THE CUSTOMER MAGAZINE FROM SONARDYNE
ISSUE 18

Baseline

FOR THIS ISSUE of Baseline, we're joined by guest authors who give their account of solving subsea challenges with Sonardyne technology. Jeff Morin, Senior Scientist with environmental solution experts RPS Ocean Science describes how planning deep water drilling campaigns can be greatly facilitated through a good understanding of ocean bottom current patterns. But what happens when your client wants the data recovered in real-time? You'll find the answer in Jeff's case study on page 18.

Then on page 22, a team from the GE group of companies talk all things SMART. They explain that to compete in today's climate of energy price instability, operators and contractors can benefit from data-driven solutions to increase their operations visibility, optimise lifecycle management and reduce costs of maintaining offshore equipment. Drawing critical insights from operational data is a crucial first step. If you'd like to feature your project in a future issue, then drop me an email: david.brown@sonardyne.com

This summer, we've seen a number of major projects coming to fruition. On page 14, Graham Brown wraps up a story that first appeared in Baseline Issue 12, describing the journey an ETI-funded project has taken from concept through to demonstration of a carbon storage integrity monitoring capability. Meanwhile, Geraint West's report on page 26 looks at how AMTs have for the last two years been helping German research institute GEOMAR gain a better understanding of how plate tectonics are moving in a project that spans from Europe to South America.

It may surprise you that we use the same gyros in our SPRINT product line as you'll find in a commercial airline. You can find out more in KIT, from page 4 onwards, where we round up everything that's new. Until next time,

David Brown Editor

Baseline » Issue 18

Front Cover
Fetch deployed by Scripps Institute of Oceanography offshore Oregon, USA for monitoring tectonic motion in the Cascadia subduction zone. The Fetch is precisely positioned using Sonardyne 6G acoustics from a Wave Glider. Photo: C. David Chadwell / WHOI ROV *Jason*

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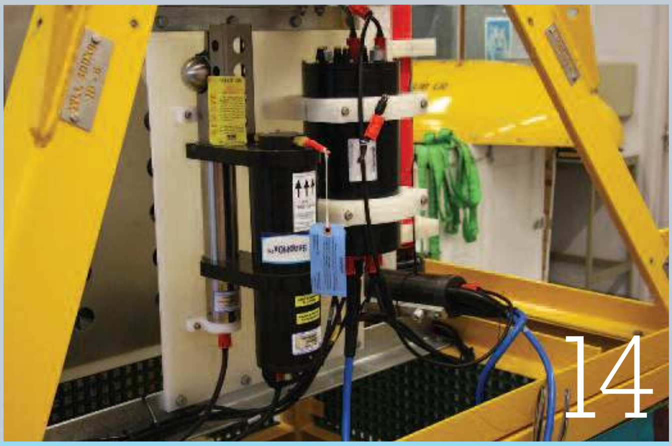

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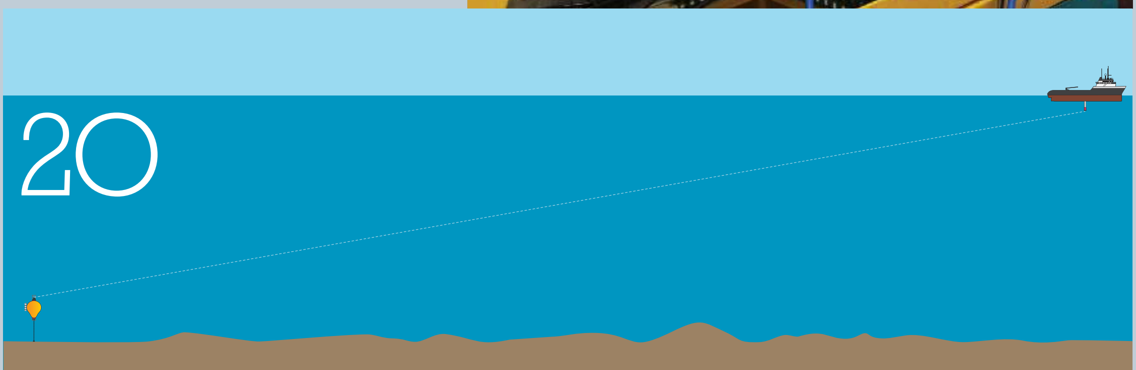

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Baseline Magazine
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Sonardyne
SOUND IN DEPTH

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»KIT

Our latest subsea technology and services

SOFTWARE

Unlock the capability of your vehicles with Ranger 2 Marine Robotics Pack

Resident semi-autonomous systems, swarms of micro Autonomous Underwater Vehicles (AUVs) and Unmanned Surface Vehicle (USV) systems working in tandem with subsea assets. Not so long ago, these were operational concepts within marine robotics but today, they are becoming the norm. That's why it's important to invest in subsea technology that can grow in functionality as your operational needs change. Our Mini-Ranger 2 and Ranger 2 USBL systems are good examples as both are now available with a dedicated Marine Robotics software pack. Used in conjunction with an AvTrak 6 multi-function transceiver on your vehicle, the pack unlocks a host of features far beyond simple target tracking. Features such as Data Exchange – used to enable modem functionality utilising Wideband 2 digital signal processing supporting user data rates from 100 to 9000 bps; or the Common Interrogate mode where your USBL transceiver can be used to broadcast messages to a whole swarm and then listen to all the individual AUV responses; and the Time Synchronisation feature which can be used to synchronise all the clocks in the swarm while submerged – vital in long duration missions. The Robotics Pack also comes equipped with a Remote Control interface that enables you to operate it via an Ethernet port suitable for Unmanned Surface Vehicle (USV) integration. You'll need to upgrade to the latest version of Ranger 2 software and update your system's security dongle. Contact your local Sonardyne office or email our customer support team **support@sonardyne.com**

The new Marine Robotics pack for Mini-Ranger 2 and Ranger 2 USBL systems unlocks many features to track, command and communicate with your robots.

TRANSPONDERS

SST 6 – Setting new standards of back deck and operational efficiency for OBS and nodal surveys

Offering high-performance, small-size, low-cost, ease of programming and rugged design our new SST 6 (Small Seismic Transponder 6) is purpose built to position your ocean bottom seismic cables and nodes. SST 6 operates in the Medium Frequency (MF) band so is compatible with the global fleet of survey vessels already equipped with our Ranger 2 USBL system. Together, Ranger 2 and SST 6 enable the position of seafloor targets to be determined very quickly and at a high update rate, saving vessel time and new standards of

SST
383 mm x 63 mm
3,000 m depth rated

Measuring just 56 mm by 88 mm, Nano DiveTrak 6 OEM is optimised for swim boards.

NAVIGATION AND COMMUNICATIONS

Nano DiveTrak 6 keeps divers and dive masters on course

A new navigation and communications acoustic instrument will soon be available for naval, police and scientific divers to enhance operational capability. Nano DiveTrak 6 is supplied specifically for integration with 'tactical swim boards,' a device many specialist underwater units currently use. Depending on the mission, these can be configured with sensors including imaging sonars and motion reference units. Nano DiveTrak 6 now adds bi-directional tracking and through-water communication to the options list. It supports telemetry and range information using the same acoustic signal. This means not only can a dive master on the surface know exactly where each diver is, the divers themselves have their position sent back to them with each update cycle as a message. The dive master has the option of sending individual text messages of any character length to any diver, helping divers to manage their dive and re-directing them if required. Messages can be broadcast to all the divers in range – enabling a quick reaction if required. Divers can also send status information and urgent pre-defined messages to the surface. Nano DiveTrak 6 is supplied to swim board manufacturers as an OEM board set built around a PCB that measures just 88 millimetres by 56 millimetres. On the surface vessel, you'll need a Mini-Ranger 2 or Ranger 2 USBL (Ultra-Short BaseLine) tracking system which have the capability to position and communicate with underwater targets over long distances, even in challenging environments. For expected availability, contact sales@sonardyne.com

efficiency for seismic operations. The Sonardyne Wideband technology inside SST 6 offers improved performance in challenging conditions such as at long range, high elevation and long layback tracking, with performance diagnostics provided for quality control. Another benefit of the SST 6 is its programming ease and flexibility. Any one of 16 group interrogation addresses and 50 reply channels provide more than 800 unique acoustic identities which can be quickly programmed into each transponder using Near Field Communications (NFC). This lends itself to the marking of seismic cables and other applications demanding dense transponder coverage. The NFC link provides the ability to enter SST 6 into a storage mode when not in use, significantly increasing overall battery endurance.

»KIT

TRANSPONDERS

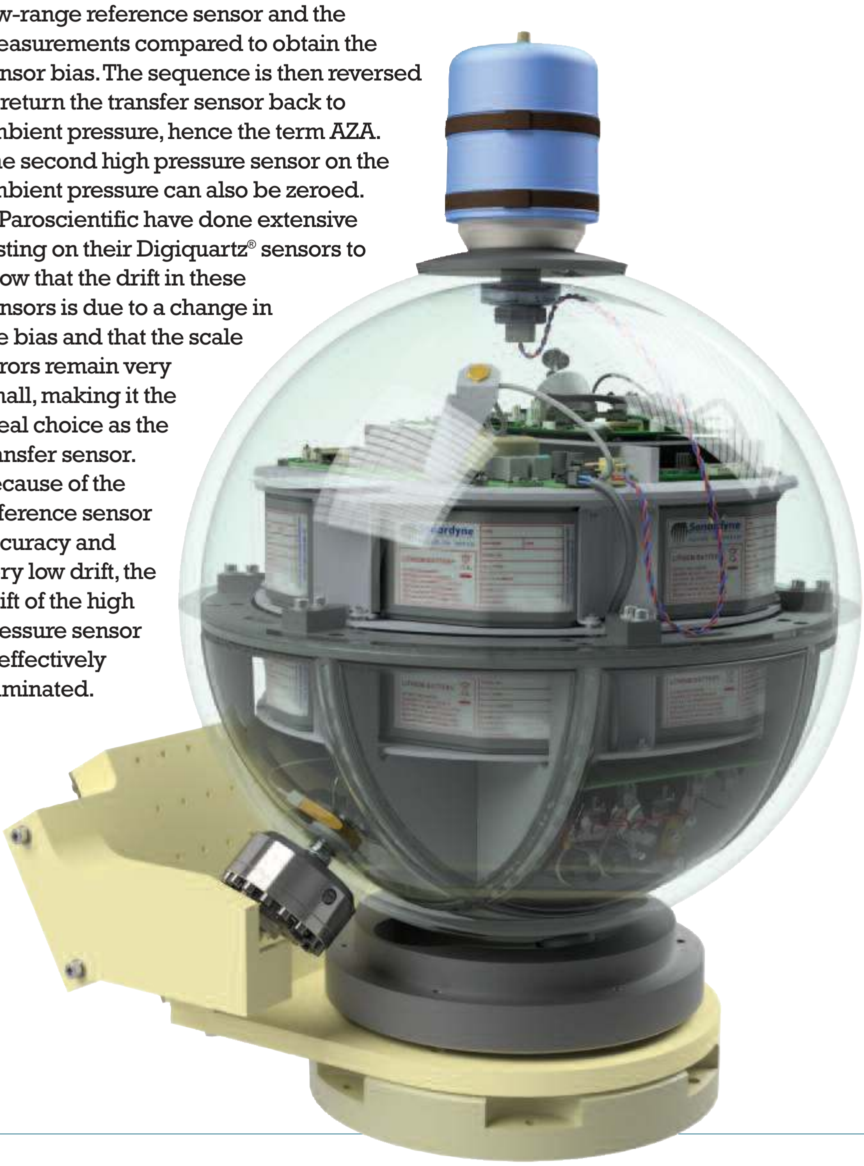
From ambient to zero and back. Fetch AZA helps solve the problem of pressure sensor drift

Transponders equipped with pressure (depth) sensors are a cost-effective way of monitoring seabed subsidence caused by hydro-carbon extraction or plate tectonic motion. However, despite the best efforts of manufacturers, all pressure sensors drift to some degree similar to or even greater than the actual subsidence signal – potentially between 2 cm and 20 cm/year in 2,000 metres of water. That's why it's important to regularly recalibrate pressure sensors but with monitoring transponders ideally deployed continuously for many years, this isn't viable.

The solution is Fetch AZA (Ambient-Zero- Ambient). It uses a patented system of two motorised valves, a pump and a reference sensor to measure the depth sensor offset sensor in situ, eliminating the need to recover equipment mid-survey. The extra long-life battery pack offers a continuous 10 year operating life.

Inside, there are two high pressure sensors normally open to the ambient pressure. One of these pressure sensors, the transfer sensor, is isolated from the ambient pressure by closing one of the valves, the pressure is then gently reduced to near zero. The second valve is then opened to connect the transfer sensor to the low-range reference sensor and the measurements compared to obtain the sensor bias. The sequence is then reversed to return the transfer sensor back to ambient pressure, hence the term AZA. The second high pressure sensor on the ambient pressure can also be zeroed.

Paroscientific have done extensive testing on their Digiquartz® sensors to show that the drift in these sensors is due to a change in the bias and that the scale errors remain very small, making it the ideal choice as the transfer sensor. Because of the reference sensor accuracy and very low drift, the drift of the high pressure sensor is effectively eliminated.



INERTIAL NAVIGATION

SPRINT flies with Honeywell inside

When our engineers selected the ring laser gyros (RLGs) and accelerometers for our hybrid acoustic inertial navigation product family, renowned sensor manufacturer Honeywell was at the top of the list.

Each SPRINT uses three Honeywell GG1320AN RLGs and three QFLEX accelerometers. The GG1320AN has been in production since 1995 and today there are more than 350,000 in service. It is *the* standard navigation gyro in almost all Airbus and Boeing airliners and is also used on many other marine vehicles, aircraft, satellites and space vehicles.

Sensor life is a key focus at Honeywell which is why the company initiated a life program for the GG1320AN more than 15 years ago. Extensive analysis of gyro field data, as well as life data taken on in-house gyros under long term test, has shown that RLGs produced today will have lifetimes, on average, of greater than 100,000 hours. Civilian aircraft usage of GG1320AN has also given Honeywell an excellent opportunity to measure the random failure rate (different from longevity or wear-out life) of gyros in inertial systems. This analysis supports a mean time between failure (MTBF) in excess of 400,000 hours.

