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Subsea Asset Monitoring
Sonardyne joins consortium to monitor Carbon Capture and Storage sites

THE CUSTOMER MAGAZINE FROM SONARDYNE
ISSUE 12

Baseline



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Exploration
Tracking, positioning and monitoring technologies for reservoir surveillance

THIS APRIL, 6G reached another major milestone. Was it because a new transponder had joined the family line-up or another deep water field development had specified it? As you'll discover on page 7, this time it was because 6G's unique benefits and the positive impact it's had on subsea projects around the world, have been recognised with The Queen's Award for Enterprise in Innovation - the highest award a UK business can receive.

So what's next for 6G? Well, alongside our automatic leak detection and sonar imaging technologies, 6G is set to be deployed in the North Sea to monitor the UK's first Carbon Capture and Storage sites. As the article on page 20 explains, offshore CCS not only has the potential to help reduce our carbon dioxide emissions, but also aids recovery from reservoirs that are still producing.

Enhanced Oil Recovery is also the theme of the reservoir surveillance feature on page 26. Our tracking, positioning and monitoring tools are enabling exploration companies to switch their focus from looking for new reserves to maximising the recovery from existing fields.

New for this issue of Baseline is The Know How, a column dedicated to giving you practical tips and advice on how to get the best performance from your Sonardyne technology. In this first edition we talk o-rings, shackles and sensor calibrations. If there's a topic area you'd like discussed, please get in touch with our customer support team.

If you enjoy reading Baseline, why not recommend it to a colleague? They can register via the Baseline link on our homepage.



David Brown Editor



Baseline » Issue 12

Front Cover
This over-the-side deployment pole fitted with a Sonardyne HPT acoustic modem was temporarily installed on a chartered vessel for a data recovery project in the North Sea. The pole is designed for easy installation, disassembly and transportation and is ideal for vessels where permanent or through-hull deployment is not required or available. Read the full article on page 26.

In this issue...

04 Kit A look at Sonardyne's recommended transponder configurations for the most popular subsea operations.

06 News Award-winning technology, exceptional imagery, OHSAS certification, workshops and seminars, data recovery and more 6G success.

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30 International The latest news from Sonardyne's regional offices around the world, including upcoming large scale projects in the Gulf of Mexico and a 21st birthday for Sonardyne in Singapore.

31 Help & Advice Introducing 'The Know How', the new advice section from Darren Taylor and his Customer Services Team where you can get the answers to the all the questions you want to ask.



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14



"CCS is an important technology; providing confidence that CO_2 is safely stored is vital to the technology's success."

