and unmanned platforms, high bandwidth communications and autonomy, data can be acquired faster, safer and greener than ever. This insight is increasing our knowledge about the underwater world and how we impact it.

As a marine technology provider for inland, coastal, off-shore and deep ocean operations, be it for science, defence, energy or food production, we're central to this ongoing expansion of what's possible. As you'll read on page 10, we've been growing. We're now part of Sonardyne Group, a family of independent companies. 2G Robotics, Chelsea Technologies, EIVA and Wavefront Systems sit alongside us, meaning that there are even more opportunities for what's possible in the solutions we deliver to you.

But, even just here at Sonardyne International, through our UK, Singapore, USA and Brazil subsidiaries, we're developing technologies and services that are generating unprecedented levels of information for our customers, through manned and unmanned operations. We're helping to unlock the secrets of the massively disruptive Gulf Loop Current, with long-endurance sensors that transmit their data to shore via unmanned surface vessels (page 18); we're providing real-time visualisation of the seabed and water column ahead of superyachts and commercial vessels and automated alarms as they navigate, so they can avoid otherwise hidden dangers, through our Vigilant Forward Looking Sonar (FLS) (page 12); and we supply the software that's reducing vessel time during survey operations (page 30).

For us, innovation happens at system and sensor level. Read about our latest instruments including: SPRINT-Nav Mini, a new offering in our SPRINT-Nav family (page 36); our second generation Gyro USBL; and our ADCP capability (page 38). Best of all, we like hearing how our customers use our technologies, including our family of Ranger Ultra-Short BaseLine positioning systems (page 22). We hope you do too.

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Baseline.
The Customer magazine from Sonardyne

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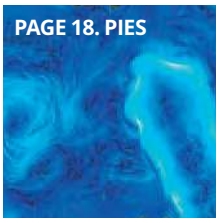
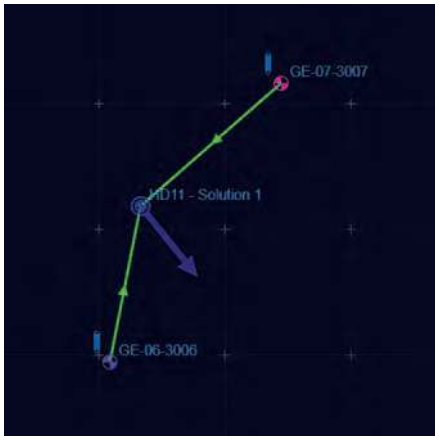
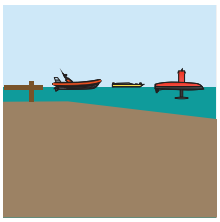
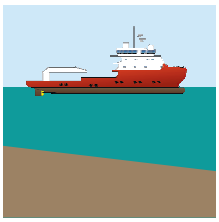
Issue #23 Cover
Our Ranger USBL family supports all your underwater tracking needs; inshore, near-shore and offshore. On the cover is Fathom Pacific's BlueROV2 during coastal survey operations supported by our compact, portable and easy to use Micro-Ranger 2 with a Nano.
Photo courtesy of Fathom Pacific.



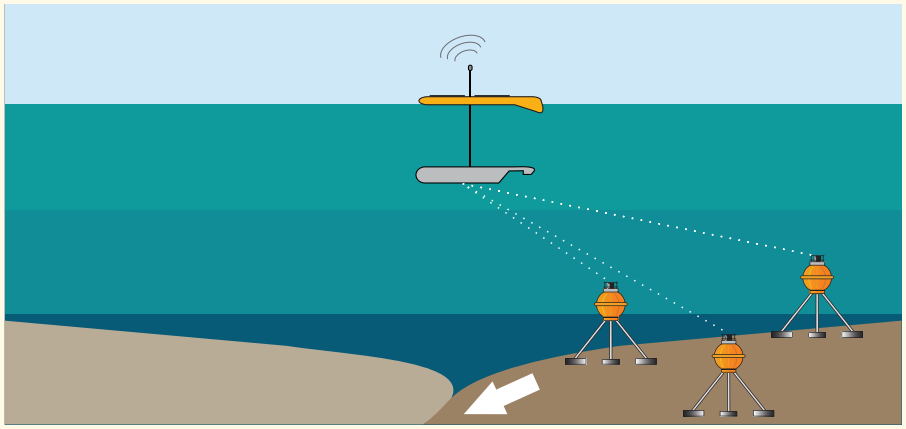






NEWS

Supporting pioneering US tsunami research – at scale



Understanding earthquake and tsunami risk has been a longstanding challenge, especially when it comes to measuring tectonic plate motion on the seabed. A major new grant is now set to make it easier for the entire US science community, using our technology.

Scripps Institution of Oceanography, through a US$5.5 million grant from the US National Science Foundation (NSF), is procuring more than 50 of our Fetch subsea sensor logging nodes. They will form a major new, nationally available equipment pool that will also include our advanced acoustic positioning modules fitted to three Liquid Robotics Wave Gliders.

These will, for the first time, make highly precise seabed monitoring capability – at scale – available to the entire US earth science community using a technique known as GNSS-A. Also known as GPS-A, GNSS-A combines GNSS-derived surface platform positions with acoustic ranging to seafloor sensors, enabling scientists to make centimetre-level globally referenced measurements of movement across geological features such as subduction zones, which can cause potentially catastrophic earth-quakes and tsunamis.

Unlike on land where these observations are easily acquired using the GNSS network, this level and type of measure-ment has been either too costly or too impractical to acquire subsea. This has resulted in there being almost no seabed geodetic information, which has limited understanding of the geological mechanisms at work.

“Seafloor geodesy is poised to be transformative. It will allow for a broad community of existing and next-generation earth scientists to study active deformation on the seafloor.”
David Chadwell, Research Geophysicist at the Marine Physics Laboratory at Scripps

South Korean submarine search and rescue capability underpinned with suite of Sonardyne technology

One of our latest orders is a great demonstration of our Ranger 2 Ultra-Short Baseline (USBL) system's ability to meet diverse operational requirements; in this case, to support submarine search and rescue operations.

Through a contract with GE Power Conversion, the Republic of Korea Navy's (RoKN's) new auxiliary submarine rescue ship, the *ASR-II*, will be fitted with a Ranger 2 system. This will interface onboard the vessel with GE's class leading Seastream Dynamic Position (DP) control system providing accurate and fast position reference updates during critical station keeping activities.

The Ranger 2 system on the *ASR-II* will also be used to simultaneously track and communicate with a new untethered Deep Search Rescue Vehicle (DSRV) that is being built to operate from the ship when it comes into service. That's because the DSRV, under a separate order with its manufacturer, James Fisher Defence, will be equipped with our Wideband Sub-Mini 6 Plus (WSM 6+) underwater tracking transponders. These will provide a two-way telemetry link between the *ASR-II* and the DSRV via Ranger 2.

Ranger 2 is installed on a global fleet of DP vessels operating within defence, offshore energy, ocean research and commercial survey. Its success in meeting the diverse operational requirements of these sectors is built around our versatile 6G hardware and Wideband 2 signal technology platforms. This combination can enable underwater targets to be tracked beyond 11 km, position updates to be acquired every second, and for a vessel to work in any water depth, shallow or deep. Read more about Ranger 2 in our extended feature from page 22.

Our order with GE Power Conversion includes everything the *ASR-II* will need to achieve the best performance from its Ranger 2 USBL, during exercises or in the event of a submarine rescue operation. This includes a seabed-deployed 3,000 m-rated Dynamic Positioning Transponder 6 (DPT 6) with recovery floatation collar. This will provide high-accuracy USBL positioning for reliable station keeping, even when operating near sources of potential noise interference such as other naval vessels.

The control room software will be configured with Ranger 2's optional Marine Robotics Pack, which unlocks an additional range of features to enable the vessel crew to send and receive data packets to and from the DSRV, as well as track it.

We're also supplying a deployment machine and gate valve, which the Ranger 2 HPT 5000 USBL transceiver will be deployed through the hull of the *ASR-II*. The HPT 5000 enables underwater targets to be tracked over a wide range of water depths and elevations so is perfect for vessels needing to undertake different tasks on a regular basis.

Shell deploys Sonardyne sensors for seabed monitoring campaign at Ormen Lange

20%

Percentage of gas supplied to the UK from the Ormen Lange field*

*Data Source: Shell

Monitoring small geophysical changes on the seabed requires precise underwater sensors that are both sensitive and long lasting.

Our Fetch pressure monitoring transponders (PMTs) do both, which is why they were chosen for work on Norway's second largest gas field, Ormen Lange, operated by Norske Shell. A comprehensive network of our Fetch PMTs have now been deployed across the field, in 800–1,100 m water depth, for a 10-year seabed subsidence monitoring mission.

It's not the first time we've deployed long-endurance sensors over Ormen Lange. Our Autonomous Monitoring Transponders (AMTs) were used on the field for five years, starting in 2010. Back then, the AMTs were used to collect millions of acoustic ranges between each instrument, as well as pressure data, to monitor seafloor deformation in three dimensions.

Over the years, we've worked with Shell to adapt these sensors. The latest deployment will see Fetch PMTs accurately collect pressure, temperature and inclination data at the seafloor, at pre-programmed intervals, throughout the full campaign. This is thanks to doubling the battery endurance of the sensors to 10 years and increased pressure sensor accuracy.

Using the data the Fetch PMTs collect, vertical displacement of the seabed will be calculated, enabling Norske Shell to better track what is happening across the field. This will help Shell to detect changes that might be caused by ongoing gas extraction operations and therefore inform its reservoir management strategy, as it continues to produce from the huge field over coming decades.

Our ultimate goal is to achieve towards <1cm per year of unresolved relative subsidence. Further advances we have made with our AZA (Ambient-Zero-Ambient) technology will move us closer to this goal. AZA automatically recalibrates itself in situ, allowing consistently accurate readings over a deployment period of up to 10 years.

"Shell has fully supported Sonardyne for over a decade in the development and improvement of seabed subsidence monitoring technologies that have been used to great effect at several of our fields," says Tomas Frafjord, Senior Project Surveyor, Norske Shell.

"While the oil and gas industry drove these initial developments, it is very pleasing to note that they have also become a key tool for the scientific community, enabling scientists and researchers to measure movements of subduction zones and tectonic plate boundaries.

"This, in turn, is helping to unlock a better understanding of the earth's dynamics and providing the information which can be used as an early warning system of potentially catastrophic events along major populated coastlines."

Sentinel harbour protection demos upping the ante at ANTX

Direct attacks on vessels, blockades of strategic shipping lanes and rising piracy – the past year was a turbulent one for navies and commercial maritime, with many predicting 2020 to be just as unstable.

Increased protection for ports and naval bases is a key objective and our Sentinel Intruder Detection Sonar (IDS) is part of the solution. Last spring, our US defence team was invited to demonstrate exactly how as part of the Advanced Naval Technology Exercise (ANTX).

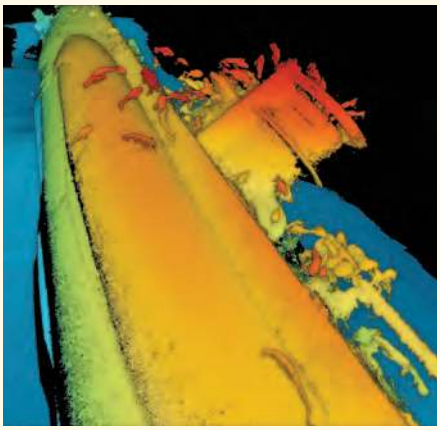
ANTX is the key annual naval technology collaboration, development and demonstration event in the US Navy's calendar. It brings together more than 1,000 naval, academic and industry attendees at the US Naval Undersea Warfare Center's Narragansett Bay Test Facility in Newport.

Ahead of the culminating showcase event at the end of August, we collaborated with BAE Systems' Riptide unmanned underwater vehicle (UUV) team, as well as elite US Navy divers, to put Sentinel through its paces. Specifically, we wanted to show the strength of Sentinel's combined active and passive intruder detection sonar for protecting ships in and close to harbour from underwater threats including very small UUVs. And it did just that, with clear results. These were presented at the end of ANTX '19 and have since been used to help further refine Sentinel's detection, tracking and classification algorithms.

Sentinel has been on duty around the world for more than a decade helping to protect critical national infrastructure, vessels, ports, offshore platforms, private yachts and VIP waterside residences. It alerts security personnel to the presence of underwater threats up to 1,500 m away, so they can deal with them quickly, before the threat is realised.

Dan Zatezalo, Technical Sales Manager, US Maritime and Defense, says, "The theme for ANTX 19 was 'Prepare for Battle: Undersea Security' and that's exactly what we offer. Sentinel is just one of the tools for navies, defence and security organisations to do just that."

2G Robotics joins Sonardyne Group



As you will read more about on page 10, Sonardyne has been growing and we're now part of a group. The latest company to join us is underwater imaging and inspection specialist 2G Robotics Inc.

As part of Sonardyne Group, 2G Robotics, which was founded in 2007 and is based in Ontario, Canada, will continue to be run as an independent business and brand. 2G Robotics' founder Jason Gillham will also continue to lead the company as Chief Executive Officer.

John Ramsden, Sonardyne's Group CEO, says, "2G Robotics has a dedicated research team and well developed product and service lines, with scope for growth. As an independent company, their offering is complementary to the growing range of products and services our wider group of companies provides to the marine sector."

Jason Gillham adds, "Sonardyne is a great fit for us, with their existing global reach. We look forward to growing with their support and working with our new partners."

Promoting marine measurement and hydrography

Last autumn we were pleased to host the 63rd Marine Measurement Forum (MMF), a non-profit, non-affiliated one day conference, held at Farnborough Air Sciences Trust (FAST) museum, just a few miles from our UK headquarters.

MMF 63 brought together people from across science and industry to discuss some of the latest initiatives and technologies in marine measurement, from tracking sea-life and broadcasting to the world live from underwater submersibles to clearing plastic from the oceans. The increasing amount of work being done with USVs, as well as basin-wide collaborative monitoring efforts, was also under focus.

Thank you to all of the speakers who gave up their time from companies including: AutoNaut, Chelsea Technologies, the Nekton Foundation, the National Oceanography Centre, the Centre for Environment, Fisheries and Aquaculture Science, XOCEAN, Plymouth Marine Laboratory, HR Wallingford, the National Physics Laboratory and R&V Hazelwood Associates. The day rounded off with The Hydrographic Society's Southern Region evening meeting, chaired by our very own Edd Moller. Find out more about the next MMF at www.mmf-uk.org

Loch Ness trials conclude long-endurance navigation research programme

Navigation technology never stands still and neither do we. With our partners, the National Oceanography Centre (NOC) and L3Harris, we recently successfully completed a two-year, £1.4 million project to set new standards in long-endurance underwater navigation and automated subsea positioning.

The Precise Positioning for Persistent Autonomous Underwater Vehicles (P3AUV) project, part funded by Innovate UK, set out to integrate existing and emerging technologies to deliver a step-change in unmanned platform endurance and navigational precision.

In addition, the project set out to increase the use of autonomy in offshore survey positioning operations using unmanned surface vessels (USVs), which will help reduce risk to personnel, environmental impacts and operating costs. The final project trials, which also saw one of the NOC's largest deployment of AUVs operating in swarms, took place in Loch Ness, Scotland.

As the only company that produces an all-in-one hybrid acoustic-inertial-Doppler navigation and communication solution for AUVs and USVs, we were uniquely placed to collaborate with the NOC and L3Harris to realise the ambitious aims of the P3AUV project. By developing and integrating each organisation's technologies, including our own SPRINT-Nav hybrid navigation instrument, we've proven it's possible for underwater platforms to make more of their available onboard power and maintain navigational accuracy over long distances without external aiding.