At 436,000 hours, MTBF for the QFLEX accelerometer is equally impressive with very few returns of accelerometers being seen over the life of an aircraft – typically 25 years. These sensors provide an unparalleled mix of technical performance, proven reliability and longevity and low cost of ownership from aerospace to subsea.

So next time you're on a flight, remember that the sensors helping to navigate your aircraft, are also perfect for piloting your subsea vehicles.

SOFTWARE

Ranger 2 equipped to track down lost 'black boxes'

As you'll read on page 13 of this issue of BaseLine, when tragedy strikes and a commercial aircraft is lost over water, the race begins to find and recover its flight data and cockpit voice recorder, commonly known as black boxes. Our Mini-Ranger 2 and Ranger 2 USBL underwater tracking systems come equipped to help as they're able to detect the acoustic signal being transmitted from the 37.5 kHz pinger attached to every black box. Ranger systems are in service around the world and can quickly be mobilised on vessels-of-opportunity.

Improvements have now been made to the pinger tracking tool in 6G Terminal, the utility tool that comes as part of every Mini-Ranger 2 or Ranger 2 software installation. The user interface has the addition of a real-time spectrogram to show any significant noise sources which can then be tracked by the USBL transceiver using a simple click. This combats the variable frequency of black box pingers whilst still allowing any frequency from 14 to 45 kHz to be tracked by dialling up the known frequency. Full instructions are contained in the 6G Terminal Lite manual.

INERTIAL NAVIGATION

Janus software; Looking backwards to look forwards

New features in the latest release of Janus include support for the SPRINT-Nav beam level DVL solution (SPRINT and Syrinx), manual position aiding (XPOS) and TOA (Time Of Arrival) setting for USBL data.

Janus is our quality control and post-processing software tool that's widely used to support projects using SPRINT acoustically aided inertial navigation system.

It works by utilising the raw data from SPRINT to replicate the real-time navigation solution which can then be optimised using Janus's advanced smoothing algorithm and outlier rejection functionality. This eliminates systematic errors such as incorrect lever arms or mounting angles.

USBL/GNSS data external from the SPRINT system (reprocessed) can be imported into Janus and used for aiding in the post-processed navigation solution. Real-time and post-processed navigation solutions can be exported into your survey suite from Janus using the six available export files that are compatible with Navipac, Winfrog and QINSy. You can even create your own custom export strings for optimal integration.

As well as being used for navigation solutions, Janus is also used to diagnose system and operational issues by displaying the health status of SPRINT's algorithms, communication ports and internal electronics for remote analysis. The calibration of DVL-to-SPRINT mounting angles is performed offline in Janus, providing a calibration file that is directly imported into the SPRINT system.

Before

After

NEWS

MARINE ROBOTICS

SPRINT selected for MBARI's Ventana and Doc Ricketts ROVs

SPRINT inertial navigation technology has been selected by the Monterey Bay Aquarium Research Institute (MBARI), for its deep-rated remotely operated vehicles (ROVs), *Ventana* and *Doc Ricketts*.

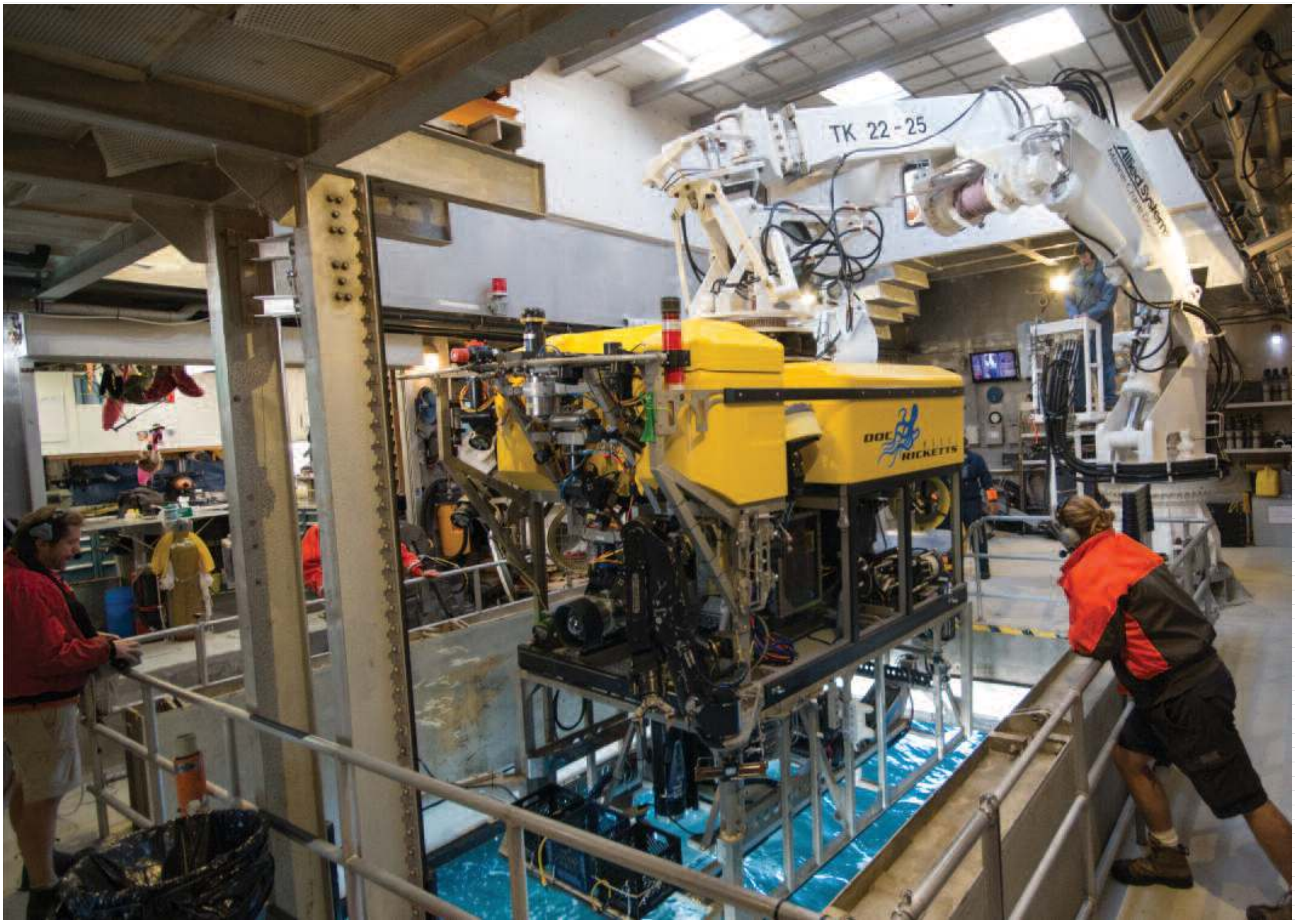
Supplied through our Houston office, the SPRINT systems will be used with MBARI's existing Ranger 2 acoustic tracking systems to improve the accuracy, precision and integrity of subsea vehicle positioning in water depths up to 13,000 feet. The SPRINT for *Ventana* has already been installed and commissioned whilst the unit ordered for *Doc Ricketts* is scheduled to be delivered in the coming months.

Located in Moss Landing, California, MBARI is recognised as a world centre for advanced research and education in ocean science and technology. To support its work, it has at its disposal a wide range of marine technology and assets including the *Ventana* and *Doc Ricketts* and the research ships which serve as their support vessels, *Rachel Carson* and *Western Flyer*.

"The need for both accurate and multiple means of subsea navigation is a priority for all missions involving marine robotic platforms."

Now in its third generation, SPRINT's high-grade inertial sensors make optimal use of acoustic aiding from data sources including USBL, LBL and Doppler Velocity Log (DVL) and pressure sensors to extend operational capability and improve vehicle control. Uniquely, SPRINT supports dual gyrocompass and INS operating modes, meaning that ROV pilots and science teams are able to simultaneously rely upon its output.

Commenting on the order, Kim Swords, Senior Application Engineer in Houston said, "The need for both accurate and multiple means of subsea navigation is a priority for all missions involving marine robotic platforms. SPRINT has been helping to do this now for more than 10 years, delivering class-leading performance that helps strengthen the value of the observations and data gathered by ROVs and AUVs."



Deploying *Doc Ricketts* for its next ocean science mission into the depths of Monterey Bay canyon.

MARITIME SECURITY

Sentinel installed to protect new ME energy facility

A **new Critical National** Infrastructure (CNI) facility in the Middle East is now protected from unauthorised access from the sea with Sentinel, our best-selling diver detection sonar.

Working with our local in-country technical partners, the programme of work included site surveys, the installation of multiple in-water sonars and redundant control room equipment in order to provide uninterrupted situational awareness over a large waterfront.

Power plants, dams, gas storage terminals and offshore oil platforms represent attractive targets for sabotage. Most sites have comprehensive above-the-water security systems such as physical barriers, access control, surface radar and long range opto-electrical sensors. However, many are vulnerable to intrusion from the water, and in particular, from below the surface.

Sentinel closes this gap. It reliably detects, tracks and classifies divers and small underwater vehicles approaching a protected asset, alerting security personnel to the potential threat. With a track record spanning more than 10 years, it's widely regarded as the security industry's most extensively deployed diver detection sonar.

The small, lightweight design of Sentinel's in-water sonar unit makes it ideal for mobile security operations but for this contract, our in-country partner installed the sonars on permanent seabed mounts placed in key locations around the shoreline. Each sonar is designed to provide 360 degrees of coverage and provides long range warning of incoming targets for the local security personnel to intercept the threat. It is even able to determine, with a high degree of probability, what type of diving equipment they are wearing; open or closed circuit.

Due to the strategic importance of the new facility within the region, for the first time we were requested to supply dual redundant control-room equipment to ensure uninterrupted service. All equipment was interfaced with the facility's third party C2 (Command and Control) security system.

EXPLORATION

Magseis orders new SST 6 for deep water seismic node positioning operations

Representatives from Magseis during a recent visit to our UK Hampshire headquarters. Left to right – Chis Baxter, Trevor Barnes (Sonardyne), Liam Flood, Ciaran Moore, Stuart French and Jonathan Snook.

N**orwegian seismic services** company, Magseis, has placed a major contract with us for our newly developed SST 6 – Small Seismic Transponder 6 as featured in KIT on page 4.

Seismic surveillance surveys conducted using stationary nodes deployed on the seabed are becoming increasingly commonplace as geophysicists generally agree that this method delivers the highest possible definition reservoir imagery.

However, any uncertainty in node positions can distort these pictures and make the behaviour of the underlying reservoirs more difficult to interpret. SST 6 devices are attached to cables or ropes adjacent to each node, and when used in conjunction with Ranger 2 installed on a surface vessel, overcome this problem by providing high quality, repeatable positioning during node deployment and when landed on the seabed.

SST 6's Near Field Communications (NFC) was one of the features that particularly appealed to Magseis as it allows the units to be checked and programmed without human intervention, supporting the company's continued vision for fully automated and efficient back-deck Ocean Bottom Seismic (OBS) operations.

Speaking about their major investment, Liam Flood, Navigation Manager at Magseis in Oslo said, "We have collaborated with Sonardyne to provide the acoustic positioning infrastructure for our OBS operations since our company was founded in 2009. The scale and capabilities of our vessel operations have increased considerably since then; Sonardyne's latest generation platform, SST 6, will allow us to deploy our seismic nodes quickly and accurately in all water depths up to 3,000 metres."

"Continuous evolution and improvement of our acoustic positioning technologies is a strong conviction held by everyone at Sonardyne so we're naturally delighted that Magseis has again chosen to place their confidence in us," said Shaun Dunn, Global Business Manager for Exploration and Surveillance.

NEWS

MARINE ROBOTICS

Teledyne Gavia charter Plymouth trials facilities to show off Gavia AUV

This summer, our sea trials and training facility in Plymouth, south-west England, played host to marine robotics vehicle manufacturer, Teledyne Gavia. They chartered our 12 metre-long survey vessel, *Echo Explorer*, and her crew to present the capabilities of their Offshore Surveyor AUV (Autonomous Underwater Vehicle) to invited clients.

During daily demonstrations in the shallow waters around Plymouth Sound, the AUV was launched from *Echo Explorer's* back deck and programmed to run survey lines away from the vessel. The AUV's every move was tracked using *Echo Explorer's* Ranger 2 USBL system and a 6G Nano transponder fitted on the AUV for the trial. Position aiding data from Ranger 2 was also telemetered from the surface to the AUV's onboard modem to update its Inertial Navigation System. Post-processing data after the vehicle was recovered showed that by using USBL to aid the navigation solution, improved absolute accuracy.

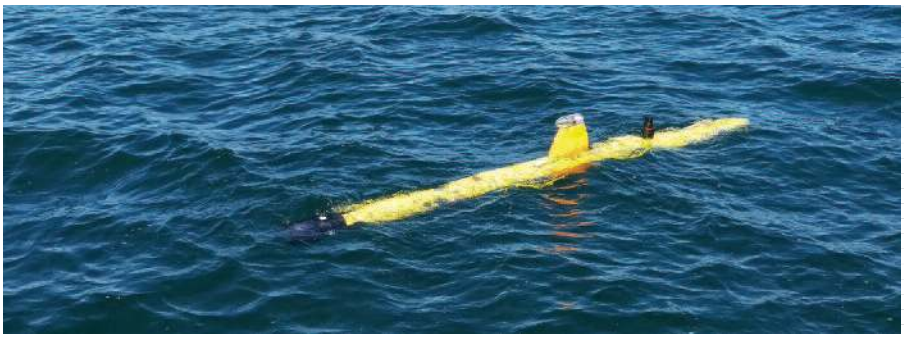
Measuring just 155 millimetres long and weighing 200 grams in water, Nano allows easy and unobtrusive fitment to man-portable AUVs, gliders, micro ROVs and divers. When used with Sonardyne's family of 6G USBL systems, these small underwater targets can be precisely and reliably tracked.