Sarah Mackintosh
Office of CCS, DECC

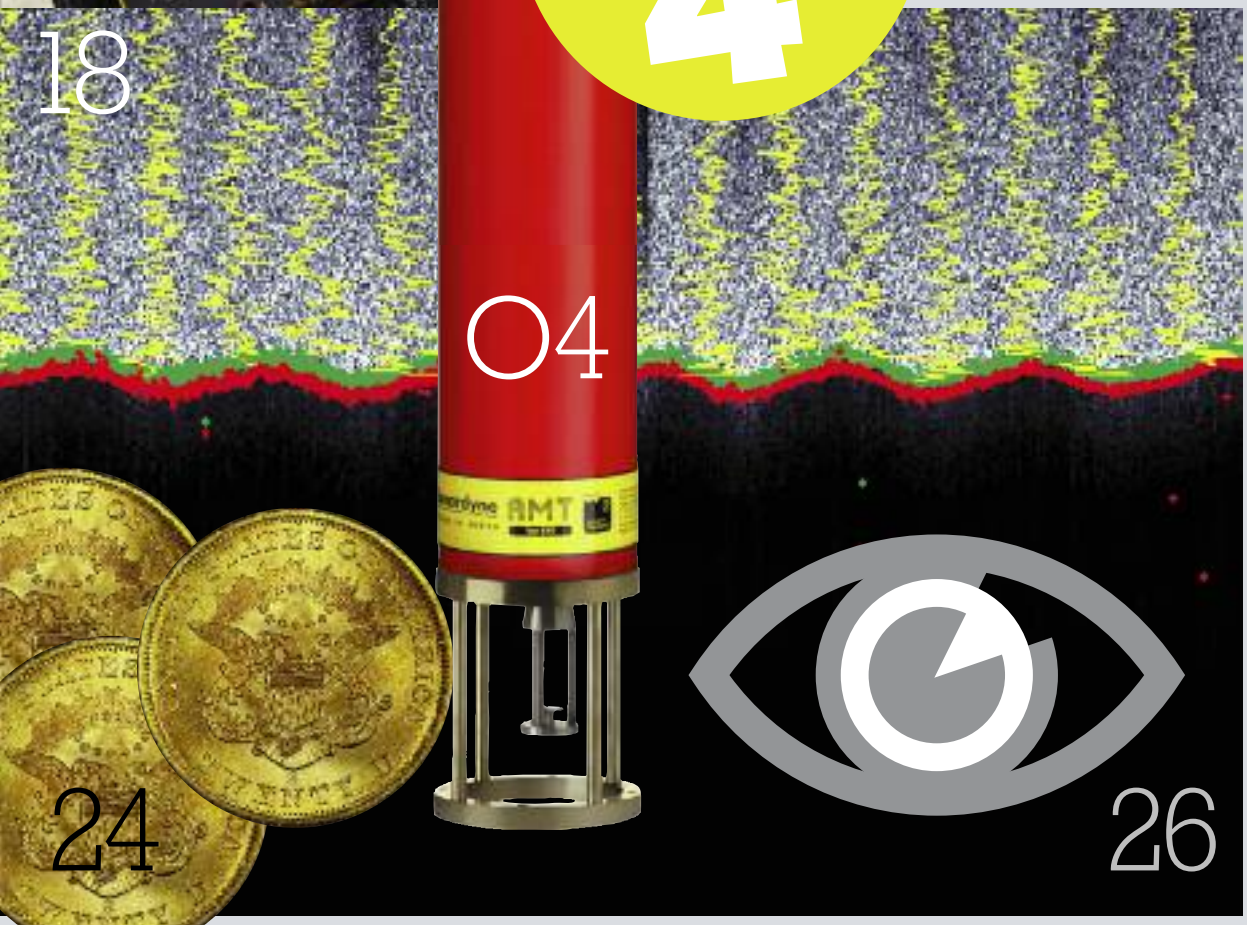
Department of Energy & Climate Change



8300 series transponders

OUR TOP 4

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Baseline Magazine
The Customer magazine from Sonardyne

Editorial Team
David Brown, Head of Marketing

Kelly Friend, Managing Editor

Anthony Hammond, Marketing Manager – Digital & Events

Design and Art Direction
Michael Lindley at TruthStudio
www.truthstudio.co.uk

Photography
Astonleigh Studios
www.astonleighstudio.co.uk
(pages 4, 5, 10, 11, 17, 19, 28, 32).

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Sonardyne
SOUND IN DEPTH

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»KIT

Transponder configurations for subsea operations

OUR TOP 4

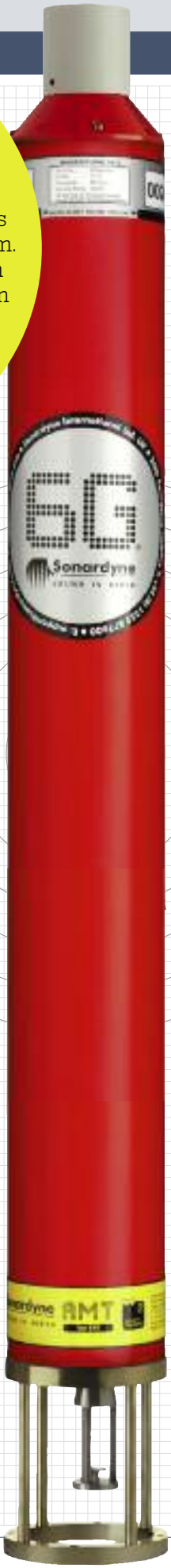
From standard LBL operations through to long life seabed surveys, there's a 8300 series transponder to meet your needs.

Sonardyne's 8300 series of 6G® subsea transponders provide integrated navigation, telemetry and modem capabilities. Over 3,600 configurations are available, all of which use Wideband 2 advanced signal processing for navigation and acoustic communication. The result? Improved acoustic performance in challenging conditions, longer range and robust multipath rejection around structures.

AMT

Deploy it: leave it

AMT transponders allow long endurance (up to 5 years) storage of sensor data. Data is recorded internally and can be recovered via its integrated high speed acoustic modem. AMTs offer additional capability such as collecting baseline ranges between transponders. Applications include seabed settlement or long term structure movement monitoring.