We've also proven the capability to autonomously calibrate networks of seafloor positioning transponders with an L3Harris C-Worker USV to make offshore survey and construction operations faster and easier.

More Brazil orders for SPRINT-Nav

Our SPRINT-Nav has further enhanced its reputation as the subsea navigation instrument of choice in Brazil.

It was chosen once again by international subsea services provider DOF Subsea for a further three vessels in the company's Brazilian offshore fleet. These additional SPRINT-Navs are now supporting five Forum Energy Technologies (FET) remotely operated vehicles (ROVs) on board the three vessels.

SPRINT-Nav combines our SPRINT inertial platform, Syrinx 600 kHz DVL (Doppler velocity log) and a high accuracy intelligent pressure sensor – all in a single, compact housing, making it the highest performing combined acoustic-inertial navigation instrument on the market.

DOF Subsea's growing fleet of SPRINT-Nav systems will be used to support the company's ROV operations, as part of construction, inspection, maintenance and repair work in Brazil's deepwater pre-salt oil fields, in depths down to 3,000 m.

New superyacht build to be protected by Sentinel IDS

With more than 150 Sentinel systems installed world-wide, our Sentinel Intruder Detection Sonar (IDS) is the market leading solution for underwater perimeter protection. It helps safeguard high value or nationally important marine and waterside assets by detecting in real time and at long range unauthorised access from the water.

This is why it's been chosen by yacht security specialist Frankentek Inc. for their latest new-build superyacht surveillance and protection project. Activated whenever the unnamed private vessel is in harbour or at an anchorage, Sentinel will provide the yacht's crew with a clear and early warning of any underwater threats approaching the yacht from any direction, such as divers, swimmers and drones, ensuring owner, guest and crew safety and privacy.

Sentinel's proven ability to recognise genuine targets with intent and non-threats, such as large fish or pleasure craft, in a wide range of operational environments, means it is the most widely deployed commercial off-the-shelf underwater IDS technology on the market. Suitable for both permanent and temporary vessel installation, Sentinel detects, tracks and classifies underwater threats at up to 1.5 km range to provide a rapidly deployable perimeter intrusion capability. It is regularly supplied to protect busy commercial ports, naval bases, VIP waterside residences and critical national infrastructure facilities including power stations and desalination plants.

Frankentek, based in Medford, New Jersey, has more than 30 years' experience working with owners' representatives, designers, shipyards and system integrators to deliver, install and support bespoke security installations for the international superyacht community.

Marc Franken, the company's president, says, "From our experience with all brands of sonar-based diver detection systems, we have the most confidence with Sonardyne's Sentinel IDS. This is experience that has been proven on other build projects that we have done, as well as diver tests we've witnessed."

VIEWPOINT

Sonardyne has been growing. We're now a group of companies; individually strong, but stronger together. So, we've created a parent company, Sonardyne Group. Baseline spoke with the leadership team about what this means for you.

You may have heard, we've been making some significant organisational changes here at Sonardyne. We have – and we're excited to tell you more. We're now a group of companies in a move that will benefit you, our customers, project partners and suppliers, while making us nimbler and more capable across all our marine markets.

Sonardyne Group, our new parent company, has been formed to better harness the joint strengths of the independent businesses that you've come to know and trust over the past five decades: Chelsea Technologies, EIVA, Sonardyne International, Wavefront Systems and, most recently of all, 2G Robotics.

Sonardyne International's Managing Director John Ramsden is now Sonardyne Group CEO. Supporting him is Simon Partridge, Group Chief Strategy Officer, and Stephen Fasham, Group Chief Operating Officer. Graham Brown takes over as Sonardyne International's Managing Director, while all other senior roles at the group companies will remain the same.

A logical move

"It was a logical move," John told Baseline. "The past 18 months have seen some significant changes. Chelsea, then EIVA, and most recently 2G Robotics, have joined the Sonardyne stable, which already included Wavefront. We acquired each company as part of our long-term growth, diversification and expansion strategy and because of the potential for closer co-operation between us. But, we also want to maintain each company's strengths and identity. We bought them because of their respective strengths; we aim to build on and deepen these through the creation of an organisational structure that will foster them."

So will the new structure impact business as usual? "The group entity will provide management and structural support, with a light touch, promoting innovation, integrated offerings and growth while enabling each group company to continue doing what it does best – but even better," Stephen says.

"Let's say, you're used to working with Sonardyne International. The only change you'll notice is that the team you talk to will be able to offer you more through our ties with EIVA, Chelsea, 2G Robotics or Wavefront. That could be making greater use of EIVA's expertise in deep learning in survey software, for example."

A global footprint

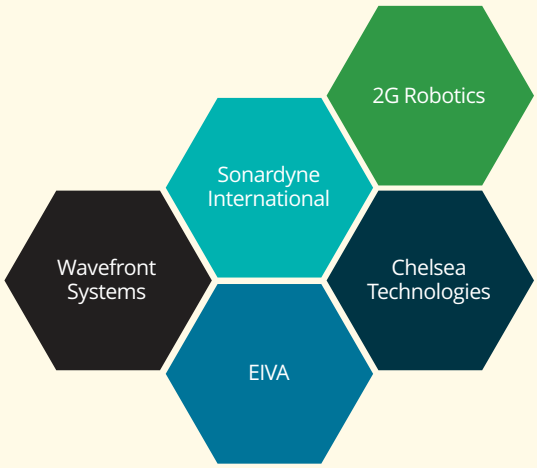
As a group, our footprint is truly global, with world-class manufacturing facilities at our headquarters in the UK, alongside our group companies' facilities, including research and development, manufacturing, sales, service and support in Canada, Denmark, Brazil, Singapore and the US.

"We can now achieve far more together than we could as independent companies," says Simon. "Each company will of course continue to focus on its own research and development, creating new and innovative technologies, but together we'll also unlock new possibilities by working in partnership and at scale, by integrating systems and by providing hybrid and single solutions for end users – so they get more with less complexity.

"What brings us together is a drive and passion for technology; for engineering the solutions to our customers' needs, whether that's marine instrumentation, systems or software," he adds.

"Our strength comes from harnessing our technical depths as individual companies to provide a greater breadth and capability as a group. For our customers, the result is access to greater possibilities, an undiluted focus on technology, with the reassurance of global service and support, whichever company or companies you're dealing with."

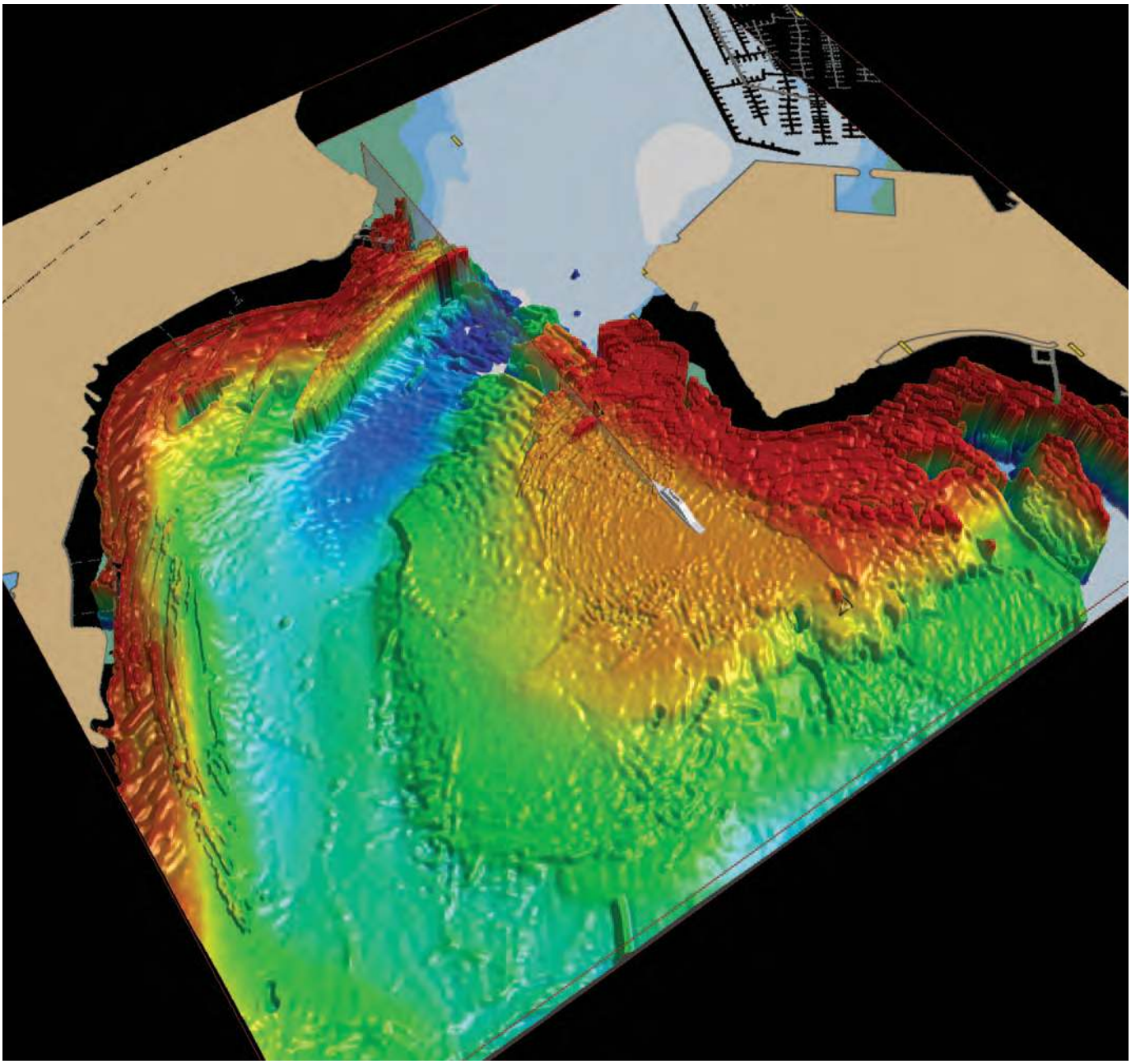
We're like-minded companies, each providing world leading solutions that enable our customers to measure, navigate, communicate and explore the world's waters and oceans across the energy, defence and civil markets. We're also still family owned and still very much about our people, our passion for engineering and where we can share that within the group and with you.

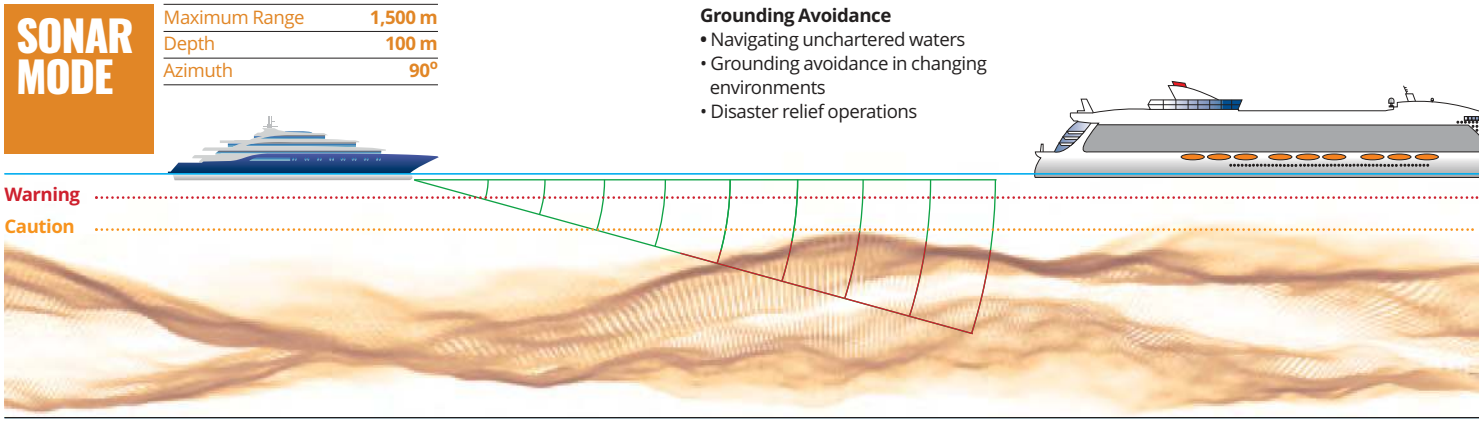


Talking strategy, L-R: Simon Partridge, Sonardyne Group Chief Strategy Officer, John Ramsden, Group Chief Executive Officer, and Stephen Fasham, Group Chief Operating Officer.

FOREWARNED. FOREARMED

US$1 BILLION COST TO INDUSTRY. 100 REPORTED ICE COLLISION INCIDENTS A YEAR IN THE BALTIC SEA. 700 CONTAINERS LOST OVERBOARD EVERY YEAR. VESSELS STRIKING AND OFTEN FATALLY INJURING WHALES. AN AVERAGE 42 COLLISIONS AND 37 GROUNDINGS A YEAR. THE STATISTICS ARE A STARK REMINDER OF THE RISKS COMMERCIAL, PRIVATE AND NAVAL SHIPS FACE AT SEA. BUT, HELP IS AT HAND IN THE COMPACT SHAPE OF OUR VIGILANT FORWARD LOOKING SONAR.





Imagine you had the equivalent of a parking sensor installed on the bow of your vessel, just beneath the water line. Imagine that it gave you a live 3D view of the seabed and the water column on your vessel heading. Imagine if that sensor also sent you automated warnings, when something in the water column ahead – hidden from sight, radar or Lidar – presents an obstacle or hazard (the equivalent of a pedestrian or bollard near your car).

We think that would be a powerful tool, de-risking day-to-day as well as the more "off-chart" navigation by the adventurous mariners among us. It would also enable more marine autonomy, providing unmanned craft, surface and sub-surface, with that additional level of situational awareness.

That's why we've built Vigilant, our new long-range, forward looking sonar (FLS). Vigilant FLS is a navigation and obstacle avoidance sonar, built from the ground up based on our previous experience in FLS systems. It provides automated alarms of objects in the water column out to 1.5 km. It also creates – with unrivalled resolution and detail – a real-time, easy to interpret 3D terrain map of the seabed ahead out to 600 m and down to 100 m water depth.

Vigilant is so good you can literally 'park' your vessel with it. Just view your crystal clear terrain data for that ideal anchorage. And, at just 31 cm-wide – comparative with a gaming console – and weighing only 14 kg in air (more than 90% lighter than our previous system), it's easy to handle and install on a wide range of vessels, from private yachts and harbour patrol vessels to offshore support vessels and research ships. It's also autonomy ready, coming with a specific mode for use with auto-pilot systems.

"It's an ideal solution for those with an adventurous streak," says Rob Crook, Research Director at sister company Wavefront Systems Ltd., who have led the development of Vigilant. "You can fit it to your superyacht or expedition cruise vessel and you're then prepared for anything, from seeking out a secluded bay or voyaging into the Article Circle to watch the Northern Lights. With our sonar on board, these vessels can navigate through unknown reefs, rocks, icy polar regions or shallow sand bars with confidence. You can even use it to examine the seabed topography ahead in order to pick the best anchorage."