Speaking of the trials, Arnar Steingrimsson, Director of Sales Strategic Business Development – AUVs for Teledyne Marine Vehicles said, "Thanks to the close partnership with Sonardyne's engineering team at their Plymouth facility, we were able to demonstrate Gavia's innovative autonomous technology to our oil and gas customers. Sonardyne's Ranger 2 is a proven technology in the oil and gas domain and was an important requirement for our customer to enable high accuracy navigation during deep water operations of Gavia AUVs. The integrated demonstration confirmed our commitment to meet their requirements."

Ioseba Tena, Global Business Manager for Sonardyne added, "It was a pleasure to welcome the Teledyne Marine team to our Plymouth facilities. We enjoyed the opportunity to work directly with the Gavia AUV and were highly impressed with how simple it was to deploy and recover both the vehicle and the data while aboard *Echo Explorer*. We look forward to continuing this collaboration to satisfy our customers' marine robotic needs."

Visit **plymouth.sonardyne.com** for details on chartering our facilities.

The Gavia AUV's every move was tracked using *Echo Explorer*'s Ranger 2 USBL.



SOCIAL RESPONSIBILITY

Safeguarding shark populations through positive change

Photo: Nick Robertson-Brown

Marine ecosystem conservation is naturally a cause we take very seriously. So when we learnt of the important work being carried out by the Shark Trust, a leading UK charity that aims to safeguard the future of shark, skate and ray populations through positive change, we took the opportunity to get involved with technical and financial support.

Sharks have evolved over millions of years to be highly successful apex predators in our oceans. They're intelligent, highly sensory creatures that play an important role in our complex marine ecosystems. However, many populations are now in critical decline through over exploitation.

Headquartered close to our trials and training facilities in Plymouth, the Shark Trust works from local to global level to push for effective management, enforced protection and responsible trade in shark products.

Simon Partridge, Engineering Director at Sonardyne believes that it is the combined efforts of scientists, industry, decision makers and the public that will help bring about change. "The Trust's work is critically important and involves influencing fishing regulations to minimise by- catch, ensure catch quota are sustainable and reduce waste.
I encourage other companies in the maritime technology sector to also support shark and ray conservation."
Visit **sharktrust.org** to find out more.


Image © Rolls Royce

OCEAN SCIENCE

Ranger 2 for RRS Sir David Attenborough

When it enters service in 2019, scientists aboard Britain's new polar research vessel, *Royal Research Ship Sir David Attenborough*, will be using Ranger 2 USBL acoustic technology to track and communicate with seafloor instruments and marine robotic platforms, including the now famous *Boaty McBoatface* AUV.

Commissioned by British Antarctic Survey, an institute of the Natural Environment Research Council (NERC), and being built by Cammell Laird in Birkenhead to a Rolls Royce design, the *RRS Sir David Attenborough* will be one of the most advanced vessels of its type. Measuring 128 metres long and 24 metres wide, the new ship will have a range of 19,000 nautical miles and be able to accommodate up to 60 scientists engaged in ocean and atmospheric research.

Ranger 2 will support the *RRS Sir David Attenborough*'s pioneering work by enabling science teams to monitor the exact position of underwater systems deployed from the vessel. The exclusive Wideband 2 acoustic signal technology and 6G (sixth generation) hardware platform allows autonomous and remotely-operated vehicles, towed platforms and seafloor landers to be simultaneously and precisely tracked beyond seven kilometres.

Alongside design and engineering services, Rolls Royce is supplying a comprehensive package of control systems and equipment for the vessel, including the vessel's dynamic positioning (DP) system. This will utilise acoustic reference data from Ranger 2 to help maintain a stable vessel position as equipment and vehicles are deployed and recovered in some of the most challenging marine environments on the planet.

Our contract includes the supply of two through-hull transceiver deployment machines, seafloor and vehicle-mounted tracking transponders, and topside control hardware and software. The first equipment deliveries to Cammell Laird for integration into the vessel have already begun.


Photo: NOC

***RRS Sir David Attenborough* and *Boaty McBoatface* will work together to advance polar research.**

The commissioning of the *RRS Sir David Attenborough* represents the UK Government's largest investment in polar science since the 1980s. When the ship comes into service, all three Royal Research Ships, *James Cook*, *Discovery* and now *Sir David Attenborough*, will be equipped with Sonardyne Ranger 2 USBL positioning and target tracking technology.

Speaking of the significance of the contract, Mark Carter, Global Business Manager for Vessel Systems at Sonardyne said, "As a privately-owned British engineering company, it's a great honour for our technology to have been selected for our nation's next polar research vessel." He added, "The work now begins to deliver Ranger 2 and support Rolls Royce, Cammell Laird and British Antarctic Survey through the installation, crew training and commissioning phases of the project."

Geraint West, Global Business Manager for Ocean Science added it was further proof of the science community's trust in Ranger 2 to meet the precise in-water and near-bottom sustained observations in nearshore, coastal and deep ocean waters.

NEWS

OCEAN SCIENCE

Indian Tsunami detection network undergoes 10 year refurbishment

A **network of deep** Bottom Pressure Recorders (BPRs) which for the past decade have provided coastal communities around India with early detection of tsunami waves, have undergone major refurbishment at our UK service centre.

BPRs detect the characteristic changes in water pressure (as little as 1 centimetre in 4,000 metres depth) caused by an earthquake in the deep ocean. If a tsunami wave is detected, an alert message is transmitted up to a satellite buoy on the surface, from where it is relayed to the Tsunami Warning Centre onshore for comparison with recent seismic activity. If validated, a widescale alarm is raised to notify vulnerable communities.

Deployed at key locations in the Bay of Bengal and Arabian Sea, the Indian Ocean Tsunami Detection System is operated by the National Institute of Ocean Technology (NIOT) based in Chennai.

Each BPR in the network is a customised version of our Compatt transponder running an algorithm that compares predicted with actual tidal pressures. Unlike other systems, our BPRs are small and self-contained and thus easy to deploy. This, together with features such as low-power consumption, long battery life and reliable through-water communications, were key factors in NIOT's decision to award us the contract to supply their nation's tsunami detection system back in 2007.

"This work included replacing acoustic transducers, calibrating pressure sensors and updating PCB firmware to the latest specification. All BPRs have now been returned to the field, equipped to provide many more years of reliable service."

NIOT's vessel visits the site of each sensor annually to carry out essential maintenance to the surface buoy and change the batteries inside each BPR – the deepest of which is deployed in 4,000 metres of water.

During their time in service, the BPRs have detected tsunami events on multiple occasions - none of which fortunately caused damage by the time they reached land. However, in reaching the 10 year anniversary, the decision was made by NIOT to recover the BPRs one at a time and return them to Sonardyne for refurbishment and re-certification. This work included replacing acoustic transducers, calibrating pressure sensors and updating PCB firmware to the latest specification. All BPRs have now been returned to the field, ready to provide many more years service.

Speaking about the performance of the Sonardyne BPRs and the contribution they have made to the international science community's understanding of tsunamis, NIOT Project Director Dr. Venkat said, "What started as a concept just after the 2004 tsunami incident, has matured to be a reliable scientific aid to the human race by providing a reliable data and a robust communication between the sea bed and the deep ocean buoys."

(Clockwise) Looking back to 2007 with NIOT's deployment crew and one of the first surface buoys ready to be installed. Cleaning marine growth from surface transceivers is undertaken during regular service visiting to each station. In air acoustic deck testing of a BPR is carried prior to deployment.

DRILLING

Noble Globetrotter I upgraded to latest Sonardyne DP reference technology

Noble Corporation plc, has selected Marksman acoustically-aided inertial navigation technology (DP-INS) for its ultra-deep water drillship *Noble Globetrotter I*. The system is being used to provide a high integrity, independent subsea position reference for the vessel's GE DP3 dynamic positioning system as it drills exploration wells in water depths up to 10,000 feet.

Marksman DP-INS improves vessel positioning performance by exploiting the long term accuracy of our Wideband acoustic signal technology combined with high integrity, high update rate inertial measurements. The resulting navigation output provides accuracy and update rate that can exceed differential GNSS whilst remaining completely independent.

In addition to the system's deep water positioning performance and safety benefits, Marksman DP-INS has been proven to deliver valuable time and cost savings for rig operators. By tightly-coupling acoustic and inertial data, robust, accurate positions can be measured using just two and three seabed transponders depending on the application. This reduces installation and calibration time, and extends transponder battery life as less frequent aiding updates from the seabed transponders are required.

For this installation, Marksman DP-INS was interfaced with *Noble Globetrotter I's* existing Sonardyne acoustic reference system using the same bridge user workstation.

"We're delighted that Noble has once again chosen to invest in our technology to support their vessel positioning and drilling activities," said Dan Zatezalo, Technical Sales Manager at Sonardyne in Houston. He added, "Marksman DP-INS is a mature, field proven technology which meets industry's requirements for a robust, independent DP reference, whilst delivering operational savings for vessel owners."

The first faint signals from the aircraft's locator pinger were detected after three hours.

SURVEY

Scout and ROV-Homer deployed in hunt for helicopter flight recorder

A mission to search for the wreckage of an Irish Coast Guard helicopter which crashed into the Atlantic earlier this year with the loss of all crew, was supported with Scout USBL and ROV-Homer acoustic tracking and relocation systems owned and operated by Ireland's Marine Institute.

Rescue 116, a Sikorsky S92 search and rescue helicopter operated by Canadian Helicopter Corporation (CHC) on behalf of the Irish Coast Guard, disappeared from radar screens at 12.46am on March 14th in the vicinity of Blackrock, an isolated rocky islet off the country's west coast.

As part of the emergency response, Ireland's Air Accident Investigation Unit (AAIU), requested equipment and personnel from the Marine Institute to assist with the initial search for the wreckage. This included the Scout USBL system which was mobilised on a local fishing vessel and onsite within four hours of the institute's team arriving.

Following a three hour search, the Scout picked up the first faint signals from the aircraft's 37.5 khz Dukane underwater locator pinger attached to its flight data recorder (FDR) lying in 40 metres of water. This was despite rough sea conditions and the vessel often operating close to the rocky coastline.

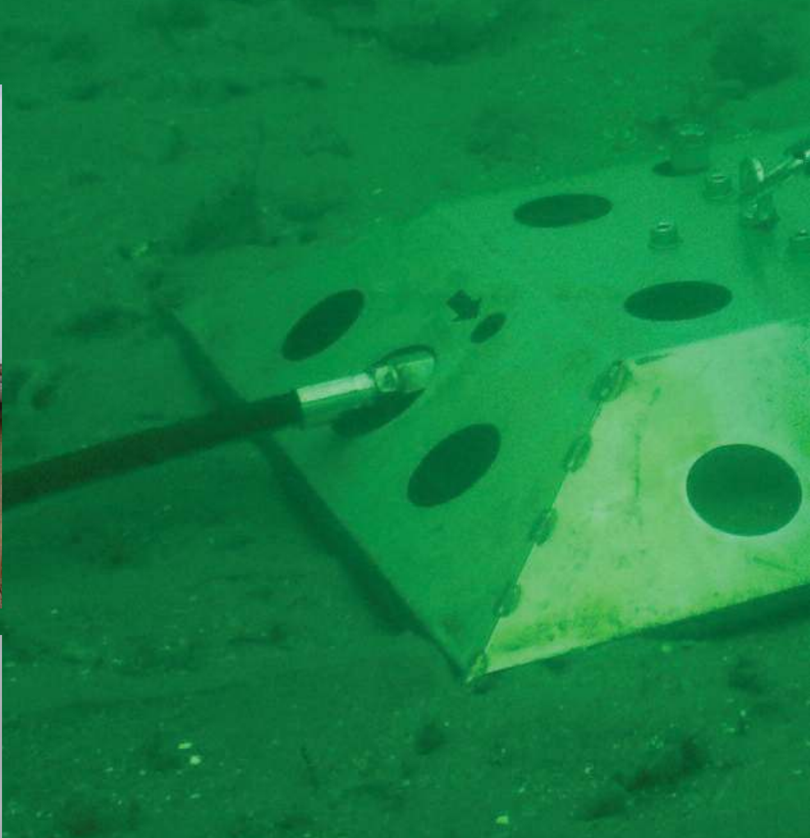
The Marine Institute deployed its Work-class ROV and using guidance from Scout, operators were able navigate it to the wreck site. The ROV was also equipped with a ROV-Homer system which was used to 'home' directly in on the signals from the pinger. To make moving around through the debris field easier for the ROV's pilot, a number of transponders compatible with the ROV-Homer were deployed to act as navigation waypoints. Irish navy divers later recovered the flight recorder which was found to be in good condition and transferred it to the UK for analysis.

Reflecting on the performance of their Sonardyne equipment during this difficult mission, Aodhan Fitzgerald, Research Vessel Manager for the Marine Institute said, "The portable design of the Scout meant that we could rapidly mobilise the system on a small fishing that was made available to us. Despite challenging sea conditions, Scout allowed us to rapidly locate the exact seabed location of the aircraft's FDR whose recovery was crucial to solving the cause behind this tragedy."