#2 Seabed Settlement Monitoring

Suggested Spec

- **Transducer** Omni-Directional
- **Housing** Maxi Ali Bronze
- **Power** Lithium
- **Endcap** Non-release
- **Sensor** High Accuracy SV, Inclinometer, Dual Depth, Temp

Compatt 6

The all-rounder

Compatt 6 is the industry standard LBL transponder used for high precision subsea survey and construction operations in all water depths. These include spoolpiece metrology, pipeline touchdown monitoring and structure installation. Compatt 6 is compatible with all of Sonardyne's USBL acoustic positioning systems.

#1 LBL Array Transponder

Suggested Spec

- **Transducer** Omni-Directional
- **Housing** Standard Aluminium
- **Power** Lithium
- **Endcap** Integrated acoustic release
- **Sensor** High Accuracy Depth, Temp, Tilt





#3 Dynamic Positioning Reference

DPT 6

Spot on target

If you need an ultra-dependable, cost effective seabed position reference beacon to use with your vessel's Dynamic Positioning system, then look no further than DPT 6. It's quick to set up on the back deck, easy to deploy and thanks to its integrated acoustic release mechanism, can be recovered without the need to send down an ROV.

Suggested Spec

=

Transducer MF Directional

+

Housing Standard Aluminium

+

Power Lithium

+

Endcap Integrated acoustic release

+

Sensors Tilt, Depth, Temp

Gyro Compatt 6

The ultimate LBL instrument

GyroCompatt integrates a Compatt 6 and Lodestar attitude, heading and reference sensor in one small, highly versatile and robust subsea instrument. Compatible with USBL and LBL positioning systems, GyroCompatt provides high update rate wireless attitude, heading, heave, surge, sway, pressure, SV and position of any subsea object.

#4 Structure Installation



Suggested Spec

=

Transducer Omni-Directional

+

Housing Standard Aluminium

+

Power Rechargeable Li-Ion

+

Sensor Heading, Roll, Pitch,Heave, Depth, SV

NEWS

SURVEY

Exceptional imagery for Bluefin Robotics

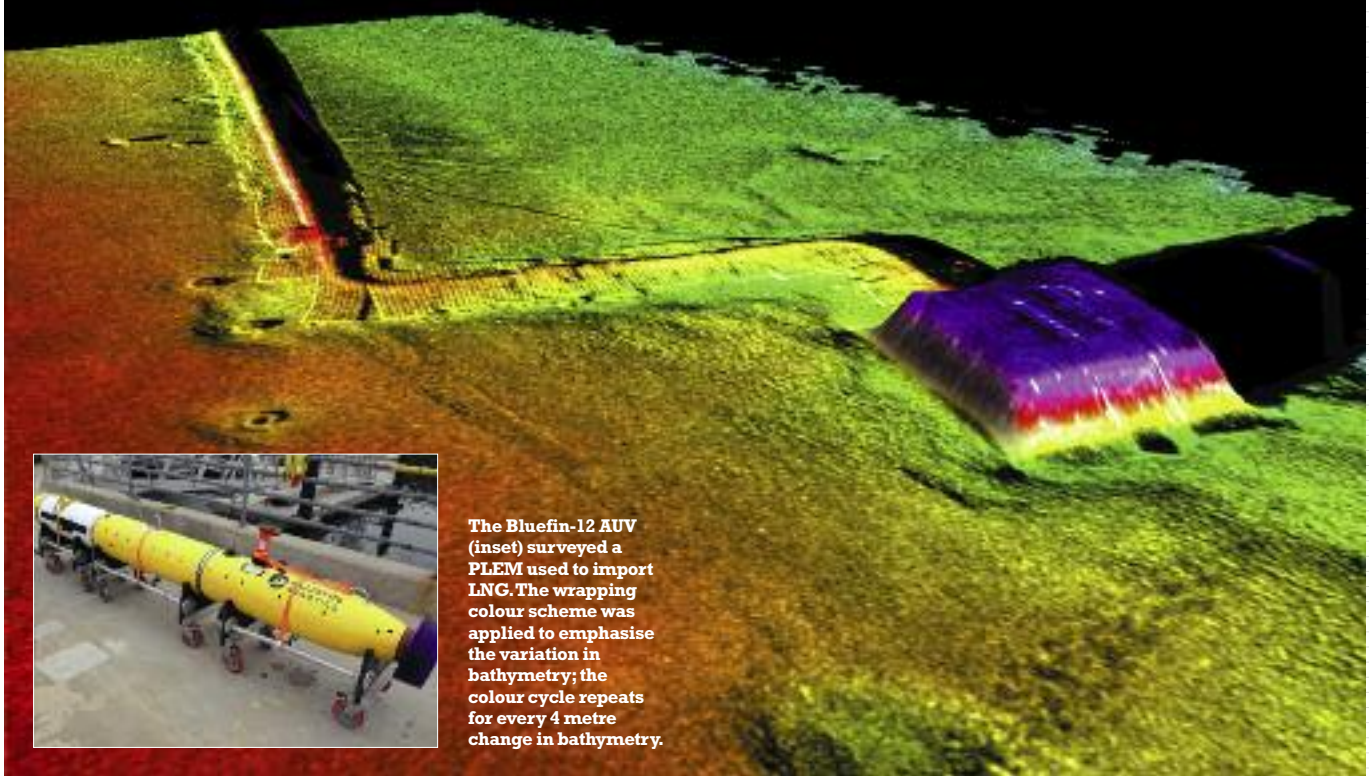
Sonardyne and Bluefin Robotics, developers of Autonomous Underwater Vehicles (AUVs), have collaborated to integrate a Solstice side scan sonar with a Bluefin-12 AUV with results of recent payload testing producing higher quality imagery than is currently available from conventional sonar. A modular vehicle that allows for swappable payloads, Bluefin-12 is most commonly used for offshore survey, search and salvage, environmental monitoring and unexploded ordnance survey operations.