AN ESSENTIAL BRIDGE TOOL

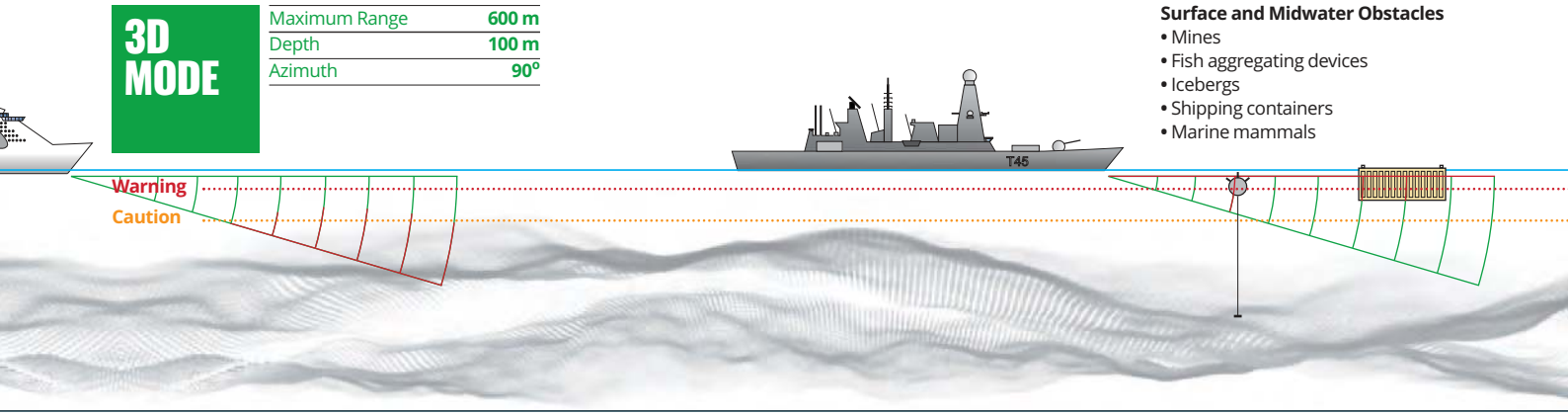
It's also ideal for those working in busy coastal waters, says Pete Tomlinson, Engineering Manager at Sonardyne. "Coastal shipping is, in fact, where the majority of known marine incidents happen. Groundings are all too common," he says. "These – and costly recovery operations – can be avoided with Vigilant's automated alarms. Timely alerts mean crew have time to take avoiding action. Offshore energy and commercial fishing operations, which often take place in busy and frequently shallow waters, would benefit too. As would vessels called upon for disaster relief operations, where they can be going in literally blind following a tsunami, earthquake or hurricane that have dramatically changed what may have previously been well charted seabed. With Vigilant, you can see the seafloor. It's no longer unknown. Even large marine mammals, like whales, can be picked up by Vigilant's computer aided detection (CAD) markers, which trigger alarms. Regrettably, whale strike happens more than you might think and can result in quite hefty fines and reputation damage.

"For naval operations, with Vigilant, operatives can be prepared for the unexpected, whether they're in a swimmer delivery vehicle (SDV), or on a coastal patrol vessel or cruiser. With its history mapping capability, which lets you see your past track, they've also got great situational awareness for tight manoeuvres or backing out of a confined area. Vigilant FLS remembers where it's been and what it's seen! Combined with our Sentinel intruder detection system, naval facilities and assets at anchor or in port can also protect themselves from underwater threats, including closed and open circuit divers and even man-portable unmanned and autonomous underwater vehicles. That's a powerful combined package."

COMPACT HARDWARE, COMPREHENSIVE COVERAGE

Vigilant really packs a punch in a compact package because a lot of focused work has gone into its design, of both the hardware and how the sonar works. It's effectively been designed from the ground up, moving the processing power to the topside and redesigning the sonar array. This has enabled the dramatic reduction in size and means it's easier to fit, not just in new builds, where it's relatively easy to design in a hull-mounted sensor, but also retrofits. In fact, our mechanical design teams have developed a novel cassette arrangement that any shipyard can install in the bow during a routine dry dock stopover.

Even more effort has gone into the acoustics involved in Vigilant. It works by transmitting acoustic energy into the water, through a 90 degree azimuth and through a vertical plane down to 100 m water depth – deeper than any other system in the market. It then listens for the sonar returns. These are then used to build an outstanding quality,



real-time 3D bathymetry map of the seafloor and enable the CAD detections out to 1.5 km. Sounds simple?

THE SCIENCE OF SEEING SUBSEA

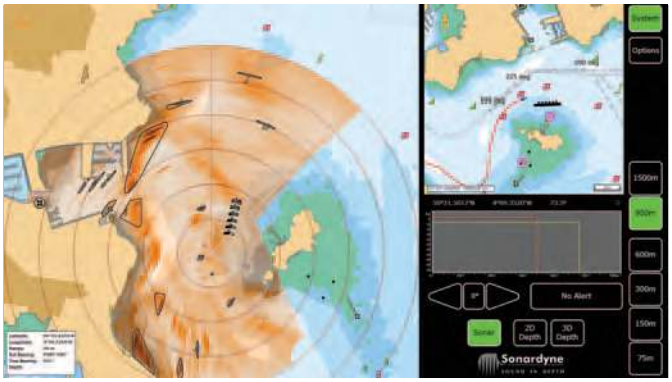
"Our new FLS probably represents the toughest design challenge Wavefront has ever faced," says Crook. "Multi-beam echo sounders (MBES) are a common type of sonar which seek to map the water column and seabed topography with a fan of beams projected directly beneath the host platform. In terms of the nature of the resulting imagery – maps of the seafloor and water column objects – this seems rather similar to what we have designed Vigilant to deliver. However, whereas MBES has the luxury of mapping directly beneath the host platform, achieving the fundamental operational requirement of an FLS means delivering the same type of information many hundreds of metres ahead of the host platform, often in shallow water. We need to 'forward look' and still provide navigationally relevant terrain and object detection data. That's not easy.

"It means imaging both the surface and the seafloor (two highly reflective surfaces) and anything inbetween. It means handling high levels of multipath interference caused by multiple reflections off these two interfaces. We have to deal with increased levels of ray-bending, associated with propagation through a predominantly horizontal sound channel. We also need to process and select for real-time display a single meaningful cut through of the dense 3D data point cloud of returns. Finally, the imagery has to be electronically stabilised against significant platform motion. With Vigilant, we've overcome these challenges and built the most capable (longest range, highest area coverage, highest resolution), commercially available forward looking sonar on the market."

Vigilant has two principal operating modes, 3D mode and Sonar mode. 3D mode produces stunning 3D bathymetry and colour coded depth imagery using our proprietary Altitude Confidence Filter (ACF), out to 600 m and down to 100 m. Sonar mode processes the intensity of the acoustic data to extract long-range positional data out to 1.5 km and over a 90 degree field of view. In this mode, the sonar returns are used to generate our CAD markers, which alert the operator (or a third-party AI based processor) to the presence of a navigationally relevant obstacle. This could be coral reefs, rocks, containers or even small icebergs.

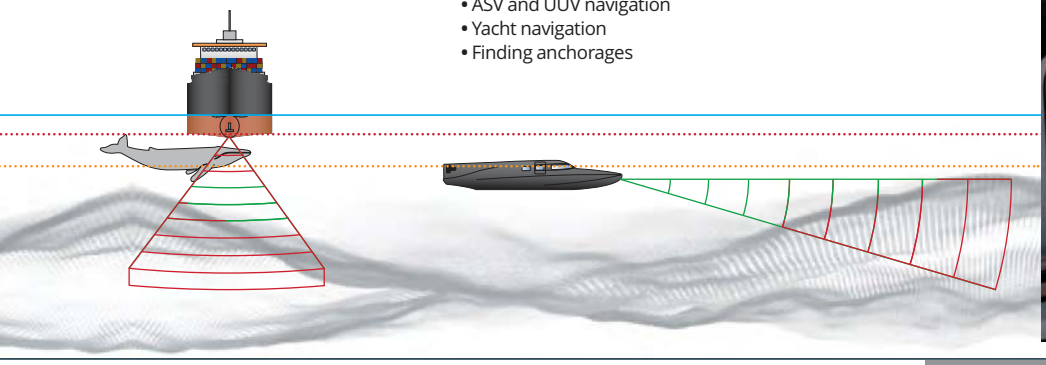
Both modes use a combination of physical array hardware and a suite of proprietary signal and data processing algorithms to deliver class leading performance.

"Vigilant really packs a punch in a compact package because a lot of focused work has gone into its design, of both the hardware and how the sonar works. It's effectively been designed from the ground up."



The long view: In Sonar mode, Vigilant provides an unparalleled 1.5 km warning system, giving mariners plenty of time to react to dangers in the water ahead.

Operating in Tight Spaces
- Swimmer delivery vehicle navigation
- ASV and UUV navigation
- Yacht navigation
- Finding anchorages



ROUTE GUIDANCE MADE EASY

Under the hood, it's not simple. But, you don't have to be a sonar expert to use Vigilant. We've focused heavily on making the graphical user interface (GUI) easy to use with automatic obstacle detection and classification. In Sonar mode, Vigilant has CAD markers showing potential obstacles, including objects like ISO shipping containers or small icebergs, as well as shallow seabed, which provide the mariner with timely, clear and easy to see warnings. That gives you more time to act. Vigilant even picks out hard objects in sandy or silty seafloor environments. A warning at 300 m, a typical range of other less capable systems, just doesn't give the vessel's crew enough time to respond.

If required, you can also view the raw profile data showing the entire water column, so you can see how deep an object is. If it's something shallow, for example, divers in an SDV could use Vigilant to see that they are able to pass underneath it.

RESULTS, WHEN YOU NEED THEM

During our rigorous testing throughout last year, we've been putting these capabilities to the test and even we're impressed. In really rough and pretty hostile acoustic conditions, in terms of salinity and temperature variations, it's been performing. During one trial, our vessel was pitching so much that every now and again the frame-mounted sonar actually came out of the water. Yet, it was still seeing things in Sonar mode in these conditions – which it wouldn't have to contend with on a large ship deployment. It's easily picking out marker buoys, more than 1 km away, in Sonar mode. That's impressive. In 3D mode, it even produces fantastic images in quite enclosed harbours; a space that's about as challenging as you can get for sonar.

Vigilant is now in production and we're already working with customers keen to see what it offers. So, if your vessel is still on the drawing board or scheduled for a dry dock this year – wherever that might be – now's a great time to speak to us about your requirements. We have 3D hardware models and data sets we can share with you and are planning several in-water demos in Europe and the Far East to showcase what it can do. Get in touch to find out more, read on to find out how SubSea Craft plans to use its Vigilant. BL

INTRODUCING THE VICTA DIVER DELIVERY UNIT

Gaining an advantage in an increasingly complex maritime security arena is a major challenge. With the advent of evermore sophisticated technologies proliferating in coastal waters, naval commanders at all levels are stretched as they seek options to maintain hard-won superiority.

Stealth, speed and reliable situational awareness both on and below the surface are vital components of comprehensive operational capability and our Vigilant forward looking sonar (FLS) is providing just that to a revolutionary new diver delivery unit (DDU), developed by UK maritime technology company, SubSea Craft.

TACTICAL ADVANTAGE

Combining cutting-edge hull design, composite material construction and an advanced control system, the company's VICTA class DDU offers the speed and endurance of a long-range insertion craft (LRIC) with the stealth and capacity of a swimmer delivery vehicle (SDV). The team behind it has extensive operational experience and the result is a first-of-kind, fly-by-wire craft that can rapidly transition from surface to sub-

surface configuration. VICTA can travel up to 250 nautical miles (nm) at speeds of up to 40 knots on the surface, to swiftly deliver up to eight operatives (two crew and six divers) to their objective area mission-ready. Below the surface, it cruises at 6 knots, with a 'sprint' capability of 8 knots, for up to 25 nm.

It's also easy to transport and deploy into a theatre of operation. At just under 12 m long, it fits comfortably into a standard shipping container and can be deployed from an unmodified surface vessel or port of opportunity. It can even be carried underslung from a heavy-lift support helicopter, such as the CH-47 Chinook.

GOING IN FOREWARNED

But, it's when VICTA is on and beneath the surface that Vigilant plays its enabling role. Being able to detect – at range – navigation hazards, before they become a real threat, is mission-critical to the sort of operations likely to feature in VICTA's play-book. Vigilant is the solution.

VICTA in numbers

Length	11.95 m
Beam	2.3 m
Draught	0.06 m
Crew	2
Divers	6
Fully loaded displacement	9,315 Kg
Surface cruising speed	30 kts
Surface top speed	40 kts
Endurance	250 nm (expandable)
Dive depth	30 m
Subsurface cruising speed	6 kts
Subsurface sprint speed	8 kts
Subsurface range	25 nm

With Vigilant integrated into VICTA, complete with its easy to use, intuitive graphic user interface, pilots can visualise the environment ahead to navigate safely and avoid obstacles ensuring safe insertion and recovery of operators, regardless of the mission. Quite simply, it provides a tactical advantage for their operations.

Using sophisticated bow-mounted transducers, Vigilant displays water depth, sub-surface obstacles and features by creating an accurate 3D model of the underwater environment over a 90° field of view. The model is displayed relative to the vessel, overlaid on standard charts in real-time, providing operators with an easily-interpreted topographical image of their navigation track. It may also enable intruder detection, potentially vital in high-risk, high-threat environments.

UNIQUE VISUALISATION

"Vigilant allows us safe and unhindered surface/sub-surface manoeuvring," says Tim

Chicken, SubSea Craft's Chief Commercial Officer. "Vigilant was selected because of a proven track-record and a compatibility with our proposed concept of operations allowing VICTA to operate safely in confined water-space owing to its unique 2D and 3D visualisation capability."

For example, pilots can use 2D, for obstacle avoidance, and 3D, for a real-time, three-dimensional view of the world around them, allowing navigation within potentially hazardous coastal – or what are known as littoral – zones where hidden threats, man-made or natural, may be lurking.

Combing all of these unique capabilities, VICTA broadens the options open to maritime, joint and special forces commanders, providing an advantage previously not available with conventional craft. It's a powerful capability able to support operational requirements ranging from advanced force insertion through to maritime counter-terrorism and constabulary operations; for all of which, situational awareness is key.

UNRIVALLED PERFORMANCE

"One of Vigilant's main advantages is its range," says Ioseba Tena, our Global Business Manager for Robotics and Defence. "It can see out to 1,500 m, in 2D mode, and then to 600 m in 3D mode, to help you plot your environment in real-time ahead of the vehicle. Performance that is unrivalled."

SubSea Craft worked in close partnership with a number of other cutting-edge marine technology and engineering businesses, including Ben Ainslie Racing Technologies and control systems specialist SCISYS. It was built by AC Marine and Composites Ltd. Why not go to our YouTube channel to watch Subsea Craft's Bill Barfoot talking about Vigilant and VICTA's capabilities at last year's DSEI London, where the craft was first revealed? BL

Find out more at www.subseacraft.com

YouTube
Watch for yourself Bill Barfoot introducing the Victa DDU at DSEI.

Previous page: Vigilant is easy to interface with third-party control systems such as SCISYS. Left: SubSea Craft's VICTA class diver delivery unit (DDU) combines cutting-edge hull design, composite material construction and an advanced control system. Right: With our Vigilant FLS onboard, operatives gain a tactical advantage, being able to see where they can navigate, including under obstacles and in confined spaces, as well as being able to easily view their past track for easy extraction.