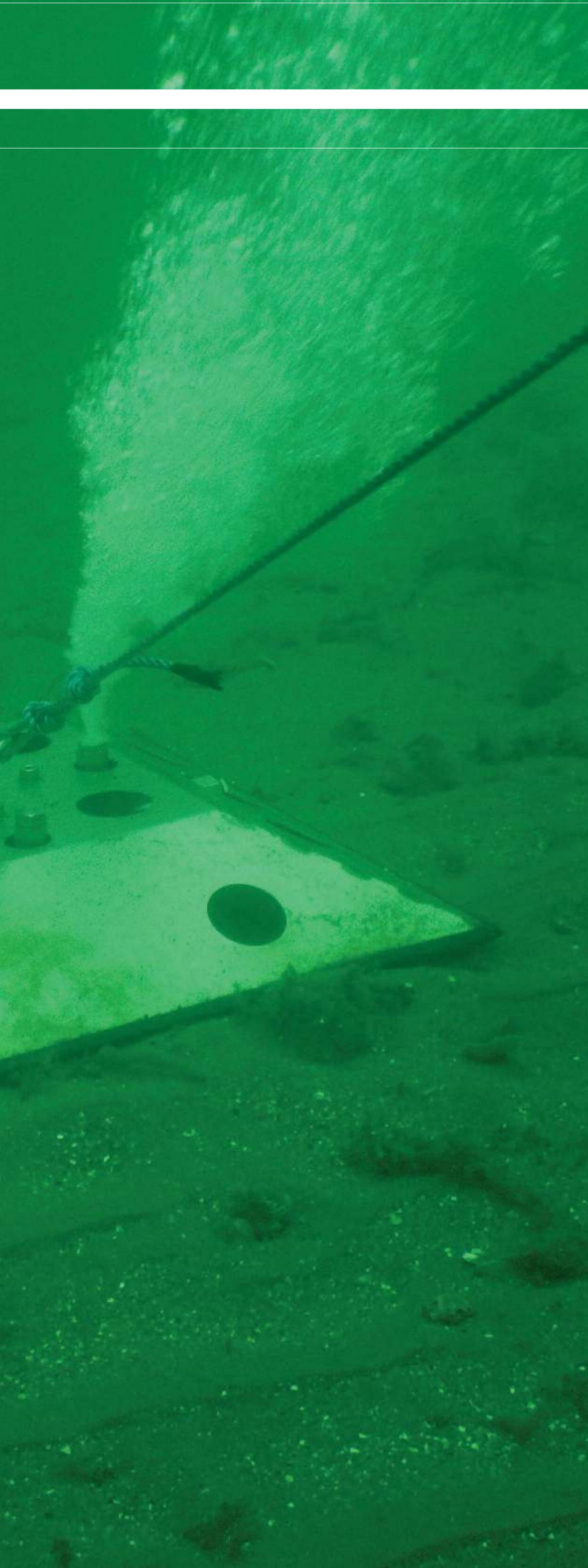
Technology

Environment: Carbon Capture and Storage

FROM CONCEPT TO REALITY: A SYSTEM TO MONITOR CCS SITES USING MARINE ROBOTICS



A seabed lander equipped with a Sentry integrity monitoring sonar and Compatt 6 communications transponder (left), NOC's *Autosub LR*, are readied for deployment ahead of several weeks of harbour testing in Portland Harbour. Both were used to hunt for simulated CO2 leak from a variable flow leak target (main image).



It's been three years since Baseline first reported on an ambitious environmental monitoring project in support of Carbon Capture and Storage (CCS). Funded by the Energy Technologies Institute (ETI) and delivered by a consortium of companies including Fugro, National Oceanographic Centre (NOC), British Geological Survey (BGS), Plymouth Marine Laboratory (PML) and Sonardyne, the project is now drawing to a close after recent successful harbour and offshore trials. **Graham Brown**, Sales and Marketing Director at Sonardyne, wraps up the story. **>>**

OFFSHORE CCS IS widely regarded as a viable option to reduce the amount of waste carbon dioxide (CO2) from power stations and industry being released into the atmosphere. Once captured, CO2 is it transported by tanker vessel or pipeline and injected into suitable geological formations offshore and stored indefinitely. An unexpected benefit of this process is that the waste CO2 can actually been used to enhance oil recovery (EOR) from aging reservoirs.

Containment failure at an offshore CO2 storage site – whilst viewed as highly unlikely – is of significant concern to regulatory bodies, operators and environmental groups. So in 2014, a three year funded research programme was kicked off with a consortium being appointed and challenged to develop the capability to reliably detect CO2 in the marine environment.

Identifying the risks

In year one, efforts were focussed on understanding the science and system engineering, the second year was spent developing and integrating systems and the third year demonstrating the system.

It became apparent early on that different storage sites pose different types of risks, so different monitoring regimes will be required throughout each store's lifecycle; such as pre-injection survey, ongoing monitoring during injection and post-closure monitoring. As outlined in Baseline Issue 12, our concept was shaped around building a 'system of systems' to equip CO2 storage site operators with the capability to carry out a risk-based plan for environmental monitoring using different techniques at different times.

In broad terms, this systems approach identified five key elements. The first is a low power and hence long endurance Autonomous Underwater Vehicle (AUV) to provide cost-effective areal survey during baseline and repeat wide-area environmental surveys. The AUV used for this project was NOC's *Autosub Long Range* (ALR).

Technology

Environment: Carbon Capture and Storage

Sentry IMS

The second and third elements were seabed landers capable of detecting and monitoring any leakage at high risk locations, made up of a combined passive sonar and chemical sensing lander and an active sonar lander. The active sonar lander, based on our Sentry integrity monitoring sonar (IMS), gives sensitive and reliable automated leak detection capability across a wide area. For instance, around an injection well, Sentry can surveil an area of over 2.3 million square metres, or some 45 million cubic metres of seawater. The passive chemical lander is also capable of detecting leaks, but offers improved classification and the potential to estimate leak rates at shorter ranges.

The fourth element is a surface gateway to enable communication between a shore-based monitoring office and the underwater systems. Such a gateway can be deployed from a fixed platform, from a moored buoy, or from an autonomous surface vessel. For this project, we used a wideband acoustic communications link between the underwater landers and a buoy on the surface with all data forwarded on via satellite communications to a server. Display and interpretation of the monitoring data was performed using a modified version of Fugro's Metis software package. Built on GIS technology, this allowed non-expert users a web portal in which to visualise data and produce reports.

HAT and SAT

Harbour acceptance testing (HAT) of each major sub-system took place in Portland Harbour on the UK's south coast in spring 2017. Over a period of a month, each element was put through its paces to ensure functionality and to understand the detection performance of various sensors at different leak rates using a target designed to simulate a real leak. This was designed to be picked up, and moved and leak rate varied – from low to high. During the HAT, the consortium team verified the detection performance of the different systems and proved the concept of operations of each element, from sensor operation, data relay by satellite and website display.

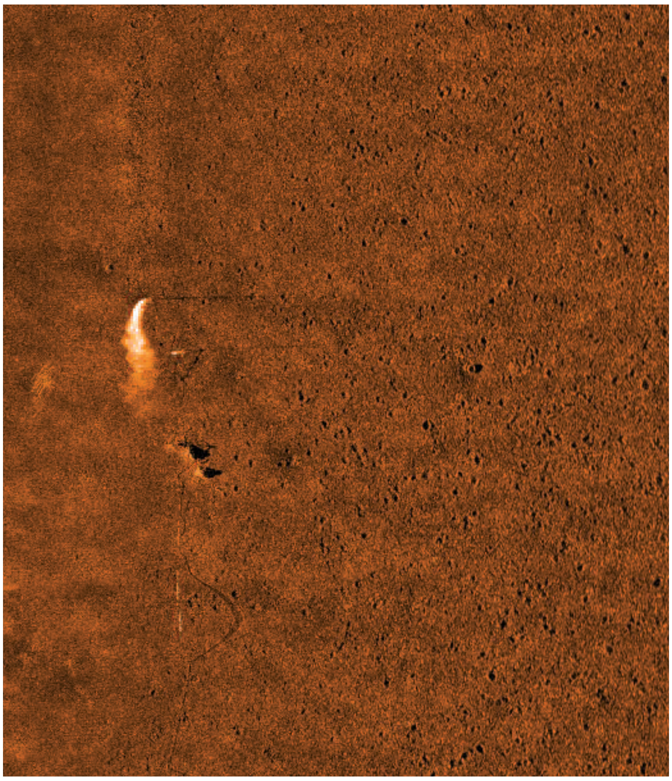
Sea acceptance testing (SAT) followed mid-summer. The leak target was deployed in the North Sea, east of Bridlington, close to the location of the proposed White Rose storage complex. NOC's *ALR* was then set to work, deployed from the small port and towed a short distance off the coast. After *ALR* performed a series of tests to demonstrate safe navigation, the leak was turned on with a flow rate of between 16 and 20 litres per minute of gas at depth, depending on the state of the tide.

This is equivalent to a leak of just less than 125 kilogrammes of CO2 per day, or around 45 tonnes per year. Though it sounds large, a leak of this size is actually only capable of changing the pH of the surrounding seawater by a few parts in a thousand. Such changes occur on an hourly basis due to entirely natural processes related to tidal mixing and respiration of all types of life in the ocean.

Big data

With the leak active, *ALR* performed a series of different wide area and fine area search patterns over the next five days searching for the leak. The sensor hub on the vehicle processed in real-time a complex set of sonar (Sonardyne Solstice), physical and chemical sensor data into useful information. The sonar data alone amounted to around 10 megabytes of raw data every second, corrected for vehicle motion.

Automatic target recognition algorithms were used to identify any leaks or regions of interest. The system would then score these regions of interest and save a small 'snippet' of the sonar image data. At regular intervals throughout the survey, *ALR* would surface and send back data via satellite, including navigation data, chemical and physical sensor



(Clockwise) Sea acceptance trials were conducted off the coastal town of Bridlington, Yorkshire. Figure 1 Solstice sonar image of a leak target with a flow rate of 15 litres per minute. The SAT was led by Fugro from the *RV Princess Royal*, a 19 metre catamaran specifically designed for marine environmental surveys.

data and details of snippets of sonar data from detected leaks – an example of which can be seen in Figure 1. The operator could then request the highest scoring images of the leaks to be transferred, allowing a high confidence of the detection of a leak whilst the survey was still in progress.

All of the uploaded data was simultaneously transferred to an internet server which allowed presentation and interpretation using Fugro's Metis software, an intuitive data delivery platform that allows

> **"During the five days, *ALR* travelled a total of 270 kilometres of and could have surveyed 54 square kilometres of seabed."**

metocean, vehicle navigation, chemical and sonar snippet data to be combined and displayed. This allowed data sharing across a wide team and supported operational decision making.

During the five days, *ALR* travelled a total of 270 kilometres and could have surveyed 54 square kilometres seabed. However, for the mode of operation used in the demonstration, a total of 16.1 square kilomteres was actually surveyed. Throughout its mission, *ALR* was remotely controlled from the shore with most of the interactions being conducted from NOC's control room in Southampton.

Project deliverables

With the ETI's project milestones now delivered, what have we achieved? In short, the consortium has demonstrated a functional 'system of systems' which could allow operators of CO2 storage complexes offshore to have a high confidence in their safe operation, and to assist in the provision of regulatory compliance and so help drive public confidence in offshore CO2 storage.

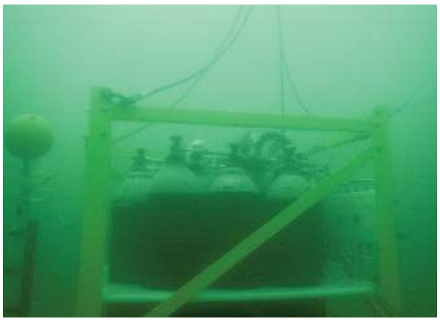
A survey was carried out over a realistic area and leaks were detected during different demonstration phases using chemical sensors, passive acoustic and active acoustic methods. However, the project outcomes could be viewed in a much wider context. For instance, it has shown that it is possible to conduct shore-to-field-to-shore environmental survey operations using a long endurance AUV operating well in excess of normal AUV deployments. This method of working only needs a small local deployment team and is supported by a remote shore-based operations and data interpretation team. The mission also included a high element of automatic data reduction to allow communication of critical information back to shore in near real-time to enable human-in-the-loop mission planning to change the mode of operation. It is also entirely possible and has been demonstrated elsewhere, that further reduction of human decision making can be achieved to reduce operator intervention.

This project has also demonstrated that it is possible to build highly cost-effective, highly autonomous sensing systems with on-board intelligence, which are both simple to deploy and operate and which could be very cost competitive with vessel-based or vessel supported AUV survey operations. At the same time, the project members also developed two flexible seabed lander packages which are capable of extended duration deployment, typically six months to a year, which can provide localised, but still wide-area monitoring, and perform automated processing of data subsea and communicate information to surface.

And looking beyond carbon capture, the potential applications of such integrated marine robotic and intelligent remote sensing technologies are many and varied across ocean science, renewables, security and naval domains. **BL**

The three-year CCS programme: At a glance

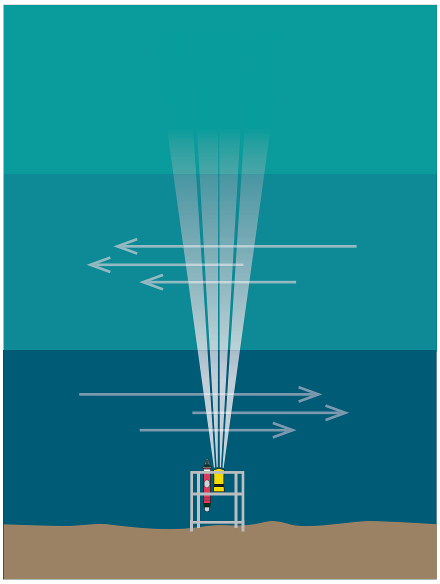
- **Shore-to-field-to-shore AUV operation over five days**
- **Reliable real time sonar based leak detection algorithms on a persistent AUV**
- **Long duration seabed monitoring with on-board data reduction**
- **Wide area leak detection using active sonar**
- **Local area passive sonar and chemical leak monitoring and classification**
- **Satellite based data relay and control**
- **Internet based data display**



(Clockwise) After the SAT was complete, recovery of one of the landers was made easier thanks to a Sonardyne Lightweight Release Transponder (LRT) fitted to it. On command, the LRT released a buoy and rope to the surface enabling a heavier lifting line to be hauled up. Engineers discuss search patterns for *Autosub LR*.

Drilling and Production

Case Study: Deep water, real-time metocean data recovery



6G acoustic communications enable current data from seabed ADCPs to be recovered in real-time, improving operational decision making.

RPS connects with 6G modems to aid deep water drilling decisions

Metocean organisation RPS Evans Hamilton Inc. design, install and maintain real-time environmental monitoring systems for drilling and production platforms worldwide. Two years ago Shell Exploration and Production (Shell E&P) approached them to expand the capabilities of their service to measure seabed current profile data at the Walker Ridge area in the Gulf of Mexico, and wirelessly transmit the observations to the surface for instant analysis. **Jeff Morin**, Senior Scientist with RPS Ocean Science (formerly Evans Hamilton Inc.), takes up the story for Baseline reporting on how 6G met the brief.