"Bluefin Robotics and Sonardyne have a long partnership; we already use products from their acoustic positioning and wireless communications technology ranges which are installed on some of our other AUV models," said David Kelly, President & CEO for Bluefin Robotics. "Installing Solstice is part of our latest development programme to demonstrate the technology as an integrated option for our customers."

Solstice produces imagery of the highest possible quality from a conventional (non-SAS) sonar. It is designed to produce wide swath coverage (±100 metres) whilst consuming only 18 Watts of power, increasing the operational and cost effectiveness of the AUV. The most recent trials of the Bluefin-12 AUV with the integrated sonar were conducted from Bluefin Robotics' headquarters in Quincy, Massachusetts, where the AUV was deployed from Bluefin's vessel, the *R/V Resolution*, to perform short missions around the Boston Harbour area in approximately 15 metres of water. Each mission consisted of runlines of 500 metres, during which the AUV flew in a pattern known as 'mowing the lawn.'

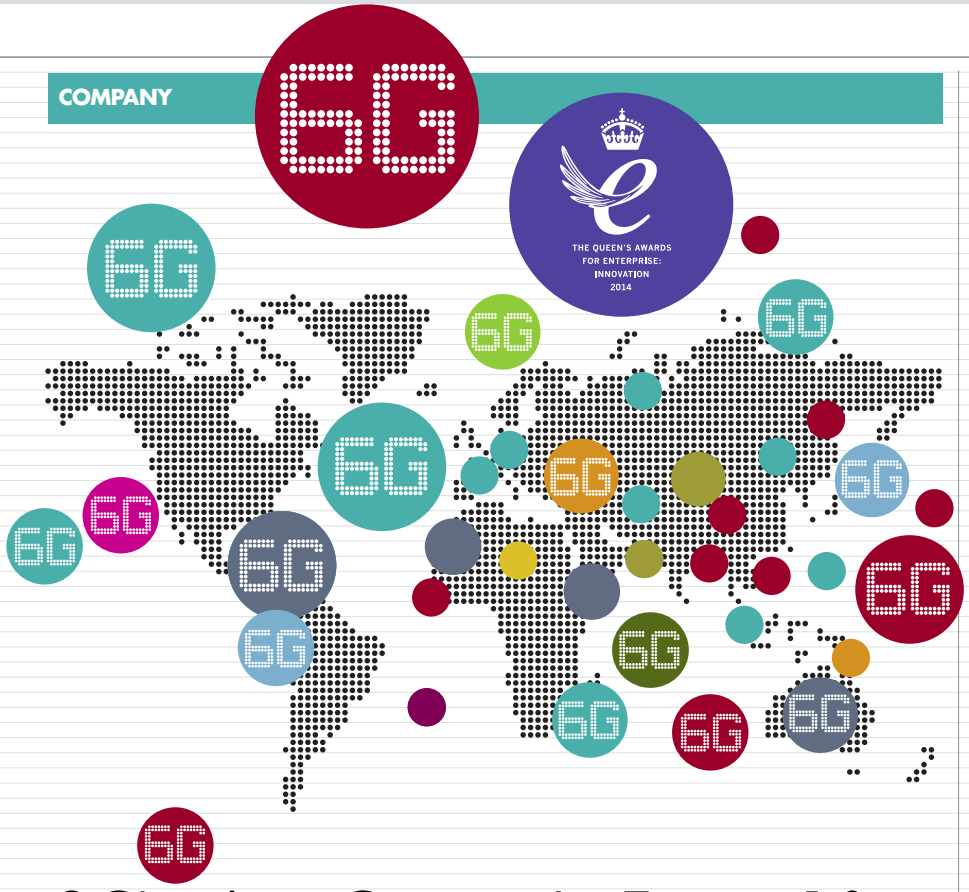
"We are pleased with how quickly we were able to integrate the sonar and collect high-quality data," said Will O'Halloran, Marine Operations Manager at Bluefin Robotics. "The imagery is some of the best I have seen in my 10 years of operating AUVs and reviewing data sets. The Solstice sonar is an excellent payload option for our clients who want exceptional imagery from low-logistics, rapidly-deployable AUVs."