THE KIT LIST
WHAT'S FEATURED IN THIS STORY

Vigilant FLS

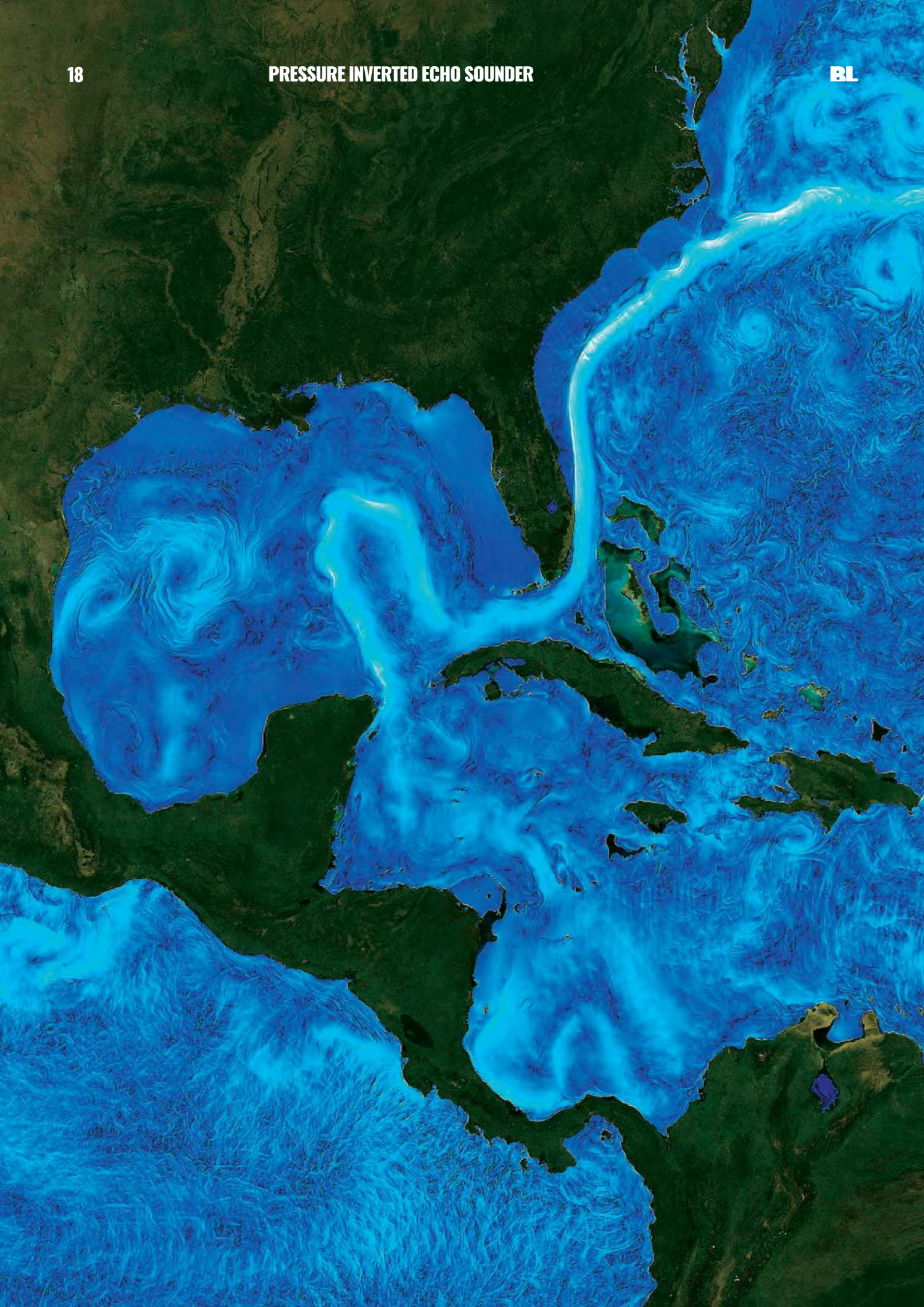
What is it?
Vigilant FLS is a long-range, forward-looking sonar for ships, unmanned surface platforms and crewed underwater vehicles. With the ability to detect uncharted navigation hazards and submerged obstacles as far away as 1,500 m, Vigilant FLS means crews have time to safely manoeuvre their vessel or vehicle around the hidden danger.

How does it work?
Vigilant's compact, bow-mounted sonar array scans the water column and builds up a highly detailed and accurate model of the seabed and submerged objects ahead of the vessel.

The intuitive display informs the crew of the seabed terrain and any potential underwater hazards up to a range of 600 m over a 90° field of view in 2D mode and 3D depth modes and out to 1,500 m.

How will it benefit your operation?
Vigilant improves underwater situational awareness for commercial, military, cruise and private yachts by reducing the risk of underwater collisions and groundings when operating in uncharted and unfamiliar waters

Its small form factor makes it suitable for both new-build installation and retro fits in existing vessels. It can be integrated with existing bridge systems and has an optional intruder detection security capability when at anchor.



PIES UNLOCK LOOP CURRENT SECRETS

RANDY WATTS, PROFESSOR OF OCEANOGRAPHY AT THE UNIVERSITY OF RHODE ISLAND, SETS OUT HOW OUR PIES ARE PART OF A PROJECT TO IMPROVE THE FORECASTING OF UNDERWATER 'STORMS' IN THE GULF OF MEXICO.

Randy Watts is Professor of Oceanography at the University of Rhode Island, one of the world's leading academic institutions for oceanography. His research has focused on understanding mesoscale dynamics of major ocean currents using moored instrumentation including observations made by inverted echo sounders, pressure gauges, current meters and hydrography.

The Gulf of Mexico is home to one of the world's most energetic oceanographic phenomena – the Gulf of Mexico Loop Current. Reaching intensities of between 2–4 knots and measurable down to 1,000 m, the Loop Current System (LCS) also regularly sheds Loop Current Eddies (LCE), which are themselves so significant that they are named in much the same way as major storms and hurricanes.

In addition, there are deep eddies, which develop when upper current systems shift and meander. These deep eddies are offset from the upper currents and can propagate independently, with intensities of between 1–1.5 knots extending down to the sea floor.

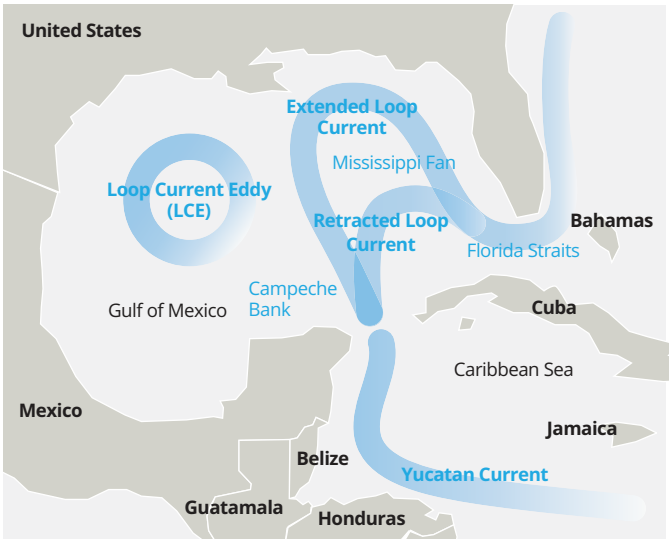
But, despite 50 years of effort by the scientific community to understand the processes underlying the LCS, its behaviour remains unpredictable. To some extent, this is because of interactions with the deep eddies, which have been difficult to track from measurements near the sea surface. For this reason, a multi-year scientific study has been launched, led by the University of Rhode Island (URI). It includes a major deployment of Sonardyne's Pressure Inverted Echo Sounders (PIES).

DISRUPTIVE EDDIES

The LCS originates from the Yucatan Straits, from which a northward current flows into the Gulf of Mexico. Sometimes, the current bends eastwards, travelling just off the north coast of Cuba before exiting the Gulf through the Florida Straits. Episodically, though, at intervals ranging from six to 19 months, the LCS extends north, towards Louisiana, Mississippi and Alabama and along the Florida Panhandle, before turning clockwise to flow south and then finally exiting east through the Florida Straits.

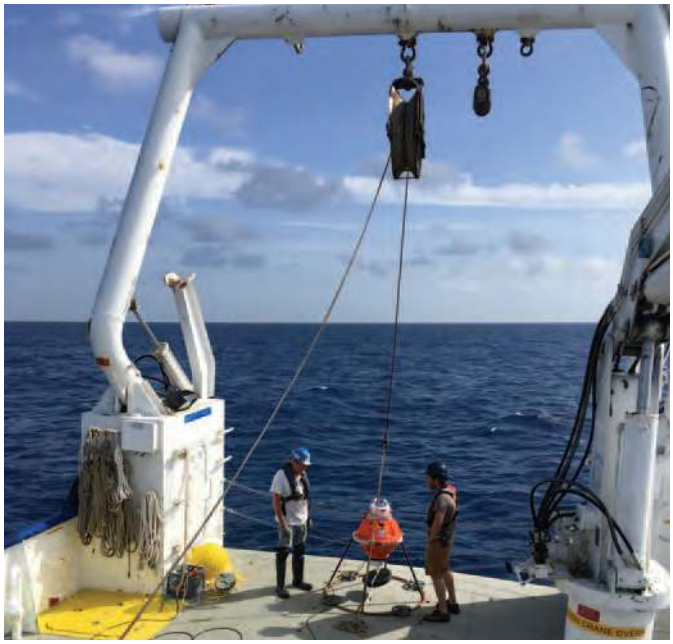
While in its 'extended' state, warm circulating eddies can break off the LCS into the western, northern and central Gulf. These eddies are so highly energetic that they regularly disrupt oil and gas operations. But, they're also critical to the Gulf of Mexico's oceanographic system, including its nutrient and food cycles and, most importantly, hurricane intensity.

Until now, most studies of the LCS have been limited to sea surface observations and satellite data, leading to a partial but in-



Previous page: The Loop Current is a huge and disruptive feature in the Gulf of Mexico. Visualisation by Christopher Henze, NASA/ Ames.

Below: The RV *Pelican* was used to deploy Sonardyne's CPIES – a variant of PIES – on the seabed in the Gulf of Mexico. CPIES, or Current PIES, allow for near-seabed current data to be harvested alongside the PIES pressure and tau measurements. Photos from Arne Diercks, University of Southern Mississippi, and URI.



complete understanding of how upper-ocean features, such as frontal eddies and meanders, are related to deep ocean flows. This has critically limited the ability to forecast behaviour of the LCS using numerical models.

That is now changing. Following a recommendation by the US National Academies of Sciences, Engineering and Medicine, a long-term, multi-million US dollar research program to plug the gaps in understanding and predicting the LCS is now underway. A core element of this scientific study is an array of seabed-mounted sensors, including Sonardyne's PIES.

PRESSURE INVERTED ECHO SOUNDERS

Sonardyne's PIES were originally developed for the marine seismic industry to measure average sound velocity in the water column. They do this by transmitting a wideband acoustic pulse from their position on the seabed. This pulse is reflected off the sea surface and returns to the seabed where it is detected by the PIES. The resulting data enables two-way travel-time to be calculated. At the same time, an accurate measurement of depth (distance to the surface) is made using a highly accurate internal pressure sensor. Average water column velocity can then be calculated directly from the depth and travel time data.

Oceanographers, however, use PIES differently. Their goal is to derive important physical data, including the strength and direction of currents. This is based on the principle that there's a strong correlation between two-way travel time (usually known as tau) and vertical profiles of temperature, salinity and density. As a consequence, where this profile has been derived from historical data, an empirical relationship can be derived, which enables the density profile to be inferred from tau. At a basic level, a laterally separated pair of PIES will, therefore, provide a vertical profile of velocity, and by deploying an array of PIES, local horizontal velocity and density fields can be mapped over the period of deployment.

URI has pioneered and refined the use of PIES for this purpose, including studies of some of the world's most significant geostrophic currents, such as the Kuroshio Current off Japan.

While URI has a long history of developing its own PIES instruments, it decided to use Sonardyne's PIES, as well as its own, following a comparison study off the coast of Oregon. This was primarily because the study indicated that the Sonardyne PIES could generate similar accuracy data efficiently, which potentially enables longer deployments – and because of their telemetry capability. Sonardyne's integrated high-speed (up to 9,000 bps) acoustic telemetry capability also enables remote reconfiguration of the instruments and retrieval of their data wirelessly to surface vessels, without interrupting the bottom pressure record.

These capabilities are based on Sonardyne's extensive expertise in underwater acoustics, signal processing, hardware design and custom engineering, which URI recognises have the potential to reinforce future PIES development.

INTRODUCING CPIES

This expertise was central to reconfiguring a standard PIES as a CPIES (Current PIES), which was needed for this project to allow for near-seabed current data to be harvested alongside the PIES pressure and tau measurements. It also delivers important data on deep eddy currents above the seabed/water interface.

The reconfiguration involved connecting an Aanderaa Doppler current sensor to the PIES, which then serves as a battery pack and data logger for the current sensor, deployed 50 m above the PIES on a float. Combining the deep current observations with the deep pressure observations enable data from the array to be referred to a common reference surface. This assumes that near-bottom currents and bottom pressure have a similar relationship to pressure and wind over the land.

The initial two-year project comprises an array of 15 URI CPIES, five Sonardyne CPIES and five Bureau of Ocean Energy Management PIES. These are in an array, spaced 60 km apart, at depths down to 3,500 m in the area of the extended LCS. Initially deployed in June 2018, for a nominal two-year study, the units are fitted with batteries that can keep them powered for up to 36 months, allowing for data gathering continuity in the event of a subsequent expansion of the program.

MAPPING MEANDERS AND DEEP EDDIES

The project's main aim is to define what conditions control the shedding of an LCE from the parent Loop Current. Specifically, the data collected by the array will be used to test a hypothesis that, as the Loop Current flows northward off the Campeche Bank, small meanders interact with deep eddies, which jointly strengthen. When the Loop Current then crosses a seabed feature called the Mississippi Fan (a seabed extension of the river's sediment delta), squashing and re-stretching occurs, which results in interaction between the deep eddies and meanders in the near surface of the Loop Current. It is these extended vertical interactions that are thought to provide the trigger mechanism for instability in the water column causing shedding of an LCE from the Loop Current.

To do this, the array has been configured to provide deep data in previously unsampled regions, including Mexican waters, as well as filling observational gaps in critical regions where the Loop Current interacts with topography. The latter will provide critical insight into the coupling process between the deep eddies and the upper meanders. Together these will enable production of daily 3D maps of the circulation of the Loop Current and its eddy field at a scientific-ally meaningful resolution.

INITIAL RESULTS

An interim data retrieval campaign using acoustic telemetry was successfully completed in September 2019. While the principal purpose of this was to recover an initial three-month-long data set, one notable feature observed in the data was echoes, thought to be from fish, shrimp or squid. This has been seen in other studies carried out by URI and we believe is related to transport of nutrients by deep currents crossing from the deeper to shallower thermocline side around the periphery of the Loop Current or a passing LCE.

Looking forward, this present array could inform planning for a longer-term campaign, which could see a substantially expanded array. The aim of this larger array would be to provide near real-time data as input into LCS forecasting models. Such forecasts have the potential to benefit a wide range of users, from oil and gas operations and hurricane forecasters to fishing and tourism. Furthermore, improving ocean modelling in the Gulf of Mexico has the potential to provide a standard for improving prediction efforts in other ocean basins. BL

What is a Loop Current Eddy (LCE)?
An LCE is a highly energetic anticyclonic (clockwise) rotating ring of warm water, roughly 300 km across and 500–1,000 m deep, with current speeds of up to 4 knots. These break away from the extended Loop Current about every 8–9 months and slowly drift west-south westward towards Texas or Mexico at about 3–5 km per day.

When an LCE forms at the height of hurricane season, it has potential to fuel rapid intensification of hurricanes. This occurred in 2005, when an LCE separated in July, just before Hurricane Katrina passed over and "bombed" into a Category 5 hurricane.