Operations in deep and ultra-deep water (6,000 to 10,000 feet) have created challenges in terms of drilling, construction and pipeline installation but these challenges can be made safer and more efficient through a good understanding of subsurface current patterns.

This type of data has largely been obtained using Acoustic Doppler Current Profilers (ADCPs) mounted near the surface looking down through the water column. However as operational depths increase, a single ADCP may not provide enough coverage, which is where a second ADCP, placed on the seabed looking-up, provides the necessary data in-fill.

The simple and typical approach has been to deploy the second ADCP for several months at a time, set to log bottom currents at intervals from minutes to hours. However, while this data is extremely useful for site surveys and planning exploration activities, the delay between collection, instrument recovery, download and analysis, has meant that its usefulness in supporting on-site decision making during operations (including complying with government directives), is limited.

(Opposite page) A Sonardyne HPT Modem configured for cable deployment from over the side of the rig. A cage provides protection from potential damage whilst weight behind it minimises drifting in surface currents. (Left) The Compatt 6 modem and Teledyne RDI Workhorse 300 kHz ADCP were co-located in a frame lowered to the seabed by crane. Water velocity profiles were generated from approximately 3 metres to 100 metre off the seabed.

Data on demand

An acoustic modem directly connected to the ADCP provides a cost-effective and increasingly popular option for users needing instant access to their data from wherever they are in the world. But as not all acoustic modems are made equal, it's vital to make sure when choosing one for use in an application such as offshore drilling, it has the signal processing and error correction techniques required to reliably deliver critical data payloads over long distances and potentially, through acoustically hostile transmission paths.

When RPS Ocean Science was approached by Shell E&P with a requirement to display water velocity and direction profiles from an upward-looking ADCP deployed at one of their sites in the Gulf of Mexico, we identified Sonardyne's 6G (sixth generation) wireless communications platform as the optimum solution. 6G has an enviable reputation across the region and today remains the only acoustic technology to have been proven as a successful monitoring solution during a well containment situation.

Dr. Pak Leung with Shell E&P's Metocean team recognises the challenges in operation ready data collection in these ultra deep environments, along with the complications of delivering the data to surface systems through a water column with unpredictable acoustic energy backgrounds. Dr. Leung determined the sample collection criteria and was the ultimate end user for operations advisories for the exploration effort. The data has been utilised by the metocean team to support exploration operations in daily advisories as well as providing a unique perspective on potential Topographic Rossby Waves thought to be a common feature in the area.

Seabed to surface

The seabed component of the monitoring system incorporated a Sonardyne Compatt 6 telemetry transponder interfaced with a Teledyne RDI Workhorse 300 kHz ADCP, mounted together in a deployment frame.

10,000 feet above, a Sonardyne HPT modem deployed from the rig acted as the surface receiver. It was enclosed within a rugged cage to protect it during deployment and recovery phases, and weighted to prevent drifting in high surface currents. The HPT was integrated with the data collection system we had previously supplied to the rig which included a 38 kHz ADCP at the surface and load handling system.

Results

The Compatt 6 and ADCP were deployed by ROV on the seabed at a depth of 9,970 feet, approximately 150 feet away from the rig's BOP.

After establishing reliable seabed to surface communications, data collection was initiated. The acquisition system is designed to receive and display data from the surface and bottom ADCPs at 10 minute intervals.

Water velocity profiles were generated from approximately 3 metres to 100 metres off the seabed. The profiles were composed of 50, 2 metre bins. Data was averaged over 75 seconds at a 1 Hz sample rate. Velocity and direction profiles were processed by the subsurface instrument and transmitted to the rig's data acquisition system where profiles were displayed, along with the velocity and direction profiles from the surface ADCP, on the platform bridge. Processed data files were also transmitted to our client's shore-based server and the National Data Buoy Center (NDBC) in near real-time.

Following initial system deployment, the signal analysis tools built into the Compatt 6 and HPT enabled the bi-directional communications link to be optimised for the local conditions, resulting in data return rates which were shown to be highly reliable with low latency.

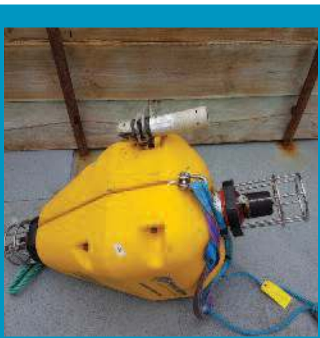
A demonstration of the system's capability took place during the summer of 2015, and since then, the RPS-Sonardyne solution has proven to offer reliable self-contained operation with long service intervals. The configuration of upward-looking ADCP and Sonardyne 6G digital modem technology perfectly complements conventional near-surface and mid-column current monitoring and contributes toward lowering operational risk and increasing the safety of drilling, survey and ROV operations in deep water.

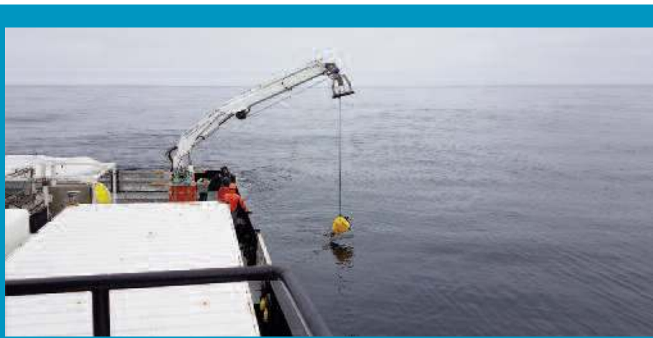
Technology

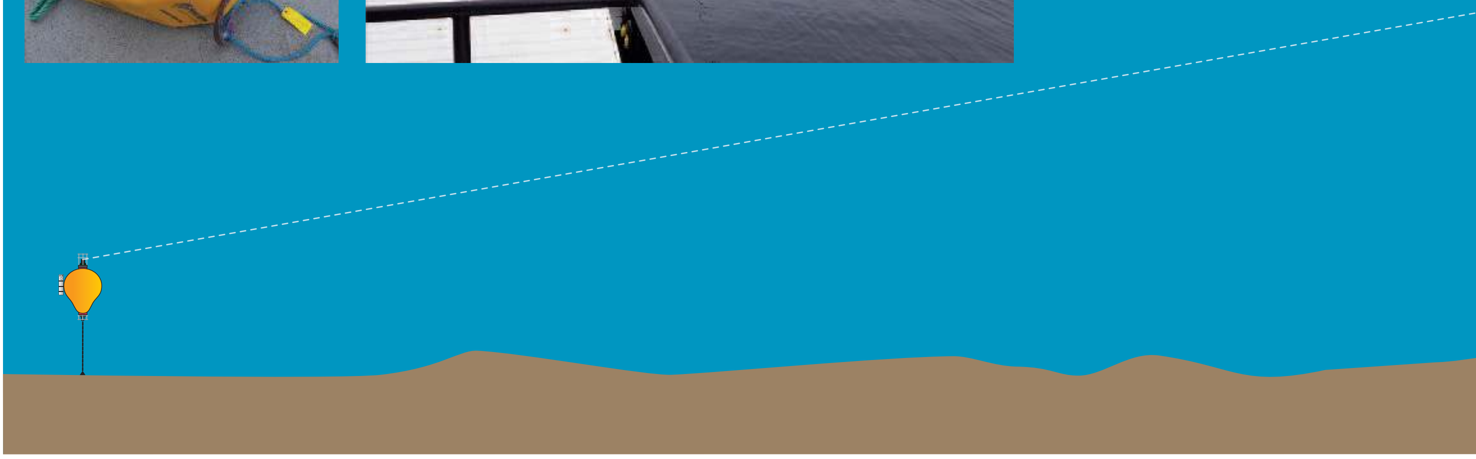
Trials Report: Long range LMF USBL tracking

RANGER 2 TRACKS FURTHER THA

Interest in Sonardyne Ultra-Short BaseLine (USBL) systems that operate at the low end of the medium fre
of AUV and manned submersible missions to explore the deep ocean. LMF systems have much longer
engineers recently set sail with Ranger 2 and scientists from the Monterey Bay Aquarium Research Instit







IT IS DIFFICULT to imagine how a USBL system can operate in scenarios up to 11,000 metres range when baselines between elements is of the order of 0.001% of the slant range (10s of millimetres). So it helps to refer back to how USBL systems actually work to show the complexities.

Frequency choice

The LMF band used by Sonardyne covers a frequency range from 14 to 19 kHz which can extend the range of underwater acoustic systems compared to the MF band by over double the range. This is due to the absorption properties of the water. In simple terms changing from 24 kHz to 16 kHz has an effect of halving the absorption caused by the water.

Time and phase

The USBL transceiver has an array of transducers that are used to receive the acoustic signal. The acoustic data is synchronously sampled on each element and then time and phase differences are used to triangulate the position of the remote beacon. This portion of the system does not change based on range, apart from reduced signal to noise. However, once the angle to the beacon has been computed the system needs to convert this to a usable bearing and elevation estimate. This involves fusing the data with pitch, roll and heading information as well as GNSS. If this is not done correctly, even the slightest of errors can cause absolute positioning errors of 10's to 100's of metres over these extended ranges.

Sound speed

One of the biggest causes of errors in any long range USBL system is caused by changes in speed of sound caused by sea temperature variation, simulation can show how a small inaccurate prediction of a speed of sound profile can change the absolute position of the target by several hundred metres – hence the importance of getting this spot on.

Hardware setup

One of the key aims of the demonstration was to use a realistic set-up with hardware that can be bought off-the-shelf. An omni-directional LMF Compatt 6 in a low-drag float deployed on the seabed acted as the team's target, whilst onboard the *RV Rachel Carson*, an LMF GyroUSBL transceiver was fitted to the vessel's through- tube deployment pole.

Onmi-directional transponders provide the greatest operational flexibility when the geometry could be anything from vertical tracking, to long layback horizontal tracking. But it's worth noting that if a directional beacon was used, the additional transmit source level from the focused

AN THE MARIANA TRENCH IS DEEP→

quency band – LMF in other words – has been ramping up recently thanks mainly due to the growth operating ranges than standard MF systems and in a bid to show just how long 'long' is, our ute (MBARI) to a test site far off the Californian coast. >>

Transmission Loss
When it comes to long range tracking, 'you can't beat the physics.' Predicted range is based on transmit power, spreading loss, absorption and acoustic noise.

acoustic source would have been over 7dB higher, allowing the performance to be pushed to higher ranges at the expense of loss of versatility.

Within a few hours sail from MBARI's headquarters in Moss Landing, scientists have access to one of the largest and deepest underwater canyons in the world, making it the ideal ocean laboratory. For the Ranger 2 test, a deployment site chosen was 3,500 metres deep and located about 80 miles off the coast.

> "With the Ranger 2 system calibrated, it was time to see how far away the *RV Rachel Carson* could sail from the Compatt before acoustic communications were lost"

As a new transceiver had been fitted to the vessel, a system calibration was performed using our Casius software tool to compute lever arms and installation offsets. This was performed directly above the Compatt with a calculated slant range error of 0.12% (1DRMS). This figure means when tracking at 11,000 metre slant range, for example, the spread of 66% of position fixes will be within just 15 metres – a pretty impressive figure given the extreme distances involved.

Sail away, sail away

With the Ranger 2 system calibrated, it was time to see how far away the *RV Rachel Carson* could sail from the Compatt before acoustic communications were lost. Sailing at about three knots, it took two hours to reach a slant range of 11,000 metres – the distance engineers had predicted for the LMF Compatt. Regular updates of telemetry were sent at varying data rates up to 9000 bps, showing capability to command, control and receive status updates from remote vehicles.

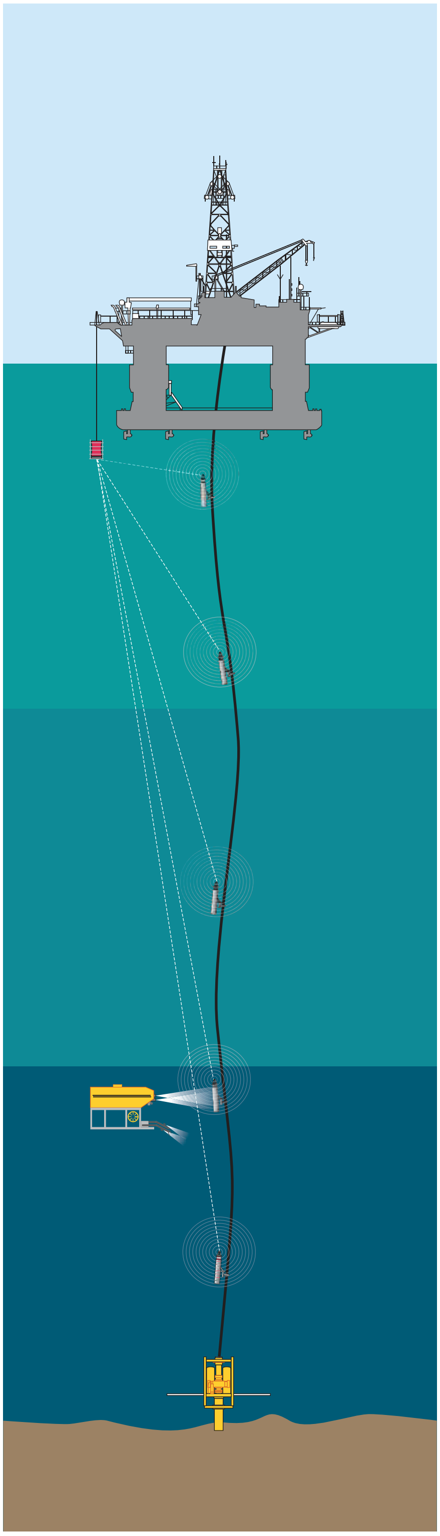
14 kilometres

Our LMF tracking system was field proven to 11 kilometres slant range during this test using a transponder fitted with an omni-directional transducer. The results show that the system would perform beyond this to a range of nearer 14 kilometres using the focused power of a directional transponder which would be more suited to positioning in large vertical distance deployments. In this scenario it is possible to reliably track a vehicle to the bottom of the the Mariana Trench.