"A surveyed pipeline end manifold (PLEM) provided an excellent target to show the resolution and contrast performance of Solstice. This PLEM consists of a large square template, pipe and mattress protectors; you can see where the individual elements of the mattress are clearly resolved in the imagery," said Nick Swift, Sonardyne's Business Manager for Maritime Security. "This is further proof of Solstice's exceptional image quality and is thanks to advanced processing techniques, inbuilt technologies and a unique array design for minimising multipath effects."



The Bluefin-12 AUV (inset) surveyed a PLEM used to import LNG. The wrapping colour scheme was applied to emphasise the variation in bathymetry; the colour cycle repeats for every 4 metre change in bathymetry.

COMPANY



6G wins Queen's Award for Enterprise in Innovation

Sonardyne is celebrating winning the Queen's Award for Enterprise in Innovation for its 6G® underwater product range. The Awards recognise and encourage commercial success resulting from outstanding innovative achievements by businesses in the UK and are conferred by HM Queen Elizabeth II, on advice of the Prime Minister. The Queen's Award is the highest award a UK business can receive.

Launched in 2010, Sonardyne's award winning 6G technology platform was judged to have addressed users' needs for underwater technology that is low risk, versatile and easy to use. Its performance over the previous generation technology can be likened to the difference between analogue and digital mobile telecommunications. 6G products have made an impact on diverse subsea operations around the world and, in 2013/14, were exported to 55 different countries. Users of the technology are found within the offshore energy, ocean research and maritime security industries.

"We are immensely proud and honoured to have won The Queen's Award for Enterprise in Innovation with our ground-breaking development of 6G," said John Ramsden, Sonardyne's Managing Director. "When we set out down the path towards 6G, we wanted to develop a family of products that would maximise operational efficiencies and, at the same time, simplify use and minimise costs for our clients. Four years of export success, culminating in this prestigious award, is recognition of our achievements. 6G has brought tangible benefits wherever it has been put to work and is helping to redefine the way in which we explore our oceans and realise our global energy needs."

HEALTH AND SAFETY

Sonardyne companies achieve OHSAS 18001 accreditation

Baseline is pleased to report that Sonardyne's regional offices in Brazil and Asia have been awarded OHSAS 18001 Safety Management System Standard accreditation.

The Occupation Health and Safety Assessment Specification (OHSAS) sets out the suggested requirements for occupational health and safety management for best practise in the workplace. It is internationally accepted as a method of assessing and auditing occupational health and safety management systems. Developed by leading trade and international standards bodies, OHSAS 18001 provides a framework for organisations to instigate proper and effective management of health and safety in the workplace.



"Gaining this certification demonstrates both Sonardyne Brazil's and Sonardyne Asia's commitment to maintaining an effective health and safety culture for their employees," said John Ramsden, Sonardyne Managing Director. "Not only will this benefit us but it will also benefit our commercial partners by minimising the risk of incidents and accidents occurring as we conduct our business operations. With Brazil and Asia already certified, we can now concentrate on achieving the same for our Houston office and UK headquarters."