THE KIT LIST
WHAT'S FEATURED IN THIS STORY

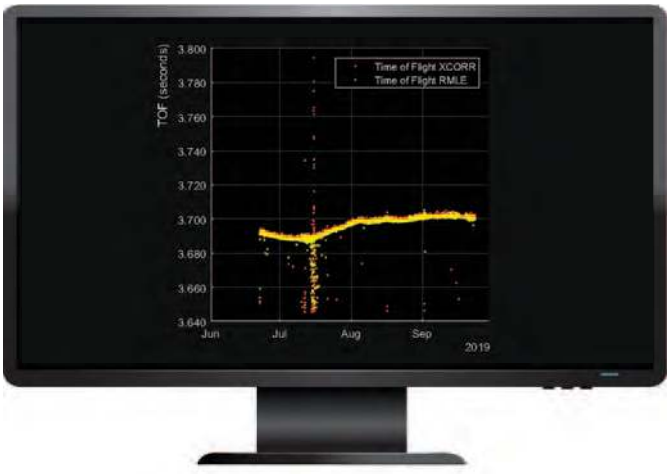
Type 8306
PIES

What is it?
PIES provide autonomous measurement and logging of pressure and two-way acoustic travel time over multiple years in depths down to 6,000 m. This data has applications in both the seismic and ocean science sectors.

How does it work?
PIES simultaneously measure the two-way travel time from the seabed to the sea surface and accurately measure depth using a highly accurate internal pressure sensor. Fitted with a high capacity primary lithium battery pack, PIES can be deployed for in excess of a decade (depending on sampling regime).

How will it benefit your operation?
Compatible with our LMF Ultra-Short BaseLine systems for deployment and recovery and wireless configuration using surface software and acoustic dunker – all of which can be operated on both manned and unmanned surface vessels.

(For more detailed information on the applications of PIES in physical oceanography, please email oceanscience@sonardyne.com for a copy of Sonardyne's white paper, which includes a comprehensive bibliography.)



In-house analysis
Our in-house data analysts are always on hand to aid interpretation – including when there are unexpected results. Following the initial PIES data retrieval, interesting patterns were noticed in the data. These were identified as fish migration, prompted by weather events, such as Hurricane Barry.

RANGER 2 USBL IT WORKS EVERYWHERE YOU DO

INSHORE, NEARSHORE, OFFSHORE. DIVER, ROV OR AUV. USV, BOAT OR SHIP. WHEREVER YOU OPERATE, WHATEVER YOU WANT TO POSITION AND FROM WHATEVER PLATFORM YOU USE, RANGER 2 HAS ALL THE FEATURES AND PERFORMANCE YOU NEED IN AN UNDERWATER TRACKING SYSTEM. AVAILABLE IN THREE MODELS – MICRO, MINI OR STANDARD – OUR RANGER 2 FAMILY DOES IT ALL.

Maybe you're diving on a historic wreck or using one of the new breed of small underwater drones to record video imagery of the wall of a dam. Or, perhaps, your work leads you to placing sensors into the deep ocean to investigate climate change. These are all very different jobs, but they have one thing in common; the need to know – for safety, cost, efficiency and data quality – where your people, robots and instruments are once they slip beneath the surface and are out of sight. That's where underwater acoustic tracking technology is needed or, more precisely, Ultra-Short BaseLine (USBL) positioning.

All USBL systems calculate the position of an underwater target by measuring the range and bearing from a surface-deployed transceiver to an acoustic transponder that's fitted to a moving target – whether the target stays moving or eventually lands on the seabed. However, not all USBL systems do it with the accuracy, precision and features offered by our Ranger 2 family.

We've been engineering USBL systems for close to 30 years. Our track record covers every type of civil, commercial, scientific and naval operation. This has taught us a lot about supporting our customers and their Sonardyne USBL systems in the real world; working with shipyards to retrofit systems, integrating equipment on experimental unmanned surface vehicles, overcoming noise interference from DP thrusters and making our transponders last longer to increase servicing intervals.

BUDGET. DEPTH. PLATFORM

We know that every marine project is different; different budgets, different water depths, different surface platforms (manned and unmanned) and different underwater targets to position. So that's why our Ranger 2 family has now grown to three; Micro, Mini and Standard.

With these to choose from, whether you're operating from a pontoon, inspecting fish farm nets in a loch, conducting an unexploded ordnance survey in a planned wind farm location or carrying out sustained observations using seabed sensors deployed for years at a time, one of our Ranger 2 systems will match your needs.

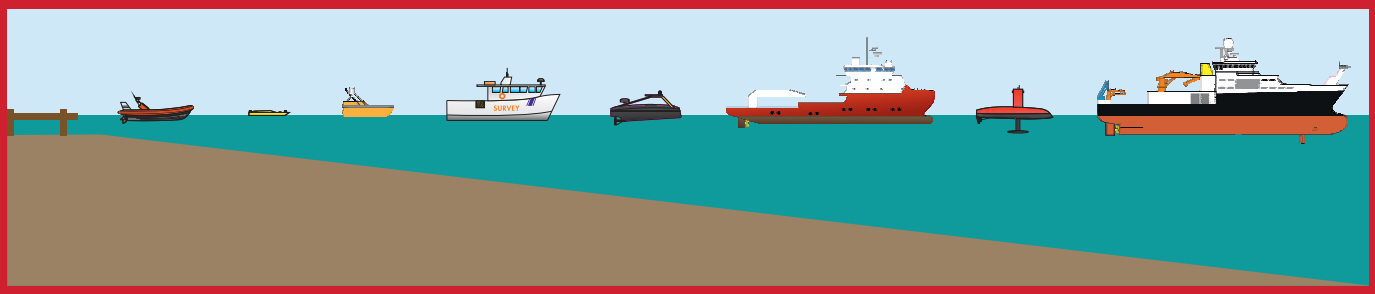
Whichever system you decide on, it comes with two key innovations; 6G (sixth generation) acoustic hardware and our Wideband digital signal architecture.

These innovations deliver valuable technical, operational and ownership benefits. Surface and subsea equipment all talk the same language and are easy to install and configure – whether you're working on a ship or remotely piloted USV. Multiple underwater targets can be tracked accurately and repeatedly. If there are other acoustic operations happening nearby, they won't interfere with what you're doing. As your needs evolve and you need additional functionality, you and your crew won't need to learn a new system. Micro, Mini and Standard Ranger 2s all use the same software

RANGER 2 AROUND THE WORLD

Over the next six pages, we take a closer look at how the Ranger 2 family is supporting marine operations around the world. Stories from and by our customers show just how versatile these systems are in a wide variety of environments. Dr Adrian Flynn, from Fathom Pacific Pty Ltd., shows how Micro-Ranger is providing an easy to deploy and important tool for monitoring coastal habitats in Australia. We also look at how Mini-Ranger 2 aided a World War II wreck recovery project by James Fisher Marine Services. Moving over to the realm of marine science, we look at how Ranger 2 was used to track an AUV from the RSS *James Cook*.

WHICH RANGER IS RIGHT FOR YOU?



MICRO-RANGER 2

Where to use it:
- Inland, Inshore

What to use it for:
- Tracking
- Commanding RT6 acoustic releases

Operating Platform:
- Dockside
- RIB
- Small boat
- Small USV

Typical Installation:
- Temporary

Expected System Accuracy:
- Up to 5% of slant range

Maximum Range:
- Up to 995 m

Maximum Targets Tracked:
- Up to 10 in sequence

Maximum Update Rate:
- 3 Hz

Feature Expansion Packs:
- Yes

MINI-RANGER 2

Where to use it:
- Nearshore

What to use it for:
- Tracking
- Data harvesting
- Commanding RT6 acoustic releases

Operating Platform:
- Survey boat
- Moored barge
- USV
- Small ship

Typical Installation:
- Temporary

Expected System Accuracy:
- Up to 1.3% of slant range

Maximum Range:
- Up to 4,000 m

Maximum Targets Tracked:
- Up to 10 simultaneously

Maximum Update Rate:
- 3 Hz

Feature Expansion Packs:
- Yes

STANDARD

Where to use it:
- Offshore

What to use it for:
- Tracking
- DP reference
- Data harvesting
- Commanding RT6 acoustic releases

Operating Platform:
- USV
- Large ship

Typical Installation:
- Permanent

Expected System Accuracy:
- Up to 0.04% of slant range

Maximum Range:
- Up to 11,000 m

Maximum Targets Tracked:
- Up to 99

Maximum Update Rate:
- 1 Hz

Feature Expansion Packs:
- Yes

MICRO. FOR WHEN GOOD IS GOOD ENOUGH

OUR SMALLEST EVER USBL, MICRO-RANGER 2, IS PROVIDING AN EASY TO DEPLOY YET IMPORTANT TOOL FOR MONITORING COASTAL HABITATS IN AUSTRALIA, AS FATHOM PACIFIC'S DIRECTOR AND PRINCIPAL CONSULTANT DR ADRIAN FLYNN SETS OUT.

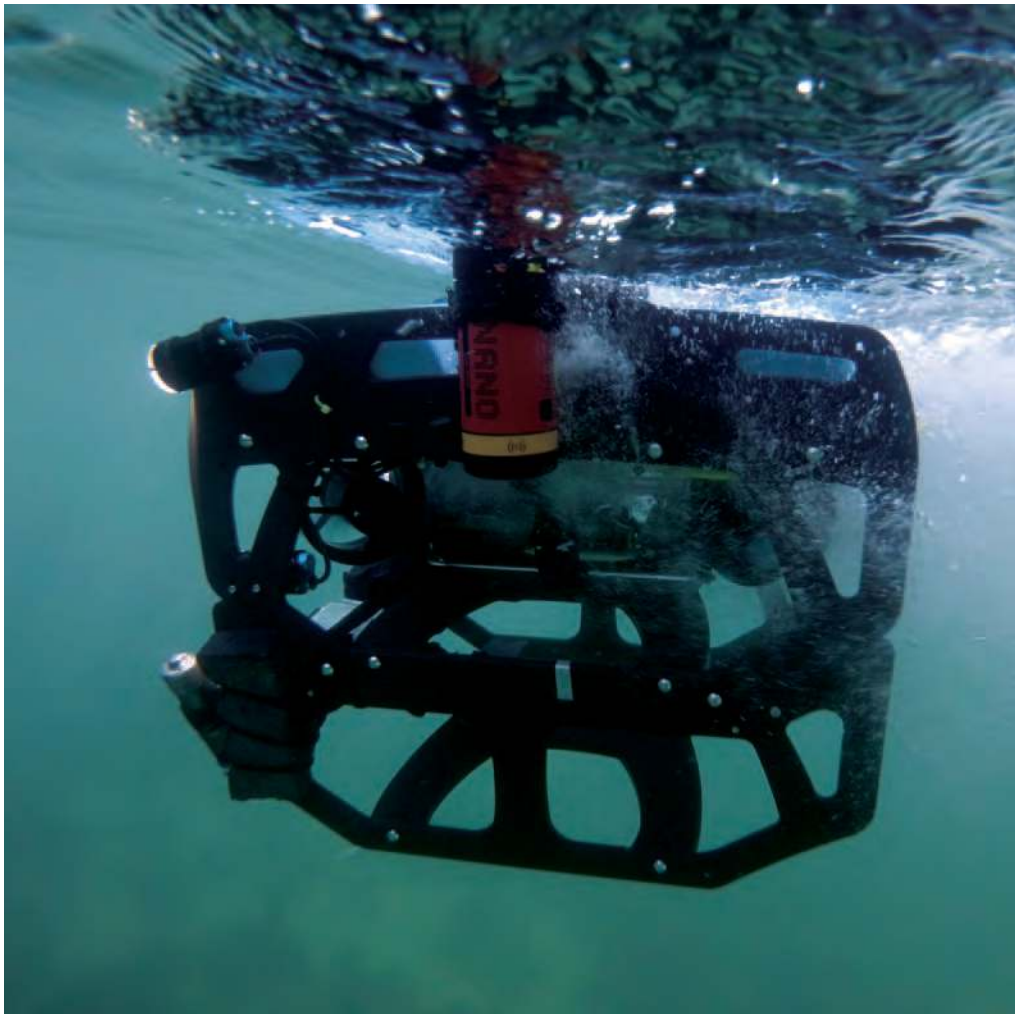
THE KIT LIST
WHAT'S FEATURED IN THIS STORY

Micro-Ranger 2
USBL System

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

How does it work?
In exactly the same way as all of our Ranger 2 USBL systems, by measuring the range and bearing from a surface transceiver to a transponder on each target. The position of each target is displayed on a radar-style software display running on your PC.

How will it benefit your operation?
Micro-Ranger 2 means safety and peace of mind. It's portable, quick to set up and easy to use, even if you've never used USBL technology before. Deploy it and track it.



Fathom Pacific has been using its BlueROV2 during coastal survey work offshore Victoria, Australia. Their operations were supported by our compact, portable and easy to use Micro-Ranger 2 with a Nano on the BlueROV2. Photos courtesy of Fathom Pacific.

As our use of the world's seas and oceans increases, so too does our need to assess and monitor our impacts accurately.

It's a challenge we face globally, not least of all, here in Australia. As part of an initiative by the Victorian Department of Environment, Land, Water and Planning (DELWP), the team at Fathom Pacific Pty. Ltd. has been carrying out studies in Port Phillip Bay, in southern Victoria.

Port Phillip Bay is home to a host of marine life, from the iconic seadragon (Victoria's marine State emblem) to brightly coloured nudibranch molluscs and fishes. It's also one of the most diverse places on the planet for seaweeds and reef systems that support a diverse array of sponges and other invertebrates. Port Phillip Bay is also shadowed by the city of Melbourne which has a growing population of nearly five million people.

SUPPORTING ENVIRONMENTAL MANAGEMENT

To protect the Bay, DELWP is implementing the Port Phillip Bay Environmental Management Plan 2017–2027 (EMP). That's where we come in, providing models and maps and monitoring the bay's marine biotopes – i.e. areas of the bay that provide habitats for specific species – to support decisions about how to manage the bay.

Firsthand ecological research and environmental monitoring are key building blocks of these models and maps, so the data we gather has to be quantitative and accurately georeferenced.

But we have to gather it in increasingly cost-efficient ways. That means we need easily available and affordable monitoring systems that we can deploy from small craft and track their whereabouts with a reasonable level of confidence. What's more, the tech we work with has to be able to work in Port Phillip Bay's challenging conditions, which has a large embayment exposed to strong winds and periods of low underwater visibility.

BLUEROV2 + MICRO-RANGER 2

The setup we've gone for is a BlueROV2 remotely operated vehicle (ROV) from Blue Robotics and a Micro-Ranger 2 USBL from Sonardyne. The HD camera onboard the ROV captures incredible detail whilst the USBL tell us where it was when we recorded it. If we have divers and other assets in the water, it can track them as well.

We've found Micro-Ranger 2 to be extremely portable and easy to mobilise; it's the ideal solution for our small-boat coastal operations.

The MRT – the part of the system that communicates with transponders fitted to underwater targets – is so small and light, we've been able to mount it to the bottom of our stern diver ladder. For something the size of a small flower pot, we've been really impressed with its range and coverage.

The Nano transponders are also perfect for our work. They are strapped to the frame of our ROV or diver's tank without affecting balance or freedom of movement. They're rechargeable and last for a full day of operations.

First time out, the whole system was simple to install and calibrate, helped by the instructional videos on YouTube. Once the software was set up and tested on our laptop, we put it straight to work supporting surveys throughout our last winter and spring, often mobilising it at very short notice due to the unpredictable weather windows we had.

ACCURATE RESULTS

The results from Micro-Ranger 2 have been impressive. The system has accurately and consistently tracked our ROV in the bay's shallow waters, even when it has been transecting some 50-100 m from the (MRT) transceiver. This is important for our assessment of the bay's biotopes during which we image the key structural and functional components of temperate reef and sediment biotopes using the ROV.

We fly ROV transects in two modes. The first is a 'video inspection mode', detailing the canopy, sub-canopy, lower strata and turfing components and identifying the associated macrofaunal biodiversity. The second is a 'still image mosaicking mode', where fixed-altitude planar stills are taken to create biotope mosaics.