The 6G family has a full range of LMF products that can be used for a variety of application such as long range USBL towfish tracking, deep water autonomous monitoring and acoustic release of deep ocean instrumentation. The benefits of a Sonardyne LMF USBL installation speak for themselves. **BL**

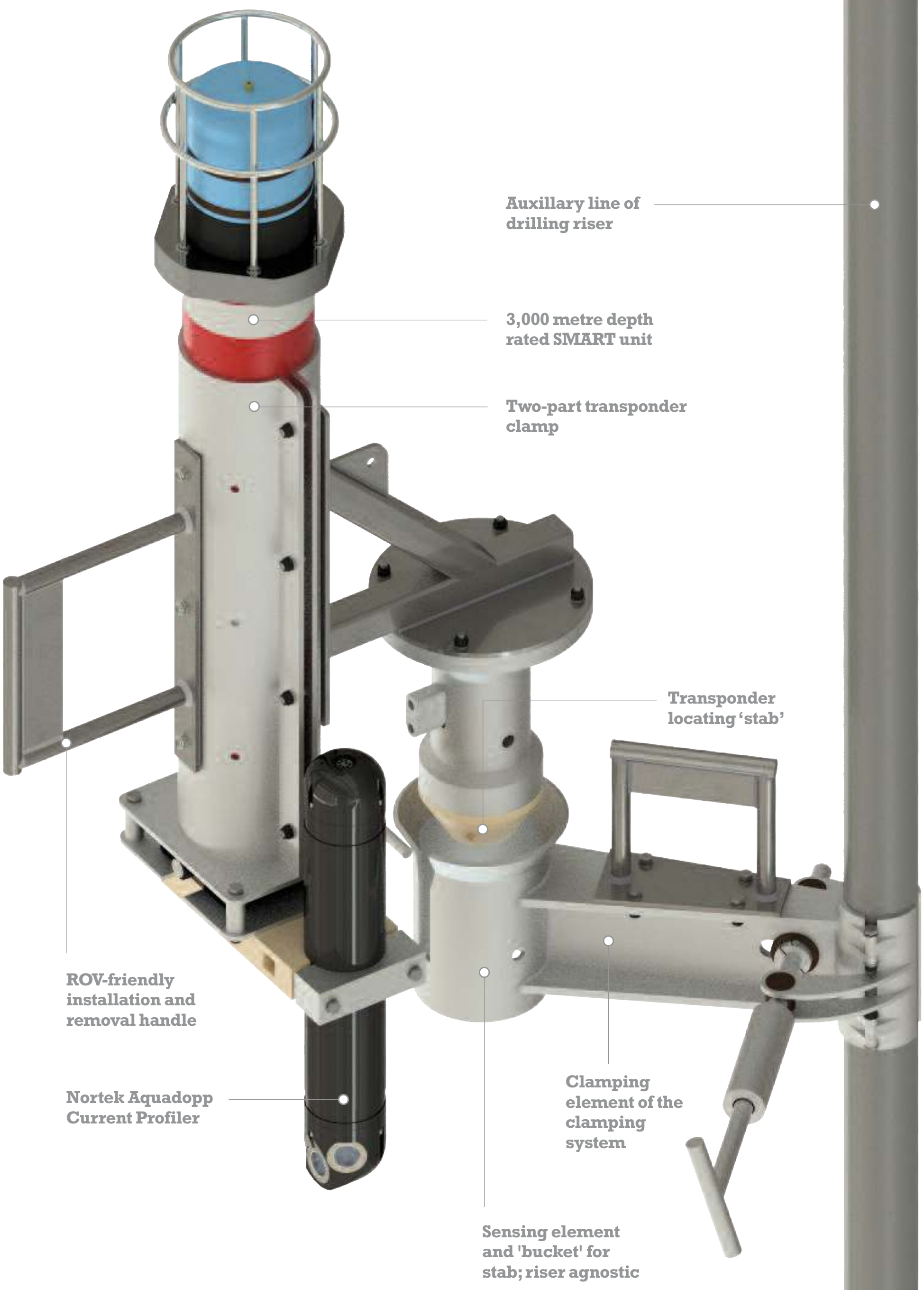
Near real-time riser integrity management system

What is a 'digital twin'?
It's a digital replica of physical assets, processes and systems that can be used for various purposes. Using SMART, GE applied the concept to create a digital representation of a marine drilling riser with the goal of reducing downtime and optimising inspection schedules.



GE GETS SMART to reduce rig production and inspection downtime

To compete in today's climate of energy price instability, operators and contractors can benefit from data-driven solutions to increase their operations visibility, optimise lifecycle management and reduce costs of maintaining offshore equipment. **Greg Myers**, Product Manager with Baker Hughes, a GE Company, and **Judith Guzzo** and **Shaopeng Liu** from GE Global Research, report on how the company is using SMART to help drillers address these challenges by creating a digital model of a physical asset, called a Marine Riser Digital Twin.



The cost drivers associated with offshore drilling activities range from unplanned downtime associated with drilling in ultra-deepwater or harsh metocean conditions, such as strong loop currents, to resources spent on travelling to inspect riser joints onshore unnecessarily.

These factors pose challenges on efficiently deploying and maintaining marine risers over their 20+ year lifespan, while meeting safety and regulatory needs. They can also cause riser curvature, hang-off deflections and high tensions at the blow out preventer (BOP) and wellhead, which impart fatigue loading damage on the equipment. Drawing critical insights from operational data is a crucial first step where creating a 'digital twin' model of a physical asset comes into play.

Digital twins are not a new idea; GE has successfully deployed thousands of them in safety critical industrial applications such as aircraft engines, wind farms and power plants using Predix, the cloud-based operating system developed for the Industrial Internet.

> **"We have seen how the digital revolution is rapidly shaping our social and consumer world, and a similar opportunity exists to transform our industrial assets and operations by connecting critical physical assets and processes to the digital world."**

Applying the concept offshore, the team created a physical and a virtual model of a marine driller riser with the goal of reducing downtime and optimising inspection schedules of these critical assets which can extend miles in length below the ocean's surface.

The GE Marine Riser Digital Twin provides drillers with data-based diagnostics and insights into what is happening to their asset during a regular day or even during an extreme event, and then picks the most optimal way to run that asset. It can help reduce excessive maintenance and costs of the main tube for drilling contractors with a data-driven approach. The system also takes the guesswork out of decisions such as when to cease drilling activities due to strong currents or other adverse metocean

Focus on: SMART

Part of our 6G product range, SMART (Reporting Transponder) has been developed to cover a diverse range of subsea asset monitoring applications. It brings together low power electronics, long duration data logging, on-board data processing and acoustic telemetry into a single, easily deployed wireless instrument. SMART has the flexibility to interface with a wide range of internal and external sensors utilising standard or bespoke data analysis algorithms, to provide operators with the critical data they need, when they need it.

Asset Monitoring

Near real-time riser integrity management system

conditions, or when it is safe to restart operations. Anything that can provide significant reductions to unplanned downtime is critical.

System approach

A modular approach was used for designing the subsea platform built around Sonardyne's SMART (Subsea Monitoring, Analysis and Reporting Transponder) – a self-contained instrument consisting of an acoustic modem, replaceable battery, tri-axial accelerometers and gyroscopes, and a micro-processor for data acquisition and processing.

Unlike conventional techniques which typically use strain gauges for direct strain/stress measurement, SMART measures the vibrations using accelerometers at select joints up and down the drilling riser. It transmits the vibration data and other sensor data, such as ocean currents, via wideband acoustic telemetry in near real-time to a topside acoustic receiver (Sonardyne's HPT Modem) cable-deployed from the rig, which is interfaced with a control-room data acquisition system.

Unlike conventional techniques which typically use strain gauges for direct strain/ stress measurement, SMART measures the vibrations using accelerometers at select joints up and down the drilling riser.

Topside, advanced machine learning techniques, coupled with a physical asset model of the entire riser string, are used to calculate fatigue life estimates for all riser joints. The digital twin, or machine learning model, is a virtual model of the riser that is continuously updated against the sensor measurements and metocean conditions.

When this data is beyond the original training conditions, a model retraining is automatically triggered. This continuous learning and update of the digital twin model provides more precise calculation of the riser fatigue life and enables optimising operations in near real-time. Visualisation and alerts are provided by software which ingests the field data and performs advanced analytics to enhance the operational decision-making for the drillers and operators.

Gulf of Mexico testing

A proof-of-concept of the digital twin was deployed in the Gulf of Mexico on a semi-submersible ultra-deepwater drilling rig for a nine week test. Five SMARTs were installed at key joints along the riser string by ROV with the lowest located at a depth of 6,200 feet and the highest 350 feet below sea level.

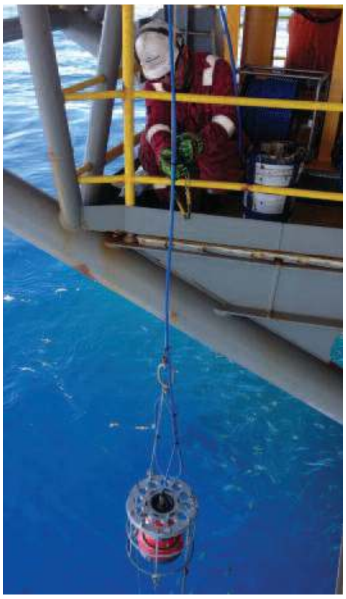
To allow each SMART to be quickly deployed and retrieved (either manually or by ROV), a two-part clamp was designed in collaboration with engineers from Sonardyne, Seanic, GE and a leading drilling contractor. The design consists of two parts; a sensing element and 'bucket' which is directly clamped onto an auxiliary line of a riser joint and has a rigid attachment to the riser, and the SMART itself. This has a locating 'stab' on one side which inserts into the bucket and on the other side, a large ROV-friendly lifting handle. The clamp is riser agnostic and easily retrofittable onto existing risers.

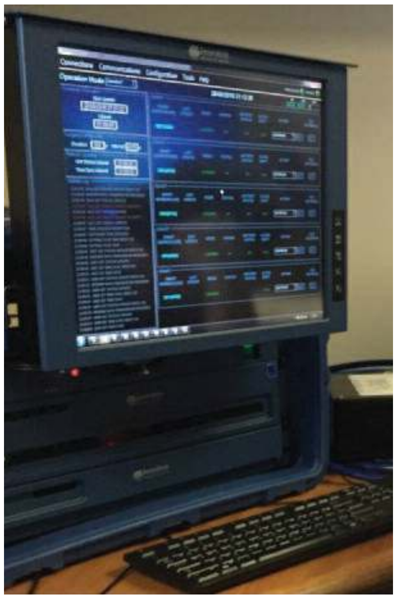
Results and next steps

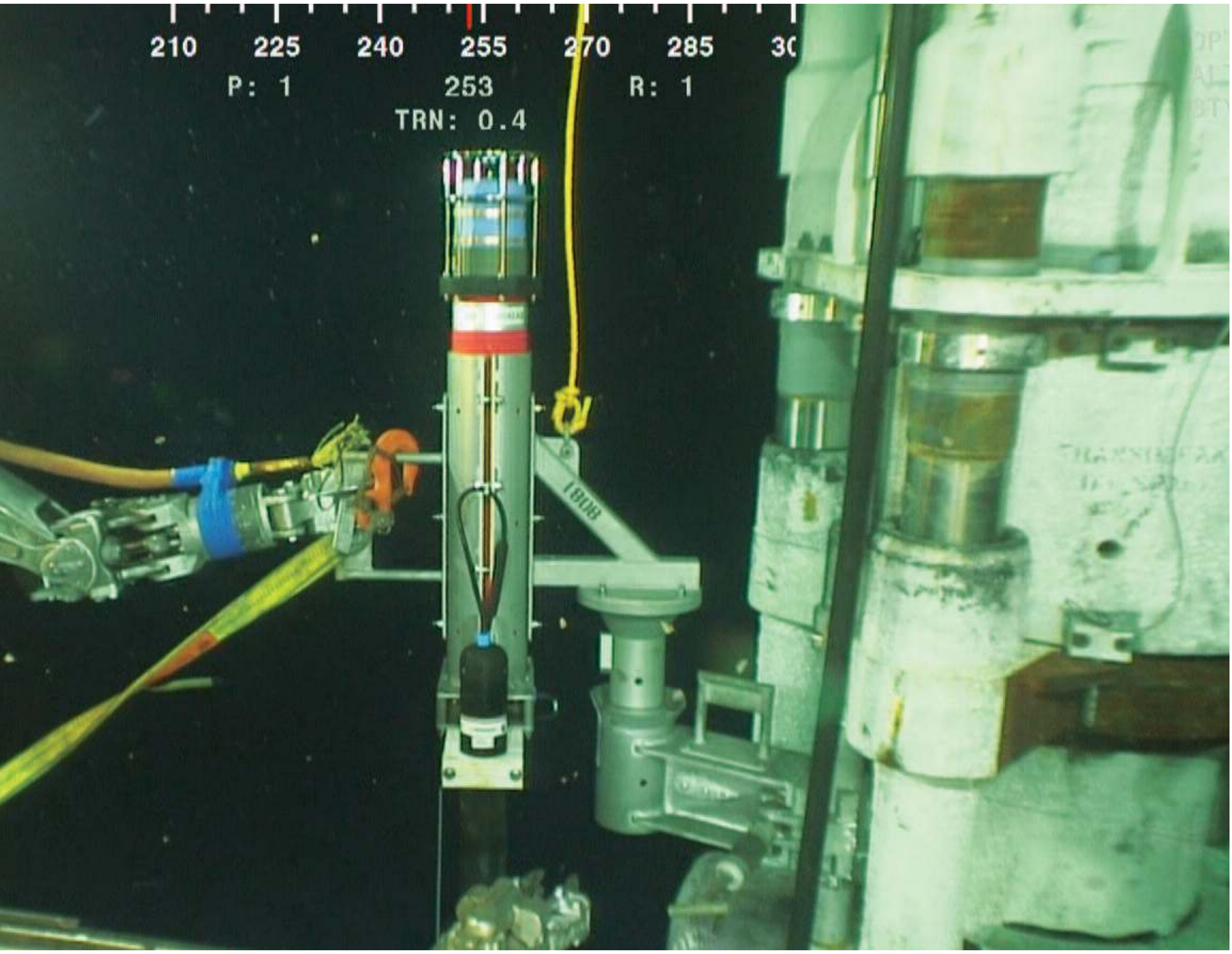
Novel aspects from this field trial test included; long-range deep water communication for near real-time sensor data collection; displaying key riser health data and analysis of data to meaningful information; demonstrating advanced machine learning techniques for fatigue damage estimation and lastly; integrated system functionality of the marine riser digital twin system on a drilling riser which is generic to the offshore drilling industry.