NEWS



Free workshops are the ideal platform for users to discuss the latest technologies and techniques.

TRAINING

Technology seminars go from strength to strength

Sonardyne's latest subsea technology and Dynamic Positioning (DP) workshops in Aberdeen and Norway were well attended by their respective industry professionals.

In Aberdeen, offshore industry representatives explored the application of inertial navigation, acoustic positioning and remote monitoring technologies for maximising efficiencies across Life of Field operations. Focusing on acoustically-aided inertial navigation technology, in particular LBL-aided INS, attendees gained insight into the operational considerations that need to be planned for and the projects it benefits.

Speaking afterwards, a project manager from a leading survey construction company commented, "It is always good to attend this kind of seminar as they help to refresh and familiarise ourselves with new products and methods being developed. I was fascinated by the real world offshore applications and results and will definitely be attending future Sonardyne workshops."

Across the North Sea, representatives from Norway's shipbuilding industry joined Sonardyne, Guidance Marine and Veripos to discover the latest advances in Position Monitoring Equipment. The event consisted of presentations from each company, individual hands-on technical sessions on current system usability and a forum discussing future capability, looking at the DP system of the future.

"Regular workshops are just one of the ways in which we show our commitment to ensuring users get the best performance from their investment in our technology," said Peter Major, Survey Manager at Sonardyne. "Workshops provide the ideal platform for equipment users and specifiers to come together and discuss the latest techniques and technologies that can influence the way in which future subsea operations are conducted."



PROJECT

Wireless data recovery: Lowering operational costs and reducing risk

A collaboration between Sonardyne, Shell and Liquid Robotics has seen the development of a Liquid Robotics Wave Glider® configured for high speed acoustic data retrieval from seafloor sensors.

For the last three years, Sonardyne's autonomous sensors have been recording pressure data for monitoring seafloor subsidence in a Shell-operated field. Now, using a Wave Glider fitted with a Sonardyne high speed acoustic modem, multiple data harvesting operations have demonstrated the capability to retrieve logged data without the intervention of a survey vessel.

The sensor logging nodes can remain deployed for several years and, depending on the parameters being investigated, a wide range of sensors can be fitted. At configured intervals, each node wakes up, logs and time-stamps sensor data before returning to standby mode until the next measurement cycle.

The data stored within each node is available for recovery on demand at the surface via the high speed acoustic modem and, during the project's early stages, data was conventionally retrieved using this technology onboard a vessel. However, the Wave Glider removes the need for this vessel and is capable of remaining at sea for many months, transiting between each node to collect data. "Using a Wave Glider to harvest data acoustically is a highly economical, and sustainable way to monitor our production," said Paul Hatchell, Geophysicist in Shell's Areal Monitoring research team.

"Deploying an autonomous marine vehicle like the Wave Glider means that we can offer clients cost-effective and safe methods of collecting subsea sensor data in remote deepwater offshore fields," commented Sudhir Pai, Vice President Operations and Technology at Liquid Robotics Oil and Gas. "This method not only significantly reduces the total cost of operations but also removes the health and safety risks associated with sending a vessel and crew to sea."

CONTRACTS

SEAMEC Princess upgrades to Ranger 2 Pro

SEAMEC Ltd., one of India's leading providers of Diving Support Vessels (DSVs) for the offshore industry, has once again chosen Sonardyne acoustic position reference technology to support its DP operations. The company has upgraded the Ranger 1 system installed on the *SEAMEC Princess* to the highest specification, current generation USBL platform, Ranger 2 Pro.

In its role as a DSV, maintaining a constant vessel position during subsea operations is a critical requirement for the *SEAMEC Princess*. As such, Ranger 2 Pro was specified for its ability to operate with a network of transponders deployed on the seabed that offer positioning redundancy in all operating conditions.

''We have used Sonardyne's Ranger technology for many years so when the time came to upgrade the system, the operational and performance gains offered by Ranger 2 made the decision a simple one,'' said KT Thomas, DGM (Tech) for SEAMEC Limited. ''The nature of the work demands that our DP system is continuously fed with good quality position reference data. By opting for Ranger 2 Pro, we'll be able to meet this requirement.''