Using Micro-Ranger 2, we were also able to place our analyses of reef biodiversity and biotopes into a spatial context by corelating our imagery data with real world coordinates. This means we can now provide ground-truth data for biotope modelling, while also establishing biotope condition and informing ecosystem models. And we can go back to exactly the same locations for future surveys.

Quite simply, our investment in Sonardyne's USBL technology is paying enormous dividends. We're better able to monitor – and therefore react to – issues like the spread of marine pests, loss of canopy-forming algae to urchin grazing, biodiversity loss, eutrophication, litter and impacts from marine industries, which are just some of the threats facing our marine systems.

THE WORK CONTINUES

DELWP's program involves the selection of suitable indicators and methods for monitoring. As we move forward, an important consideration for future monitoring will be the selection of robust indicators at multiple levels of the ecosystem and the application of methods that are repeatable, auditable and affordable.

This, along with increasing appropriately-gauged citizen science contributions to monitoring programs, will require linking imaging systems and other science sensors with affordable and adaptable subsea positioning systems.

Micro-Ranger 2 provides this capability. In fact, we're using the system again shortly to survey unique bryozoan reefs in Western Port, also in Victoria. There, georeferenced image mosaics will be used to monitor the extent and condition of these delicate reefs. The system will also be used to ground-truth remote sensing products including multibeam bathymetry.

With Micro-Ranger 2, we have an important addition to our operational versatility and responsiveness. We can now deploy to the field with minimal fuss, achieve excellent positioning and deliver high quality outcomes. ■

MINI. TRACKING WITHOUT COMPLEXITY

SMALL YET OFFERING MANY OF THE FEATURES OF OUR TOP PERFORMING SYSTEM, MINI-RANGER 2 HAS BEEN HELPING JAMES FISHER MARINE SERVICES RECOVER OTHERWISE LOST WORLD WAR II AVIATION HISTORY.

THE KIT LIST
WHAT'S FEATURED IN THIS STORY

Mini-Ranger 2 USBL System

What is it?
Mini-Ranger 2 is our mid-level USBL that's also able to support data harvesting from seabed nodes. It has an operating range of 995 m (extendable to 4,000 m) and can track up to 10 subsea targets at very fast update rates.

How does it work?
Ranger 2 delivers survey-grade positioning and robust telemetry in a wide range of operating scenarios, including high elevation.

How will it benefit your operation?
Mini-Ranger 2 can be fitted to a small survey vessel, barge or unmanned surface vessel. But it's more than just an underwater tracking system. Communications are Ethernet-based, for hassle-free connection to a topside computer (via an Ethernet Serial Hub).

The Fairey Barracuda

The first prototype Fairey Barracuda was flown in December 1940, but production models weren't available for service until 1943. Capable of carrying a single 16 inch torpedo, a combination of 250 and 500 lb bombs or anti-submarine depth charges, the Barracuda was a formidable attack aircraft.

A Fairey Barracuda campaign pinned the German battleship Tirpitz in Alta Fjord, Norway, where the RAF's heavy bombers were able to target her. The aircraft also made an impact in the Pacific campaign and was the first all metal, monoplane torpedo bomber ordered by the Royal Navy.

Above: The wreck could be seen in the silt, which had to be removed as much as possible before the parts could be recovered, including the engine block, also shown below. Images from James Fisher Marine. Fairey Barracuda image courtesy of the Fleet Air Arm Museum.

A CHANCE DISCOVERY

In its working life, there were more than 2,500 Fairey Barracudas delivered to the Royal Navy's Fleet Air Arm. That's more than any other type ordered by the Royal Navy to date. A three-seat, single engine torpedo bomber, it was launched from aircraft carrier decks during World War II, carrying their lethal load to drop on to targets.

But, despite the numbers that were built, none remain in the UK today, at least not in complete form. However, restoration engineers at the Fleet Air Arm Museum (FAAM) in Yeovilton are looking to change that and a chance find in the English Solent is helping them on their way.

It's the wreck of a Mk II Fairey Barracuda, discovered in 2018 by James Fisher Marine Services (JFMS) during a UXO survey for a new 204 km long power interconnector as part of the IFA2 (Interconnexion France-Angleterre 2) project.

A SHORT FLIGHT

The wreck is believed to be one of two Barracuda aircraft. Both were based at Lee-On-Solent, Gosport, and both suffered forced landings in the Solent during WW2, shortly after take-off from HMS Daedalus airfield. While both pilots survived, making it through the remainder of WW2, their planes remained on the seabed.

Recovery of the wreck offered a great opportunity to the Fairey Barracuda restoration effort. But, it also posed a number of challenges, not least the water depth – or rather lack of it. Lying in just 5 m, Robin Fidler, Survey Operations Manager at JFMS expected to encounter acoustic interference problems tracking his divers due to signals bouncing off the seafloor and sea surface – often referred to as multipath.

Multipath can cause a USBL transceiver at the surface to falsely detect (or completely miss) a genuine reply signal from a transponder, leading to unstable tracking performance. Previous generation USBLs were particularly susceptible to multipath and needed careful setup to overcome the problem – not always successfully. However, the digital signal processing techniques used by all our Ranger 2 USBLs – we call it Wideband 2 – means that multipath is largely a thing of the past, freeing up users to deploy our USBLs virtually anywhere.

"We were really impressed with just how Mini-Ranger 2 operated," says Fidler. "We thought we were going to have to use a (Fanbeam) laser radar system, tracking a reflective buoy attached to the diver to give us a range and bearing to the diver. We didn't have to use it once; we could do it all with USBL, no matter what the tide, which made our lives much easier and that's all we could ask."

MINI-RANGER 2 AIDS RECOVERY

Six divers were used on the three-week project from the *Stour* jackup barge, with one diver in the water at any one time. The barge itself was fitted with an HPT 3000 transceiver mounted to the side, cabled back to a survey shack where the diving operations were controlled from.

WSM 6+ transponders fitted to each diver's cylinder enabled the HPT to track every moment of their dive, providing a valuable layer of safety to the operation. Each diver additionally carried one of our Nano transponders in their pocket, to position directly on top of any archaeological finds, so that precise waypoints for each artefact they discovered could be logged (and individually named) in the Mini-Ranger 2 USBL software. This information is then available for offline analysis.

"The USBL didn't miss a beat. We were up and running with it quickly meaning that we were able to maximise the three week window we had on site."

The crash site was heavily silted so it needed to be cleared away so that sections of the aircraft could be lifted out of the water. Artefacts retrieved included one of the pilot's boots, a boost gauge and the underwing pitot head and mounting bracket – a delicate instrument which would have recorded the aircraft's airspeed. The fact that this was found intact implies that the Barracuda was almost at stalling speed by the time it reached the water, says Wessex Archaeology's Senior Project Manager Euan Mc Neill.

FAAM museum curator David Morris, who has been leading the Barracuda rebuild project for several years and visited four other crash sites to retrieve parts, says, "This find is a huge step forward for our project and we can't wait to get it back to the museum and begin the preservation process." Ongoing research and archaeological and forensic analysis of the recovered parts will help determine exactly which of the two aircraft the wreck actually is.

Fidler concluded by saying, "The USBL didn't miss a beat. We were up and running with it quickly meaning that we were able to maximise the three week window we had on site."

For more information about the project and how you can support it, visit *www.fleetairarm.com.* Also, follow progress at the Fairey Barracuda restoration page on Facebook. ■

STANDARD. IT'S ANYTHING BUT

WITH OUR RANGER 2 PERMANENTLY INSTALLED ONBOARD THE RRS *JAMES COOK*, A TEAM FROM THE UK'S NATIONAL OCEANOGRAPHY CENTRE WAS ABLE TO SIGNIFICANTLY REDUCE THE UNCERTAINTY AROUND THE POSITION OF THEIR AUTONOMOUS UNDERWATER VEHICLE.

THE KIT LIST

WHAT'S FEATURED IN THIS STORY

Ranger 2
USBL System

What is it?
Our highest performing USBL tracking, telemetry and DP reference system, configurable for almost any operation. Operational on global fleets of offshore and ocean science vessels. Options for permanent and portable configurations.

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

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

MISSION GOLDENEYE

It was on a mission that formed a key part of a research project focusing on carbon capture and storage (CCS) in the UK North Sea. The project was the European Union Horizon 2020-funded Strategies for Environmental Monitoring of Marine CCS (STEMM-CCS) project.

The project, involving researchers from Germany, Norway, Austria and the UK and industry partner Shell centred on Shell's decommissioned Goldeneye field, about 100 km offshore Scotland in about 120 m water depth. In May 2019, researchers and scientists onboard the RRS *James Cook* set out for Goldeneye for an intense period of scientific activity. They wanted to simulate carbon dioxide (CO_2) leaks from the seafloor in order to test various sensors and systems for their ability to detect potential CO_2 leakages and to help understand how the gas behaves, if it seeps out of the seabed and up through the water column.

For mapping the area and wide-area chemical sensing, they used a Gavia autonomous underwater vehicle (AUV) called Freya. But, because the Gavia had been adapted specifically for the mission – including fitting additional sensors to its body – operators were uncertain about how it would now fly through the water.

Our Ranger 2 system has underpinned the ocean science carried out by the RRS *James Cook* since it went into service with the National Oceanographic Centre (NOC) in 2006. It's helped to track a whole host of vehicles and instruments, including NOC's Isis ROV to 5,000 m deep. Indeed, on this latest mission, Isis, with a 6G Wideband Mini Transponder (WMT) onboard, was tracked using Ranger 2 during its many trips to the seafloor where it helped to accurately install an array of seabed equipment, sensors and instrumentation.

TRACKING FREYA

But, back to tracking Freya. Classed as a low-logistics vehicle – meaning that only two people are required to deploy and recover it – Gavias measure anywhere between 1.8 m and 4.5 m in length, and just 200 mm in diameter. So when it came to choosing which USBL transponder to equip Freya with, there was really only one option – Nano.

It's our smallest 6G-enabled USBL transponder (just 160 mm tall by 52 mm diameter) and comes with features such as wireless charging, depth sensor and lightweight plastic construction. For this mission, Freya's mission payload included a GeoSwath system for sidescan sonar and bathymetry, mounted externally to the hull, supported by additional buoyancy. This provided a convenient place to site the Nano. Freya was also used for photographic surveys and chemical sensing for pH using the SeaFET system.

For maximum operational flexibility, the RSS *James Cook* is permanently fitted with both our HPT 5000 (wide area) and HPT 7000 (deep water optimised) transceivers to separate, through-hull deployment spars. Whilst either of these medium frequency transceivers is capable of tracking a Nano, the shallow water at Goldeneye meant that the Gavia was tracked with the HPT 5000.

"We were able to use the displays from Ranger 2 to see that the Gavia was getting down to its working depth, usually around 100 m, as we were mapping the seabed," says Mike Smart, Glider Engineer, Marine Autonomous and Robotic Systems, National Marine Facilities, NOC. "This was very useful as there was quite a lot

Above and below: A modified Gavia AUV, complete with its added sensors and a Nano transponder, was deployed and tracked from the RRS *James Cook*, using Ranger 2, close to the Goldeneye facilities in the UK North Sea.
Photos courtesy of NOC /Ben Roche.

of uncertainty about how the Gavia would behave given the extra payload it was carrying. Tracking data from Ranger 2 was also shared across our network with survey and science teams elsewhere onboard.

"Being able to track the progress of the mission was also a nice feature. With a much longer and heavier configuration of Gavia than we usually deploy, the time it needed to resurface was longer than we had predicted. So, being able to view the vehicle's precise location, aided by regular depth updates from the Nano, meant we could more accurately predict surface times and not be anxiously waiting for the Freya to reappear at the end of her survey run."

CCS A REALITY

CCS is increasingly seen as one of the key measures to help us reduce greenhouse gas emissions. Capturing it is one thing, storing it and making sure it stays stored is another, which is why the NOC and others have been working to understand the nature of potential CO_2 leaks and test sensor capability to detect these.

This is just the latest time we've been involved in the work towards CCS, with past work having demonstrated how our Sentry leak detection sonar and our Solstice side scan sonar are able to detect leaks, as static and dynamic sensors. Our instruments have also been shown to be able to support so-called chemical "sniffers" that can detect CO_2 (see Baselines 12 and 18).

While it's still an emerging area, industry is getting closer to making CCS offshore a reality – the first offshore carbon storage license was awarded in the UK in 2018, followed by a new license for a significant storage site awarded in Norway in 2019.
Read more: *www.stemm-ccs.eu* ■

Saving time with Fusion 2 onboard Subsea 7's *Seven Borealis.* Photo from Subsea 7.

REWRITING THE RULES

FUSION 2 IS NOT JUST SIMPLIFYING OFFSHORE SURVEY OPERATIONS, IT'S CHANGING HOW PEOPLE OPERATE, FOR THE BETTER. MIKE CLARK, GLOBAL SURVEY MANAGER, I-TECH 7 (SUBSEA 7'S LIFE OF FIELD BUSINESS UNIT), TOLD BASELINE ABOUT THEIR ROUTE TO DEMONSTRATING REDUCTIONS IN OFFSHORE VESSEL SCHEDULES FOR SUBSEA 7'S DEEP WATER FIELD DEVELOPMENT PROJECTS USING THE REAL-TIME SLAM CAPABILITY IN FUSION 2, WHILE OUR SURVEY SUPPORT GROUP MANAGER, SIMON WATERFIELD, DELVES INTO THE TECHNICAL DETAIL.

There is a need to be smarter and more efficient, reduce vessel days, increase safety and lessen our environmental footprint – all without losing accuracy and reliability in our subsea positioning. To make significant steps to address these requirements, we need to use the opportunities presented by technology to change the way we operate.

The underwater survey and construction industry can be quite risk-averse, especially to changes in procedures and methods. And rightly so. The potential negative impact of a downtime or rectification event on a subsea construction project means that trusted equipment and techniques are frequently preferred in the heat of an operation, instead of new technology and methods.

But, if you could both reduce the number of Compatts you need put down for a Long BaseLine (LBL) array for a pipeline installation project and reduce your calibration routine, saving not just hours, but days of vessel time, without compromising positioning accuracy, why wouldn't you?

By adopting Sonardyne's Fusion 2 all-in-one software platform for inertial navigation system (INS) and LBL operations, i-Tech 7 have been able to do just this. Between August and November 2019, a minimum of 11 vessel days were saved across five separate deep water (1,000–1,500 m) projects in the US Gulf of Mexico, by taking advantage of Fusion 2's real-time SLAM (simultaneous localisation and mapping) capability.

Choosing to operate a sparse LBL on paper delivers a reduction of Compatts. However if the sparse array cannot be calibrated using traditional LBL baseline calibration, the benefit can be lost due to the extra time that has to be spent performing additional 'box-ins' or collecting data and attempting to perform a post processed SLAM position of the Compatts.

This isn't the case with real-time SLAM where you can reduce the number of Compatt transponders used to create the 'sparse' LBL array and then also calibrate those Compatts by flying the ROV through the array, acquiring the necessary observables to SLAM the array.

With careful planning, this SLAM process can be done during other ROV survey operations, such as pre-lay surveys, thus removing an the entire baseline calibration work flow from the project schedule, by using real-time SLAM.

BACK TO THE FUSION FUTURE

But, first let's take a step-back. How did we get here? At i-Tech 7 , we are always looking for ways to improve our operations whilst managing risk and reducing complexity. That can mean taking a staged approach – assessing the options, undertaking trials and working with technology suppliers to ensure what's introduced will work.