As the Marine Riser Digital Twin advances toward a commercial product, it is envisioned that the entire twin deployment and running process will be handled by standard rig crew teams. When fully deployed, advanced digital technologies such as SMART, will change the way we work and improve the integrity and performance of our subsea assets.

(Clockwise from left) Judith Guzzo (GE Global Research) and Kyle Warren (Sonardyne). A HPT modem, cable deployed from the rig's drill floor was used to recover physical and metocean data captured by each of the five SMARTs installed on the riser. Software takes the SMART data and performs analytics to create valuable insight for operators. Successful docking of a SMART in over 4,600 feet of water.



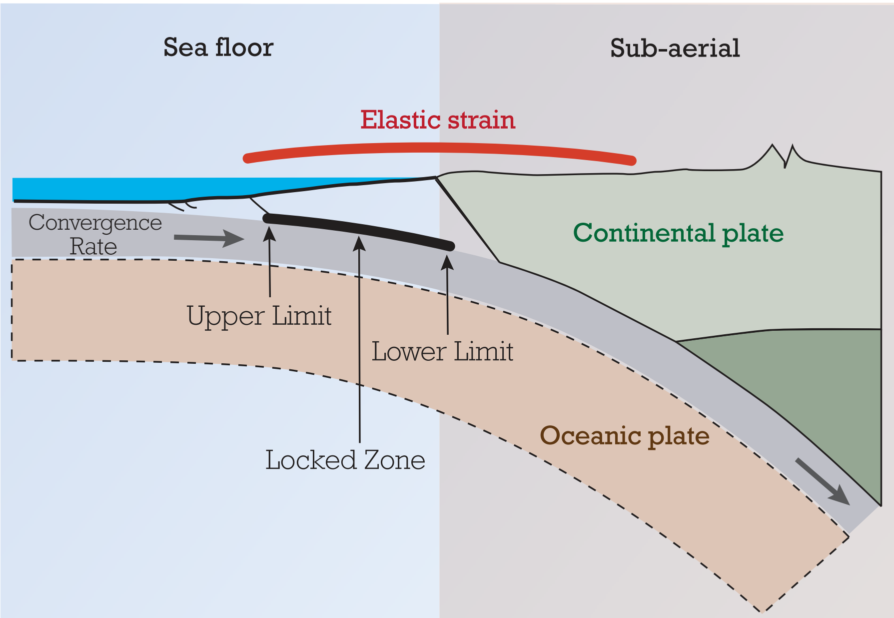




Seafloor Geodesy

Case Study: Long endurance tectonic motion monitoring

For more than two years, one of the world's leading marine sciences institutes, GEOMAR Helmholtz Centre for Ocean Research in Kiel, has been using networks of our Autonomous Monitoring Transponders (AMTs) deployed in the deep sea to study some of the globe's most tectonically active areas. **Geraint West**, Global Business Manager for Ocean Science, takes up the story for BaseLine reporting on studies off the coasts of Chile, Turkey and Italy.



Seafloor geodesy enables scientists to study the earth's most dangerous plate boundaries, all of which lie deep underwater. A network of our acoustic transponders acting as 'seabed monuments' placed within the affected region, enables plate movement to be precisely and autonomously measured over many years.

Subduction zones are tectonic plate collision boundaries where typically higher density oceanic crust is being pushed under continental crust and are consequently one of the most important processes in the evolution of the Earth's morphology. These zones comprise extremely large thrust faults, known as megathrusts, and are the source of the world's most dangerous volcanoes and earthquakes. In between larger earthquakes, megathrusts comprise complex heterogeneous distributions of locking and therefore strain accumulation.

On land, GPS and laser observations enable precise geodetic measurements, but until recently, the inability to undertake cost-effective complementary observations in the outermost subduction zone offshore, has been a critical flaw. This is where much of the elastic strain build-up and release occurs and consequently, improving scientific understanding of the seafloor movement in these regions is an important basis for future seismic hazard assessment.

In response to this challenge, Sonardyne has worked with a number of research institutes, including GEOMAR, to supply networks of Autonomous Monitoring Transponders (AMTs) – seabed instruments that are capable of taking hundreds of thousands of stable, highly precise geodetic observations, safely log the data and on command, wirelessly transmit it up to the surface.

Originally developed for the offshore industry to precisely measure vertical and horizontal seabed displacements caused by reservoir depletion, AMT is a long-life (up to five years depending configuration), deep-rated acoustic instrument fitted with high resolution pressure, sound velocity and temperature sensors, all built around our 6G hardware platform and Wideband 2 digital signal technology.

"Seafloor geodetic measurements provide perhaps the only way to successfully deal with these problems, allowing us to directly measure deformation in some of the most active (and potentially destructive) places on Earth."
Professor Heidrun Kopp from GEOMAR, RV Sonne SO244 Leg II Cruise Report

AMTs run a fully automated logging regime gathering acoustic travel time (range) between neighbouring units, pressure, sound velocity, temperature and tilt data at intervals defined by the user. A passing AUV, vessel of opportunity, gateway buoy or unmanned surface platform can harvest data on demand and at any point, the user may amend the logging regime of any or all of the AMTs, using the bi-directional communications link.

Chilean array

GEOMAR have now deployed three AMT seabed arrays, the largest of which is the Geodetic Earthquake Observatory on the SEAfloor (GeoSEA) project, offshore northern Chile on the Nazca-South American plate boundary.

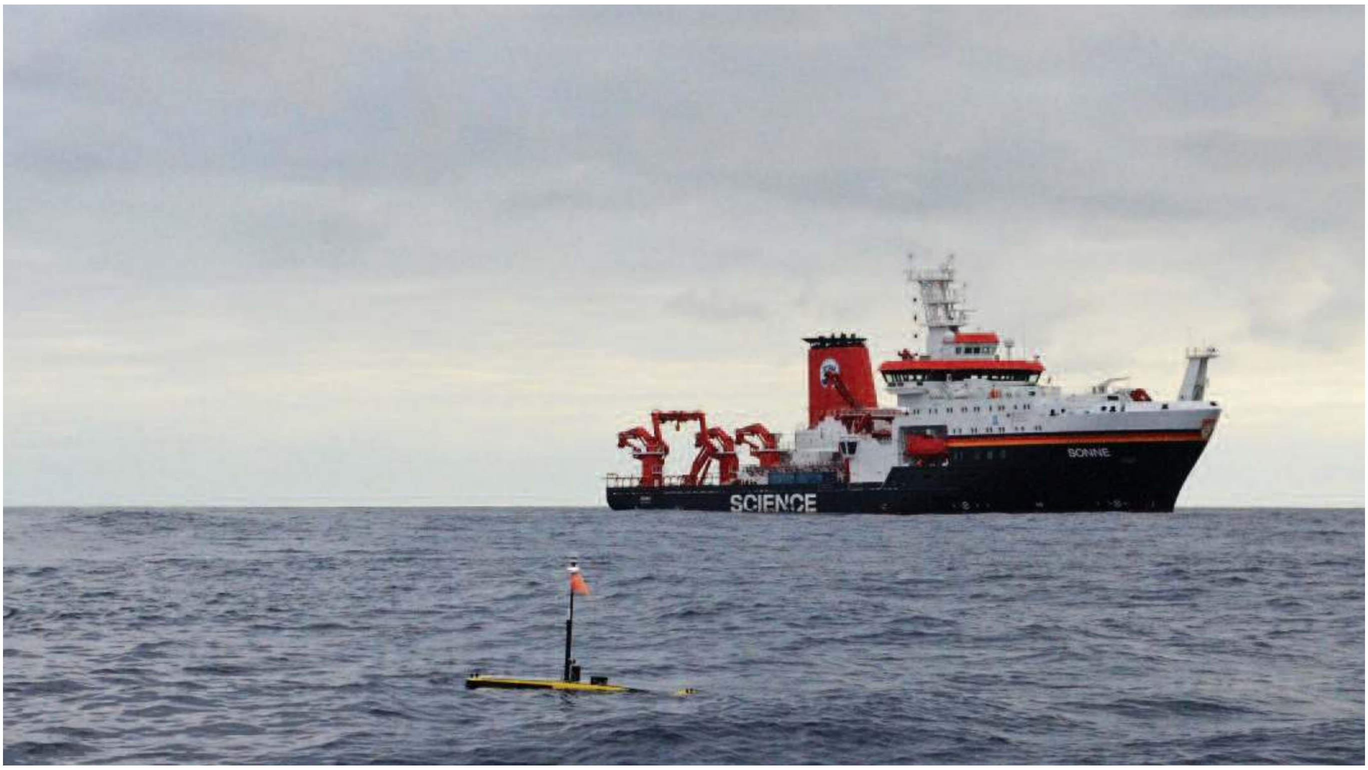
In the array location, the boundary last ruptured in a major earthquake in 1877 and was identified as a seismic gap prior to the 2014 Iquique/ Pisagua 8.1 magnitude earthquake.

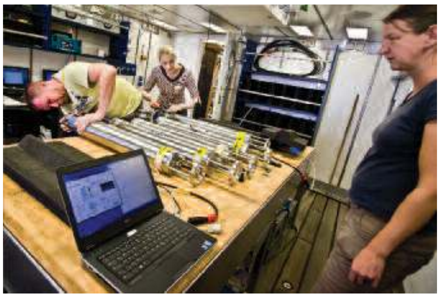
Nevertheless, the southern portion of the segment remains unbroken by recent earthquake activity and so, with the two plates converging at a rate of around 65 millimetres per year, new tension is being continuously built up. "Therefore the region is a focus site for seismologists to understand strain build-up prior to an earthquake," says Professor Kopp.

OCK SECRETS OF G PLATES AMTS

Seafloor Geodesy

Case Study: Long endurance tectonic motion monitoring





Array design, planning and installation
The GeoSEA array consists of 23 AMTs deployed from the German Research Vessel Sonne in late 2015 and comprises three sub-arrays that monitor different sections of the megathrust. The tectonic nature of the seabed gives rise to a variety of complex topographies, so our in-house Survey Support Group worked closely with scientists from GEOMAR to plan the sub-array layouts based on multibeam data collected during the preceding research leg. Precise placement in the order of a few tens of metres was required and in one case, an AMT had to be sited on a ledge on the side of a ridge that was only 50 metres wide and 150 metres long.

The first area is located on the middle continental slope between the main trench and the Chile coast and consists of eight transponders laid in pairs on a stairway-like feature of four topographic ridges at a depth of around 2,800 metres. The ridges, which are surface expressions of faults at depth, are approximately 100 metres high with around an 800 metre flat area between.

On the opposite (seaward) side of the trench from Chile, a further five AMTs were deployed in depths approaching 4,100 metres to monitor extension across plate-bending related normal faults. Here, faulting of the Nazca Plate is caused by stretching of its surface as it is pushed downwards under the South American plate, and thus the fault lines are relatively new and active. The AMTs were laid at the intersection of multiple faults lines separating three or four blocks, with two being placed on the same block to provide a sound speed reference baseline.

The deepest area, located between 5,100 and 5,400 metres deep, is on the lower continental slope and comprises a circular pattern of eight AMTs surrounding two central instruments. This pattern provides

Focus on: AMTs

6,000m
Depth rated

9,000
Bits per second telemetry

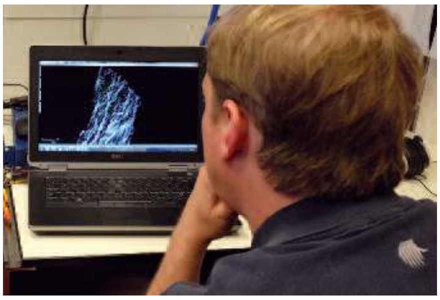
5 year
Deployment capability

<15mm
Ranging precision

+/-0.01%
Pressure sensor precision

(Opposite page) A GeoSURF Wave Glider equipped with a Sonardyne modem in its hull was one of the methods used to recover stored data from each AMT with the GeoSEA array. Shown is the German research vessel *Sonne* which was used to deploy the network of 23 AMTs in 2015. The second method of harvesting data used a HPT modem deployed over-the-side (centre image).

(This page, clockwise from left) GEOMAR scientists ready the next batch of AMTs prior to deployment. Each unit can be pre-configured with the chosen log regime prior to deployment using a laptop and serial test cable. Then after deployment, logging regimes can be altered remotely via acoustic communications with no need to recover each unit. The AMTs were deployed in rigid seaframes frame to prevent movement from seabed currents. A number of different designs were used throughout the project. An engineer verifies the location of each AMT. Images: Jan Steffen/ Darren Murphy



a variety of short and long baselines to measure diffuse strain build-up in a highly faulted area made up of separate geological blocks, which are under high compression.

To cope with these extreme conditions, the AMTs used for the GeoSEA project are 6,000 metre-rated Lower Medium Frequency (LMF 14-19 kHz) omni-directional units. Sampling at rates between one and a half and three hours, the GeoSEA AMTs are planned for an initial three and a half year deployment. However, the four metre high seabed frame in which each unit sits enables it to be easily removed by ROV, returned to the surface to allow its battery to be exchanged then placed back in the frame in the same position – giving scientists the option of extending the survey if required.

Early results

Since initial deployment, data from the array has been recovered by a US research ship using a Sonardyne HPT 7000 dunking modem deployed over the side, as well as GEOMAR's GeoSURF Wave Glider, equipped with a 6G acoustic communication module fitted in its hull.

Commenting on GEOMAR's experience, Professor Kopp said recently, "Overall, our experience with Sonardyne's instruments is superb and our results have been beyond our expectations. It has been a pleasure for us to work with infrastructure that we can fully rely on."