Daniel Tan, Regional Sales Manager for Sonardyne Asia commented, ''We have a long standing relationship with SEAMEC so we're pleased to continue supporting them with the latest technology that will improve the efficiency of their subsea operations, reduce vessel time and generate savings.''





Ranger 2 Pro has been installed on the SEAMEC Princess DSV, upgrading from Sonardyne's original Ranger system.

EXPLORATION

EMGS ASA explore capabilities of 6G for nodal surveys



6G is used to position the EM Source as it flies above deployed seabed receivers during CSEM.

Electromagnetic Geoservices ASA (EMGS), specialists in Controlled-Source Electromagnetic Surveying (CSEM), is using 6G for improved precision and redundancy in EM source positioning. The technology will also be used to position and retrieve EM seabed receivers.

A Ranger 2 USBL system has been installed on the *EM Leader* vessel with DPT 6 mini transponders mounted on the EM source and the dipole at regular intervals along its length. The system then tracks the position of the DPT 6s – and therefore, the EM source – as it flies above the seabed receivers. Once data acquisition is complete, Ranger 2 is used to relocate the seabed receivers (each fitted with a transponder) and issues a command to release the receiver and float to the surface for recovery and data retrieval.

''We wanted a system we could rely on to accurately and precisely position both the EM source and the receivers,'' commented Jonathan Fletcher, Supervisor Navigation Support at EMGS. ''We have considerable experience with Sonardyne technology and with 6G, we know that all our requirements will be fulfilled.''

Dynamic Positioning

Technology: Acoustically Aided Navigation

ACOUSTIC AND INERTIAL. PERI



Mikael Larsen, Principal Engineer – INS at Sonardyne, explains the differences between Loose, Tight and Ultra-Tight integration for DP-INS technology.

FECTLY ALIGNED



It's well known that combining acoustic positioning with an Inertial Navigation System (INS) benefits Dynamic Positioning by improving accuracy, update rate and reliability of position data. Sonardyne's first generation 'loosely' integrated solution delivered notable performance gains; four years on, the arrival of a 'tightly' integrated DP-INS technology represents a genuine break-through to rival state-of-the-art satellite navigation performance even far offshore in ultra-deep water. Writing for Baseline, **Dr Mikael Larsen**, Principal Engineer – INS, pieces the story together.

ACOUSTIC POSITIONING and INS have complementary characteristics and their combined use was first suggested in 1975. Since then, technology and systems have matured with acoustic-inertial systems available from different vendors having been in successful operational use for many years. For a long time, LUSBL (Long and Ultra-Short BaseLine) acoustic positioning was the only practical complement to satellite based DP in deep water. Sonardyne's first introduction of loosely integrated INS in 2010 provided a third type of positioning reference by extending USBL positioning into deeper water via reduction of noise and bridging of small dropouts in acoustic positioning. DP using a single seabed transponder was proven in water depths up to 3,070 metres (10,072 feet) and this configuration remains in use for operation in benign conditions where time is at a premium.

While operationally efficient, single transponder USBL aided inertial navigation does have limitations. Complex acoustic degradation can arise from severe thruster wash, turbulence, aeration or an obstructed line of sight. Under harsh operational conditions, these error sources can be of sufficient magnitude and duration for the INS to drift outside of acceptable positioning tolerances. The latest generation Sonardyne DP-INS tightly integrated acoustic-inertial position reference system has been in operational use since 2013, offering optimal and seamless use of any number of transponders – from single transponder use in benign conditions to full LUSBL array use for the most challenging operations.

Loose, Tight and Ultra-Tight integration

Using terminology from GNSS (Global Navigation Satellite System), the integration of INS with measurements from external aiding sensors is