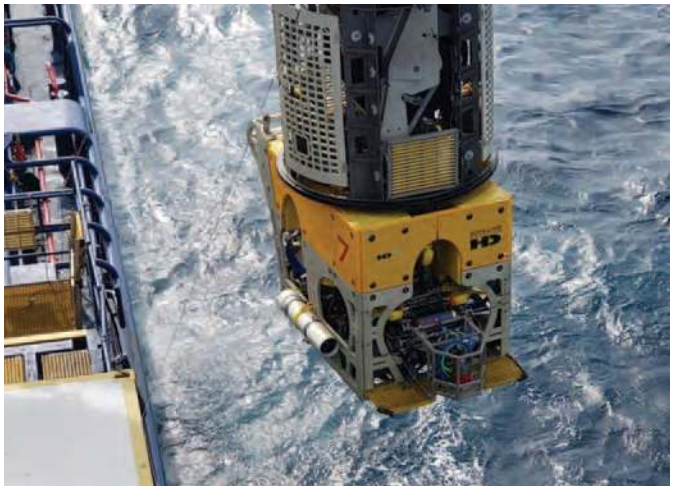
In recent years different combinations of subsea positioning technologies have been used in support of survey and construction projects that, whilst delivering an incremental improvement, have also resulted in increased complexity in integration and operation. There have been separate INS and LBL solutions requiring to be integrated via online navigation software, as well as the added complication of the physical mounting, calibration and interfacing of INS and Doppler velocity logs (DVL) on remotely operated vehicles (ROVs). The increased complexity adds cost in training and support, as well as increasing risk through having to control many separate parts from different vendors.

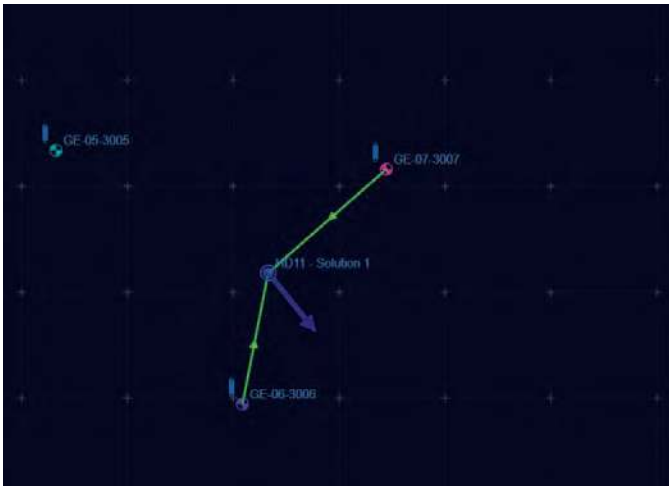
Co-locating a Sonardyne SPRINT INS with a separate DVL on to our ROVs was a first step in reducing the complexity. Using SPRINT enabled us to work more closely with Sonardyne to optimise sparse LBL operations, reducing the number of Compatts required for an LBL array by 50–66%, with Sonardyne post-processing SLAM calibrations for us. We were doing this back in 2017, with the support of Sonardyne while they refined their INS algorithms for both tracking and calibration. Then, in 2018, we introduced SPRINT-Nav on to our ROVs, further reducing integration complexity and increasing navigation and positioning performance.

All the experience and knowledge learned since our first use of SPRINT INS in 2012 has enabled Sonardyne to build SLAM calibration routines directly into Fusion 2. That's the step that's taken the simplification to a new level, enabling real-time SLAM operations in our 2019 projects – with more efficient trajectories.

REAL-TIME BENEFITS

The benefits of real-time sparse LBL SLAM are quite simple. Having already reduced the number of Compatts we need for an array – reducing how much time we spend deploying them and calibrating them – we can reduce the time allocated on project schedules for the lengthy box-in routines required in a traditional array.





"Simply looking at the time saved on deploying Compatts and performing box-ins, we estimate at least 11 vessel days have been saved over just five projects".

To give an example, on one of our pipelay projects in 2019, we had three cut-to-length locations, over a 5 km-long corridor, which would have required 14 Compatts and three box-in routines in a traditional LBL array and baseline calibration. For an INS-aided sparse LBL array, which maintained four-Compatt arrays at the critical lay-down locations, we could reduce the total number of Compatts to nine, but would have required seven box-ins. With Fusion 2, and real-time SLAM capability, we were able to reduce the number of box-ins to two, while the rest of the Compatts were SLAM-calibrated during the pre-lay survey with an ROV fitted with a ROVNav 6+ and SPRINT-Nav, removing the need for a dedicated baseline calibration exercise.

In fact, following that pre-lay survey last year, an offshore manager asked one of our offshore surveyors how long the array calibration would take before pipe lay operations could start. The answer? It had already been done.

Simply looking at the time saved on deploying Compatts and performing box-ins, we estimate at least 11 vessel days have been saved over just five projects, all in 1,000–1,500 m water depth. That means operators can get to first oil faster.

In order to demonstrate the accuracy and reliability of real-time SLAM calibration, we deployed the technique on projects that had arrays with full LBL sections, which could be baseline calibrated, as well as sparse LBL arrays, which we SLAM calibrated. On several of these we ran the real-time SLAM calibration and also a traditional LBL calibration, where they overlapped, and compared the results. This showed centimetric agreement and proof that the real-time SLAM is giving us near traditional LBL levels of precision and accuracy.

Throughout the journey to successfully operating, and 'real-time' SLAM calibrating, sparse LBL projects, i-Tech 7 have proved we can be smarter, more efficient, quicker, safer and help lessen the overall environmental footprint of a major subsea installation project – all without losing positioning accuracy and reliability. This technique will continue to benefit our work with Subsea 7 and their customers and will provide a step change in performance wherever we require field-wide LBL accuracies.

The next challenge is enabling i-Tech 7 and Subsea 7 to bring these advantages onto all the projects we can. We're often impaired by legacy industry specifications, which don't always reflect the latest advances in technology, allowing us to conduct operations in a way that can realise the benefits that are available to us today. With real-time SLAM calibration we are shifting from over 30 years of prescribed ways of working and best practice and we now need to consider how we collaborate with operators and validate and qualify the solution for the next 30 years and more. BL

Two-range Sparse LBL tracking, after Compatt 6+ SLAM calibration, using a Schilling HD Work Class ROV (left), fitted with our SPRINT-Nav hybrid navigation instrument.

THE KIT LIST
WHAT'S FEATURED IN THIS STORY

Type 8300 Compatt 6+

What is it?
Compatt 6+ is the new industry standard; a Wideband 3-enabled LBL transponder capable of supporting sparse or full life-of-field survey and construction tasks.

How does it work?
Compatt 6+s measure ranges to each other to better than +/- 7.5mm accuracy. Wideband 3 protocols support ranging and telemetry simultaneously for faster operations such as structure tracking. It's optimised for Fusion 2 and backwards compatible with Fusion 1 setups.

Type 8310 ROVNav 6+

What is it?
ROVNav 6+ is a 3,000 m rated (options for deeper) LBL ranging and telemetry transceiver for use on work class ROVs. It also supports data harvesting and USBL responder modes.

How does it work?
ROVNav 6+ measures ranges from the ROV to a seabed array and structure-mounted Compatts. It supports sparse and full LBL operations and structure tracking with sensor data can run at below two second update rates.

Type 8315 iWand

What is it?
iWand is our portable acoustic 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 deck or on ROVs and subsea structures before deployment.

How will this kit benefit your operation?
Fusion 2 software and 6G+ hardware vastly simplifies and reduces the time needed to conduct construction and survey operations, with less hardware, simpler workflows and fewer interfaces.

SLAM DUNK

DIGGING A LITTLE DEEPER, SIMON WATERFIELD, SURVEY SUPPORT GROUP MANAGER AT SONARDYNE, EXPLAINS HOW REAL-TIME SLAM HAS BEEN DEVELOPED AND WHERE WE'RE GOING.

To do real-time SLAM, a new set of algorithms was developed using raw ranges from Compatt 6+ transponders in the SPRINT INS, which is in turn managed by Fusion 2, all in real-time. All you need is a ROVNav 6+ on your ROV, a SPRINT-Nav (or SPRINT INS and a DVL), and one Compatt 6+ transponder at a known or boxed-in location. Starting at your known location, you then pilot your ROV on a SLAM trajectory, while ranging to the known location and to the Compatts required to be calibrated, to perform SLAM calibrations on each Compatt 6+ in turn – a routine that can be performed concurrently to your pre-lay survey. We have a white paper on what we have learned with regards how to perform SLAM calibrations which is available for people to use for working into their procedures. Just ask us if you'd like to see it.

In a brownfield location, where there are already known positions, and you are, for example, laying a new pipeline for a tieback project into an existing asset, the SLAM process can be further optimised; put a Compatt at that known location and you're ready to SLAM straight away, potentially no box-ins required.

In Fusion 2, the real-time status of the calibration is displayed intuitively and as soon as the SLAM calibration meets your accuracy criteria the calibration can be finished, and you are straight into tracking. There are no delays due to post processing.

ALL THAT, AND THEN SOME

This is still just the start of the journey. We're still evaluating how much scope there is to re-think and simplify survey tasks by taking advantage of SPRINT INS-aided operations in Fusion 2.

We're currently looking at structure tracking. We're releasing a wireless structure deflection monitoring feature inside Fusion 2 and we already have Fast-LBL, enabling up to two second update rates of structures being tracked in full LBL arrays with sensor data – depth, sound velocity, pitch, roll and heading – being streamed wirelessly at the same time. At the moment, you cannot track a mobile Compatt on a structure within a sparse array as you haven't got a SPRINT INS on it. But, you can dock an ROV with SPRINT INS onto a structure whilst you track that in sparse LBL mode during installation. Or why not track an ROV in sparse LBL mode, install sand bags as visual markers to mark the structure landing area, and, knowing the markers are installed correctly, position the structure visually. It's going back to basics but it works. Picking up from Mike, a lot of how we operate is restricted due to operator specifications.

They say we must have a positioning transponder on the structure to land it, but why? BL

• Want to learn more? If you're trained in Fusion 1, all you need is one day on our top up course to be able to be up and running with Fusion 2. We also offer the one day course as a bolt-on to our three-day Fusion 1 courses, or for people with less LBL or INS experience we offer a full three to five day Fusion 2 INS / LBL course. Contact our Training Team at *training@sonardyne.com* for more details.

WHAT ELSE CAN YOU DO WITH FUSION 2?

FAST, FLEXIBLE, MULTI-FUNCTIONAL

FUSION 2 DELIVERS THE BEST POSSIBLE EXPERIENCE FOR YOUR LIFE-OF-FIELD OPERATIONS. PACKED WITH NEW FEATURES FROM FASTER BOX-INS TO REAL-TIME STRUCTURE TRACKING, TO WIRELESS DEFLECTION MONITORING, TO CONFIGURATION-WHILE-RANGING CAPABILITY, FUSION 2 KEEPS YOU AND YOUR PROJECTS ON TRACK, QUITE LITERALLY. HERE ARE JUST SOME OF THE BENEFITS OF USING FUSION 2.

1. Faster box-ins
Complete your box-ins faster and with more assurance thanks to real-time processing and QC. See your ranges coming in, address any issues as they happen. So no more waiting until it's processed then having to re-run a calibration.

2. Structure touchdown
Get more structure position updates, faster. ROVNav 6+ collects all the acoustic range replies from your array and from your mobile Compatt 6+. Fusion 2 continuously processes them to provide the latest positions on screen, with no need to wait for telemetry when landing.

3. Structure deflection
Simplify your structure deflection monitoring with a wireless system. With one Compatt 6+ on each corner and Fusion 2 with a structure deflection module, you have all you need to make sure your critical structures aren't unduly strained during installation.
Easy to install, easy to retrieve, fast, continuous updates.

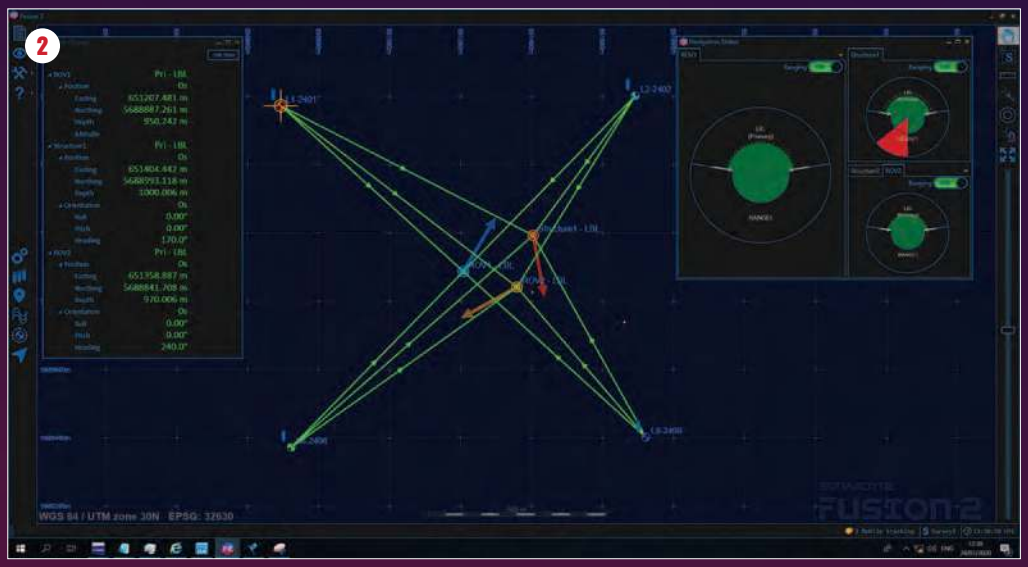
4. Stress-free box-ins
Boxing-in an LBL array can be done using a vessel's pre-installed Ultra-Short BaseLine (USBL) system – even when it's not one of ours. But if the vessel's DP'ing at the same time, survey teams are often prevented from accessing it. With Fusion 2, this disappears as the two systems now don't need to be directly interfaced. Data is simply exported from the USBL for processing.

5. Acoustically derived structure heading
No access to a Gyro Compatt 6? No problem. Get position and orientation with every ranging cycle with just two Compatt 6+s on your structure.

6. Built for Compatt 6+
(Re-)configure your Compatt 6+s on the fly without pausing your range updates. Sensor data comes embedded in your range updates – without interrupting tracking. Now, the same can be done with configuration commands.

Simplified simultaneous operations with multi-user as standard. Up to five addresses available on each Compatt 6+. Enable structure tracking and ROV tracking in the same Long BaseLine (LBL) array, concurrently, from multiple vessels.


1
WGS 84 / UTM zone 30N EPSG: 32630
FUSION2


2
WGS 84 / UTM zone 30N EPSG: 32630
FUSION2


3
FWD-PORT
Depth 89.674 m
Deflection -0.079 m
Penetration --- m
Age 1 s
Orientation
From Gyro From Depth
Roll -0.30° -0.40°
Pitch 0.50° 0.34°
Heading 8.3°
Inclination 0.58° 0.52°
Direction 337.3° 318.9°
FWD-STBD
Depth 89.565 m
Deflection 0.079 m
Penetration --- m
Age 1 s
AFT-PORT
Depth 89.694 m
Deflection 0.079 m
Penetration --- m
Age 1 s
Forward Roll
-0.62°
Port Pitch
0.11°
Stbd Pitch
0.57°
Aft Roll
-0.17°
AFT-STBD
Depth 89.664 m
Deflection -0.079 m
Penetration --- m
Age 1 s


4


5


6

TECH

SPOTLIGHT: OUR SUBSEA TECHNOLOGY ESSENTIALS FOR YOUR OPERATIONS

SPRINT-NAV MINI
300 m

SPRINT-NAV MINI
4,000 m

(SHOWN TO SCALE)

SPRINT-Nav SPRINT-Nav Mini

Punching above its weight
When you want survey grade positioning, SPRINT-Nav provides the performance you need; it's in a class of its own. For inspection and intervention vehicle control and guidance, when size, weight and power are key considerations, SPRINT-Nav Mini is the ideal solution for you. Plug-and-play control and guidance in one compact instrument.