Turkey and Mount Etna

In addition to the GeoSEA array, GEOMAR have also deployed two smaller arrays in the Sea of Marmara off Turkey and on the submerged flanks of Mount Etna. The first of these was deployed in October 2014 in association with the Institut Universitaire Européen de la Mer (IUEM), with four sites occupied by both GEOMAR and IUEM and an additional two by GEOMAR only. The array is due for recovery at the end of 2017.

An array of five AMTs was deployed in spring 2016 in water depths of around 1,000 metres on the eastern underwater slope of Mount Etna. Terrestrial observations indicate that this slope of the volcano is unstable and is moving seawards, which poses a tsunami risk, similar to the 1908 tsunami triggered by an earthquake in the Strait of Messina that killed approximately 2,000 people.

Results from these deployments are currently subject to embargo prior to being published in the academic press, but scientists are excited by the new opportunities that this technology offers. GEOMAR's Doctor Dietrich Lange summarises that, "With this approach, we are taking a new path in earthquake research since previously, measurements of a few millimetres, were hardly possible."

International

News from our Regions Around the World

Middle East, SE Asia

Anthony Gleeson Vice President

This summer, Jose Puig joined the our team as Regional Sales Manager. A well known figure within the survey community, Jose's educational background is in physical oceanography but in 1998, he made the move offshore to what is now Subsea 7. In his time, Jose has also worked for DOF and UTEC specialising in acoustic metrology and LBL projects so it's fair to say he already has a great understanding of our technology and market requirements.

Mini-Ranger 2 proves invaluable

Our customer evaluation Mini-Ranger 2 systems was recently put to the test by local survey company Neptune in support of a project to remove the *Harita Berlian 18* wreck in the the Singapore Straits. Mobilised on a crane barge, the kit was used to track an ROV as it manoeuvred around the site. James Hope from Neptune reports that Mini-Ranger 2, "proved invaluable." The next issue of Baseline will have the full story but why not try it for yourself? Just get in touch.

More 7815s for the region

Our long history of providing the acoustic positioning technology to support ocean bottom seismic operations across the region continues following a large order that's just landed for our popular Type 7815 low-cost transponder. It really does continue to set the benchmark for large-scale shallow water surveys.

Europe, Africa, S. America

Barry Cairns Vice President

As uncertain market conditions continue to worry the energy industry, we have continued to provide free product education to show how Sonardyne's products can greatly assist in saving expensive vessel time during EPIC operations.

Our recent 'Shared Sensor' workshops in Aberdeen were a great success, with attendees from various oil companies, Tier 1 contractors, survey companies and rental companies learning how our 6G product range can be utilised for a variety of tasks during a typical field development campaign. We're hoping to repeat these workshops in Norway and the Netherlands in the coming months. And speaking of workshops, I'm pleased to announce that Colin Sutherland who many of your know from our service and repair workshop, has moved into sales, bringing with him many years offshore experience of our kit.

Field-resident ROVs

Lately, the team have supplied SPRINT-Nav units to several ROV manufacturers and operators. They've seen for themselves how this unique, tightly integrated INS/DVL platform has improved subsea navigation and expanded the operational envelope of their vehicles – in particular when the vehicles are permanently deployed, field-resident ROVs.

German research vessels

We are also assisting the German ocean science community to install a new Ranger 2 system onboard the *Maria S. Merian*, a vessel which is part of the German research group of vessels. It replaces another manufacturer's system which is being removed. Another research institute in Germany is also about to take delivery of a Ranger 2 system for very long layback tracking, using a GyroiUSBL transceiver installed on their towfish. Keep an eye on our social media channels for more details on these significant wins.

North America

Simon Reeves Senior Vice President

The show must go on

Following the recent catastrophic flooding here in Texas, it looked for a while as though the seismic industry's premier conference and exposition, SEG 2017, which this year was being hosted in Houston, would be called off. But the city's resilience showed through and the show went ahead as planned with our team reporting a successful event.
Much of the talk centred on our Pressure Inverted Echo Sounder (PIES), a self-contained instrument that measures average water velocity through a water column – something that geophysicists go to great lengths to understand. Seabed Geosolutions is the latest company to specify PIES, with a large order for an upcoming survey.

SPRINT-Nav heads inland

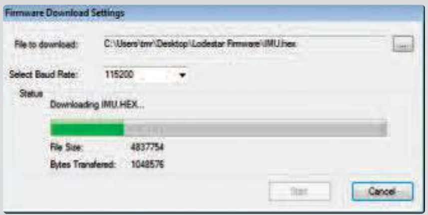
There's nothing like seeing technology in action to really understand the benefits it will bring to your operations. So back in June, clients travelled an hour north to Lake Conroe to get hands-on with SPRINT-Nav our combined INS and DVL. Aboard the pontoon-style boat we rigged to mimic an ROV, SPRINT-Nav was the sole navigation tool using tightly coupled beam-level aiding to help steer a safe course. On some legs, beams were turned off to show how bottom lock is maintained in challenging conditions. Keep up to date with all future learning events via our social media channels.

THE KNOW HOW

Tips and advice from our product specialists.
Have a question for them?
Email **training@sonardyne.com**

Installing new Lodestar and SPRINT firmware? Here's how

Connect to the unit using the configuration tool software and click on 'Download Firmware,' then click 'Yes' to confirm you wish to proceed. In the Firmware Download Settings window, navigate to the IMU.hex firmware file you have been provided, and click 'Yes' to confirm it is the correct file. Set the baud rate to 115200 if not already set and click 'Start.' The IMU.hex file will now be downloaded to the unit's memory card ready to be installed – this process may take several minutes. Once complete, click 'Done' and the firmware will then be loaded internally in the Lodestar/ SPRINT. This takes around 120 seconds (count down is displayed).



How to programme a Nano

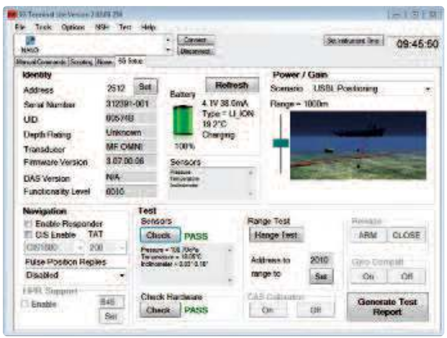
Connect your Nano's docking station to a PC installed with 6G Terminal Lite. Insert the Nano in the station. If the 'ENABLE/DISABLE' light on the station is red, press the black button next to it until it turns green. Click on 'Connect' and select 'Nano' from the drop down menu. A hardware check is conducted automatically; perform a sensor test by clicking the associated 'Check' button.

To confirm the acoustics are working correctly, carry out a Range Test using another enabled Nano placed close by. In the Range Test box click 'Set' and select the unit address of the nearby transponder, then click 'Range Test.' Listen for the units chirping as they communicate with each other. A green PASS indication will be displayed if successful. Slide the Range tab to set appropriate maximum slant range for your job; this will apply the correct power and gain settings.

If you want to track multiple Nanos simultaneously, in the Navigation section, check the 'CIS Enable' box and ensure all your transponders are set to the same CIS channel from the drop down list. Use the 'TAT' drop-down list to select different acoustic Turn-Around-Times if your transponders will be operating close to each other, minimising interference.

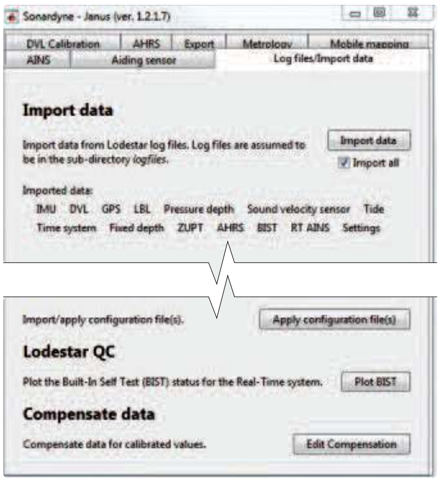
A Nano's address is displayed at the top left of the main table. Change it by clicking 'Set' and select the address required from the new window that opens. There are separate tabs for WBV2 and WBV2+ addresses.

Once configured, click on 'Generate Test Report' to create a PDF for your records. Your Nano is now ready to deploy. To conserve its battery while not in use, 'ENABLE/DISABLE' until the light goes red. Prior to deployment simply re-insert it and enable it.



Is your SPRINT healthy? Built-In Self-Test lets you find out

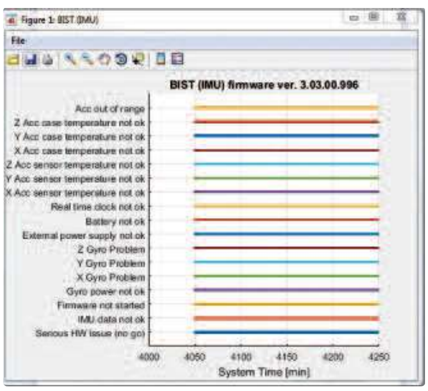
To perform a quick health check on your SPRINT, launch the Janus post processing software application. Upload a log file from SPRINT into Janus by navigating to the 'AINS' tab and selecting the root directory where the log file has been stored. Switch to the 'Log files/Import data tab,' then click on 'Import Data.' Once the log files are imported, you should see available imported data and an option to 'Plot BIST.' Five graphical displays will be presented representing various

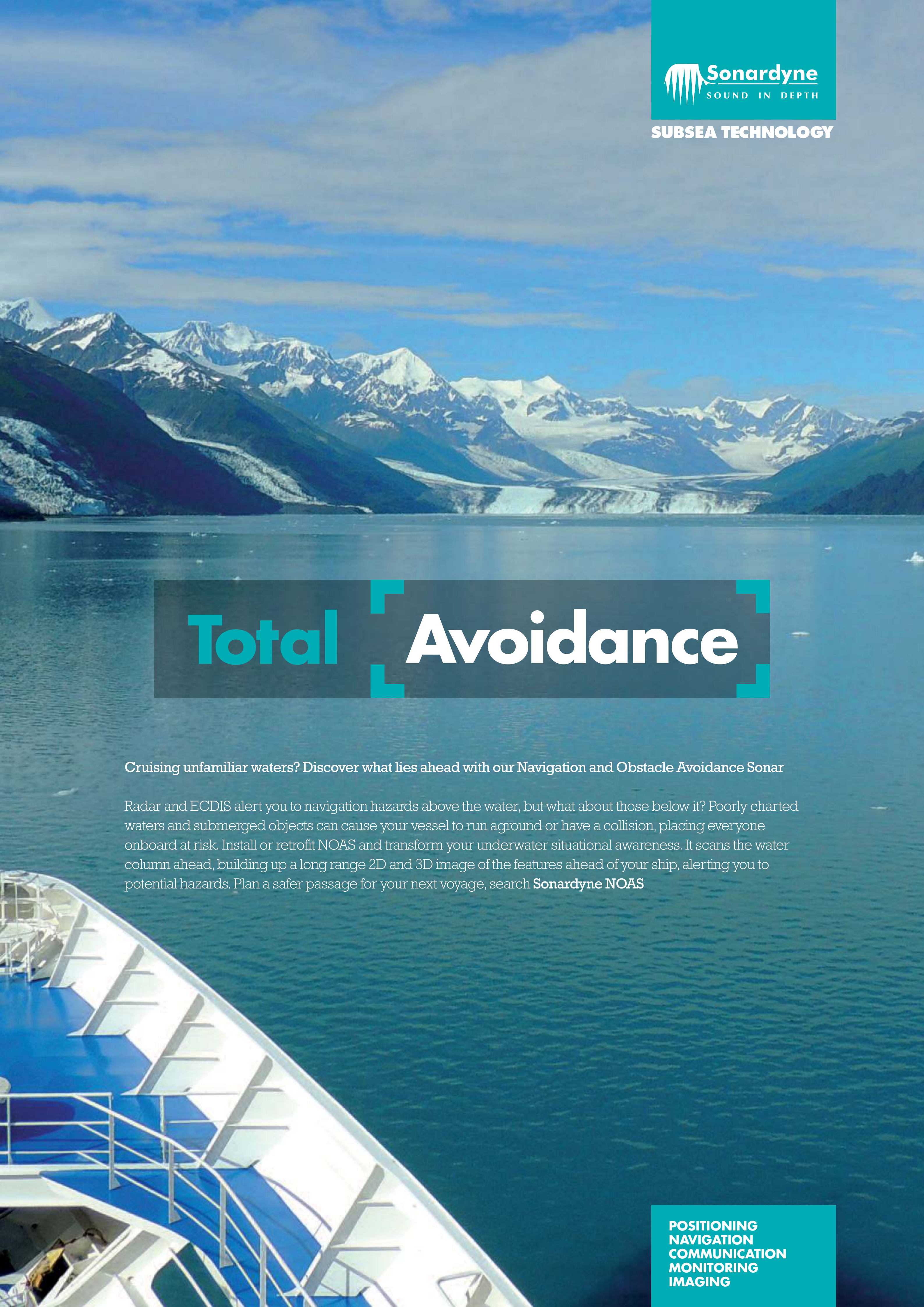


functions within the SPRINT unit; the IMU, the AHRS the AINS algorithms, physical hardware and communications.

Performance information for each element can be quickly reviewed and any potential errors clearly displayed as deviations in the normally flat lines on the graphs. It is important to read the statement first and then any deviation will represent as 'true' to the statement.

If no peaks are evident , this indicates that your SPRINT is in good health and ready for use.




Sonardyne
SOUND IN DEPTH
SUBSEA TECHNOLOGY
Total Avoidance
Cruising unfamiliar waters? Discover what lies ahead with our Navigation and Obstacle Avoidance Sonar
Radar and ECDIS alert you to navigation hazards above the water, but what about those below it? Poorly charted waters and submerged objects can cause your vessel to run aground or have a collision, placing everyone onboard at risk. Install or retrofit NOAS and transform your underwater situational awareness. It scans the water column ahead, building up a long range 2D and 3D image of the features ahead of your ship, alerting you to potential hazards. Plan a safer passage for your next voyage, search Sonardyne NOAS
POSITIONING
NAVIGATION
COMMUNICATION
MONITORING
IMAGING