SPRINT-Nav Mini performance at a glance


	300 m	4,000 m
Heading Accuracy	0.5° (sec Lat)	0.5° (sec Lat)
Pitch Roll Accuracy	0.1°	0.1°
Altitude Range	0.3 m – 200 m	0.3 m – 200 m
Housing	POM-C	Titanium
Diameter x Height	Ø149 x 215 mm	Ø149 x 215 mm
Depth Rating	300 m	4,000 m
Weight air/ water	3.6 Kg / 0.7 Kg	7.1 Kg/ 4.2 Kg
Update Rate	200 Hz	200 Hz

SPRINT-NAV MINI
ULTRA-COMPACT GUIDANCE AND CONTROL

SPRINT-Nav brought a new performance class in underwater navigation to the market; now we're bringing our leading expertise in the tight integration of INS and acoustics to a whole new range of instruments. This will mean more underwater vehicles can benefit from our advanced guidance and navigation solutions.

First out of the box is our SPRINT-Nav Mini. It's the most compact ROV guidance and control solution in the market, weighing just 0.7 kg in water for operations down to 300 m. Not only does it provide all your standard ROV guidance and control outputs – orientation, velocity, altitude and depth – in a single housing, it goes much further.

It fuses the information from each sensor, giving you fast, precise, robust and fixed frequency outputs, independent of the individual update rates from any one sensor. So, no more drifting off station because your DVL has lost bottom lock and no more depth variation because your pressure sensor is affected by wave action.

SPRINT-Nav Mini does the thinking for you, all in a single plug-and-play unit, supporting station keeping and autopilot. Just plug it in, give it a latitude, and away you go; all with just one cable. It's that easy.

Compact, constant control
SPRINT-Nav Mini is ideal for your inspection and light intervention ROVs, where size and payload capacity can be limited, but you still need robust control. It's a great solution for compact work class systems, as well as light intervention and inspection ROVs that still need a robust guidance solution, but size, weight and power can be a constraint.

You only have to see SPRINT-Nav Mini to get it. In fact, it's so compact it fits easily on an A4 page – at full scale – with space to spare. It's a third smaller than competing systems in the market and has far lower power requirements. Our 300 m depth rated SPRINT-Nav Mini weights just 3.6 kg in air, thanks to its corrosion free POM-C (polyacetal copolymer) housing. It's perfect for applications where you're not going deep, where vehicle payload is restricted and where you don't need the highest level survey-grade solution. If you are going deep, the 4,000 m rated SPRINT-Nav Mini – which comes in the same ultra-compact form factor – is also a great choice.

Plug in and play
Traditionally, you've had to choose between integrating separate instruments, providing AHRS, DVL and depth, or integrating a potentially complex and less cost-efficient aided-INS solution. Now, you can benefit from the robust performance of a hybrid acoustic-inertial solution, without the complexity. Tight integration with the DVL and pressure sensor enables SPRINT-Nav Mini to provide orientation, velocity, altitude and depth; free from noise and immune to short term DVL acoustic outages. When you have these messages, including quality metrics, at a constant output rate of up to 200 Hz, your vehicle guidance and control is improved – making autopilot systems far more reliable. It's also all from one manufacturer, so support is simpler.

SPRINT-Nav Mini comes bundled with a quick-start guide, mounting hardware and an easy to use Web UI, which provides an intuitive dashboard view as well as configuration and detailed status pages for integration and troubleshooting. So we're confident you'll be up and running, trouble free.

Choosing and integrating any new technology in vehicle platforms can have its challenges. Our Applications Group and Survey Support Group are two specialist teams within Sonardyne that are on hand to support you, from product selection and commissioning to day-to-day operational project planning.

MARINE COMPUTER
THE POWER BEHIND OUR SOFTWARE

The Marine Computer is our most powerful computer yet, designed to effortlessly run all of your Sonardyne software applications, from Fusion 2 to Ranger 2 and everything in between. It's our first computer certified to DNVGL-CG-0339 so it's suitable for use on ships' bridges and is built to withstand harsh operating environments where dust, vibration and constant high temperatures are present.

It's also our first fanless computer, powered by an Intel eighth generation CPU and 512 GB solid state disk. Temperature tolerant components contribute to its impressive operating range spanning -15°C to 70°C. All this makes the Marine Computer an extremely versatile and reliable tool in virtually any marine installation condition: desk mounted, in a small survey boat; within a ship's bridge console; or, when supplied with a custom 2U chassis, mounted in a server room rack.

The Marine Computer is available to order now and replaces our familiar blue Navigation Computer which has been discontinued. But, don't worry, support for your Navigation computers will still be available. Contact your local Sonardyne office for price and availability.

MODEM 6
LINKING YOU TO YOUR DATA

Modem 6, a reliable and cost-effective tool for simple point-to-point wireless underwater sensor data transfer. Use with multi-parameter loggers, current profilers, CTDs and more. Available in different sizes, depth ratings and frequency bands (MF 21-32.5 kHz and LMF 14–19 kHz), there is a Modem 6 suitable for many data retrieval needs.

Modem 6 runs on our Wideband 2 signal architecture, so you'll achieve a secure acoustic communications link, in all marine environments. Using robust, digital spread spectrum signals and intelligent data packet stitching, data throughput is maximised (200–9,000 bps), delivered error free with minimised latency.

Modem 6 also uses the same field-proven technology as our Sixth Generation (6G) product range, so you can use it with other 6G instruments that support location or remote data harvesting functions. For more complex functions, such as precise positioning, on-board sensors or complex multi-node array telemetry, we have other solutions for your needs. Get in touch so we can identify the right solution for your project.

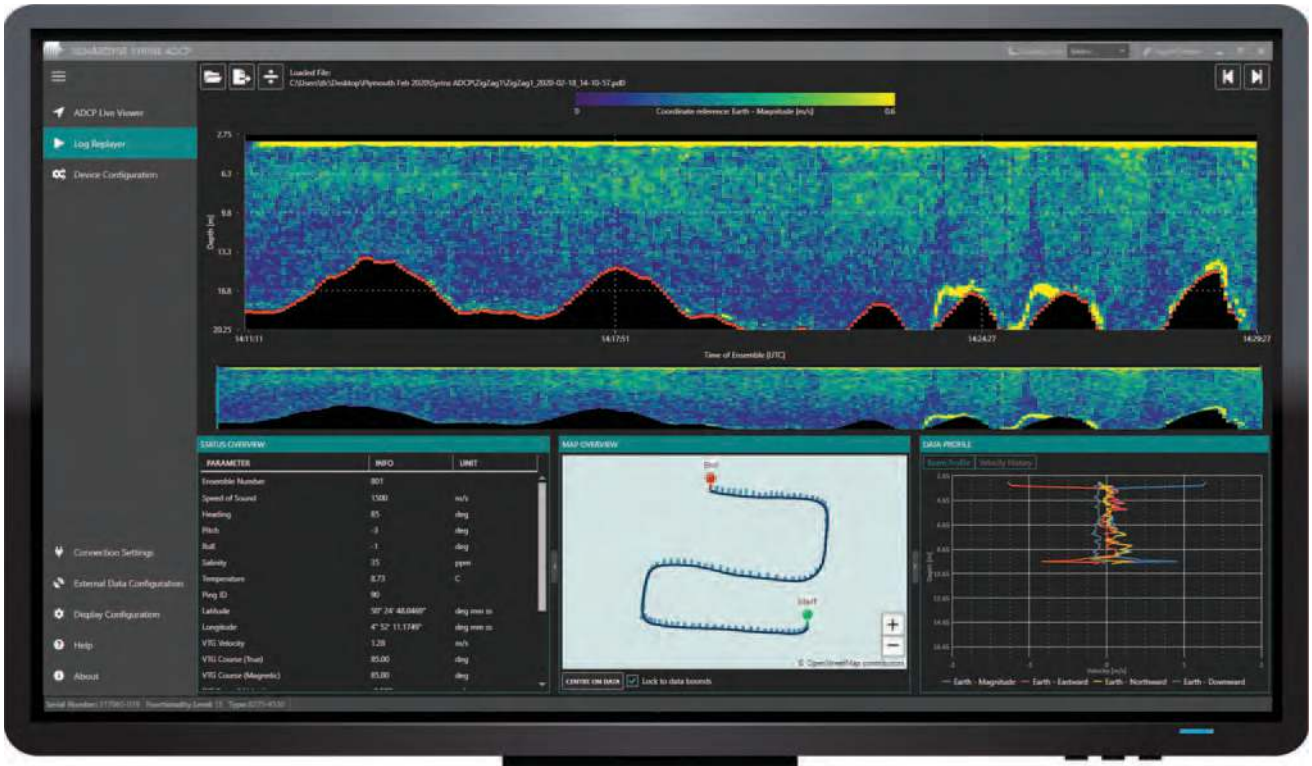
GYRO USBL
LIGHTER, SMALLER, JUST AS CAPABLE

Ultra-Short BaseLine (USBL) system performance is critically dependent upon knowing the heading, roll and pitch of your vessel relative to your acoustic transceiver. Our Gyro USBL does this all-in-one – and it's now lighter and smaller, opening new opportunities to use it. Using the experience gained from designing complex and compact sensor assemblies for our SPRINT INS (inertial navigation system), we've built a second-generation Gyro USBL.

Depending on the variant you choose, it's 20-30% shorter and 9-19 kg (15-40%) lighter than the design it's replacing. Inside, it's still our tightly integrated 6G High Precision Transceiver (HPT) and Lodestar AHRS (Attitude and Heading Reference System) – a combination engineered to meet any project specification you present it with.
A smaller, lighter Gyro USBL brings more and easier installation options. With height shaved off, it will now fit into tighter spaces, like small sea chests, where the original one might not have. With the weight reduction, it's easier to handle, including when fitting to the end of an over-the-side pole or a pipelay stinger, reducing your HSE risk.

Standard and +
We're offering two versions, standard and +. The first will cover your entire standard USBL operational needs at the same price as our first generation Gyro USBL, but with the added benefit that it now comes in-water pre-calibrated, at no extra cost. So, just fit your Gyro USBL and go – saving time and operational costs. It's also perfect for installing on USVs and forms a powerful package when used with our Ranger 2 USBL and Marine Robotics Pack for tracking your underwater assets. Gyro USBL + is for when you need that extra reach during challenging operations, such as tracking towfish or autonomous underwater vehicles (AUVs) at extreme lay backs. This version can also be used for DP-INS operations.

Both versions are available in two different arrays designs, HPT 5000 and HPT 7000, just like our first generation Gyro USBL. They'll also still be manufactured in corrosion-resistance aluminium-bronze, so ideally suited to use in any waters.



SYRINX DVL/ADCP
GOING TO ANOTHER LEVEL

Measure the current and your speed over ground, simultaneously. Combine your Doppler velocity log (DVL) and current profiling capability, to constrain your position uncertainty. Continue navigating, even when other navigation aids, such as GPS, bottom lock or acoustic ranging, are unavailable. Or just measure current profile over ranges of 0.4 m to 80 m.

These are some of the capabilities that our Syrinx 600 kHz DVL now provides for your underwater vehicle operations, on its own or integrated with our class-leading SPRINT-Nav hybrid navigation instrument.

That's because our Doppler engineers have spent the last year extending Syrinx's capabilities. So now, all Syrinx DVLs will be able to perform acoustic current Doppler profiling (ADCP), as an optional capability, with just a firmware upgrade. That means you can do ADCP profiling with your Syrinx. You can also do dual ADCP/DVL with your Syrinx; without compromising your bottom track. When integrated into our SPRINT-Nav, ADCP functionality within its inbuilt Syrinx DVL really comes into its own; you can get absolute profile velocities while maintaining SPRINT-Nav's class-leading navigation performance.

With ADCP functionality, SPRINT-Nav enables you to collect profile velocities in the most challenging conditions. This is because we tightly couple the Syrinx and SPRINT INS (inertial navigation system) data. When bottom track is not available, inertial velocities from SPRINT are used by Syrinx to compensate the ADCP water column velocities for vehicle motion. The result? Absolute water velocities through the local water column, even when you have no DVL bottom lock.

This offers huge benefits when working in or ascending/descending through deep water, out of the DVL's 175 m range, because the vehicle is still able to use the current profile data to minimise its navigation uncertainty.

Furthermore, by using your SPRINT inertial data, you're getting velocities independent of your bottom track, so you can also see when your DVL might be subjected to a systematic bias introduced by fluid or moving seabed conditions.

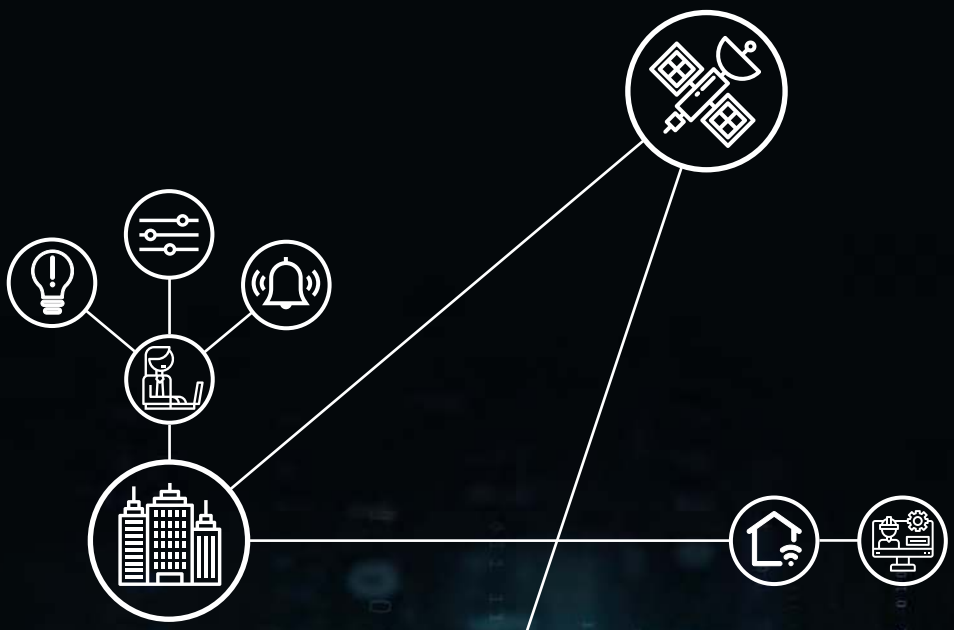
This is all easy to view in your data because we're also providing an intuitive application, Echo Observer for Syrinx, which allows you to inspect and QC your ADCP data in real time, and perform useful analysis and data processing offline.

All our new ADCP enabled and upgraded Syrinx DVLs also support an extended PD0 data format, which means it's compatible with most industry standard processing software. So there's no need to modify or change your existing setup. The extended PD0 format also supports inclusion of inertial velocities, enabling comparison with bottom track and profile data.

Get in touch to find out how to upgrade your existing Syrinx. It's a simple firmware upgrade we can do for you. If you're buying a new Syrinx DVL, we'll be offering the new capability already installed for a limited period, so you'll be ready to go, right out of the box. Contact your local office for a quote and delivery times.

Sonardyne
SOUND IN DEPTH

SUBSEA TECHNOLOGY



Seabed to shore, your data delivered.

We're growing and evolving. In organisational structure, in the markets we serve, in the waters where we work, in the technologies that we pioneer, and in the services that we offer. Through this transformation, our business has never been better equipped to help your vessels and unmanned platforms acquire and deliver data from the seabed to the shore, driving faster and better-informed decision making. And we're doing this more safely, responsibly and efficiently than ever before. Independent with global footprint, we are also now part of a group of companies, working in partnership and at scale, focussed on unlocking even greater possibilities within the marine space. Let us show you how.

SONARDYNE.COM

POSITIONING
NAVIGATION
COMMUNICATION
MONITORING
IMAGING