Dynamic Positioning

Technology: Acoustically Aided Navigation

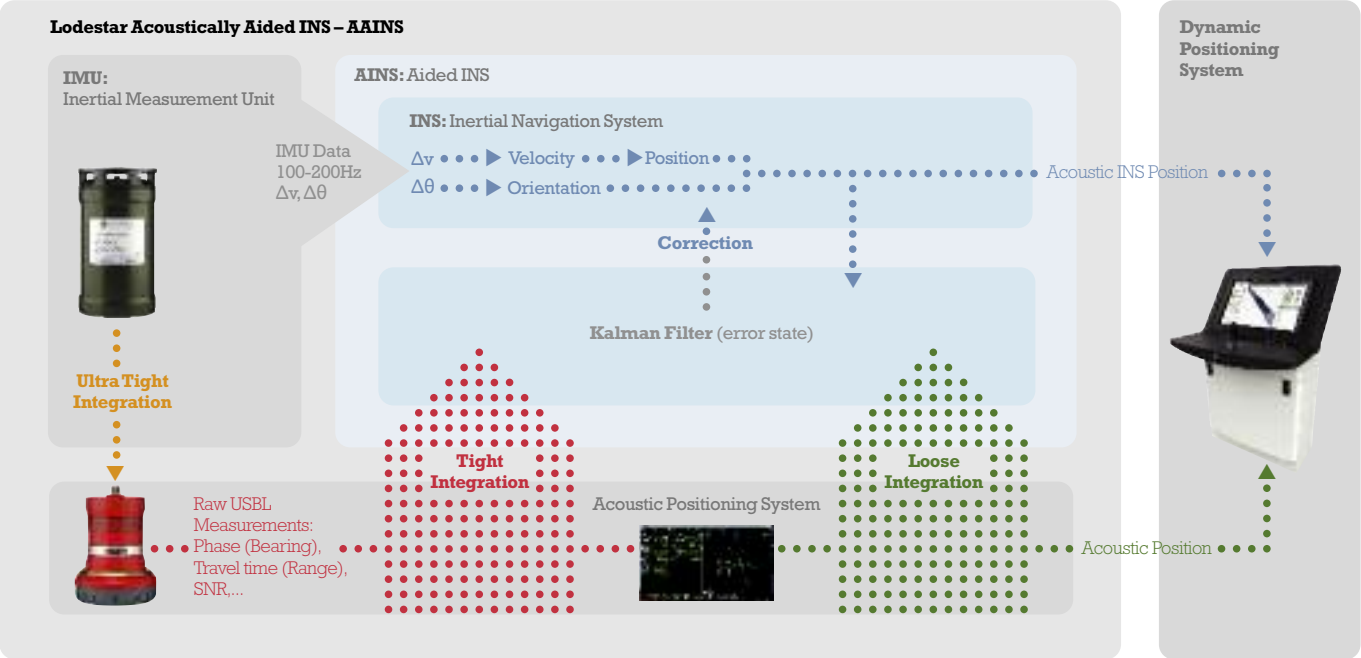


Figure 1 Loose, Tight and Ultra-Tight INS integration

categorised respectively as Loose, Tight or Ultra-Tight depending on the level at which integration takes place.

Figure 1 shows the internal workings of an Acoustically Aided INS (AAINS), including the different levels of integration. Orthogonal accelerometer and gyroscope triads within the IMU (Inertial Measurement Unit) measures change in velocity (Δv) and orientation (Δθ). INS algorithms integrate the IMU data to output position, orientation and velocity. Aided INS (AINS) uses an error state Kalman filter to continuously estimate and correct INS error by processing measurements from external sensors – here USBL.

In a loosely integrated configuration, the INS is aided by the positions computed by a conventional acoustic positioning system. Tight integration makes use of the individual acoustic measurements from the USBL transceiver – two way travel time (range) and phase differences (direction). Accuracy and robustness is known to improve with the level of integration but so is the required engineering effort. Ultra-tight integration refers to additionally using inertial measurements to improve the low-level measurement process of the aiding sensor. Military use of ultra-tightly integrated GNSS/INS enable GNSS receivers to maintain tracking of the satellite signals in scenarios with severely reduced signal to noise ratio. Future ultra-tight integration between USBL and INS may similarly enhance acoustic tracking in high-noise conditions.

Accuracy break-through

Figure 2 illustrates acoustic positioning and the difference between loose and tight acoustic-inertial integration in high noise conditions. In deep water, it takes several seconds for the acoustic signals to travel from the USBL transceiver to the seabed transponders and back. Wave or thruster induced vessel motion during this time period is not easily compensated for in a standalone acoustic system. This results in latency and reduced accuracy of the computed position and so also severely limits the performance of a loosely integrated acoustic-inertial solution. It is easily within the capability of a quality INS to measure and compensate for vessel motion during an acoustic cycle. In a tightly integrated configuration, this allows full utility of the robust centimetric level range measurement precision of modern Sonardyne 6G wideband acoustics.

The net result is a genuine break-through in real-world performance. It is now possible to achieve centimetric level positioning accuracy/

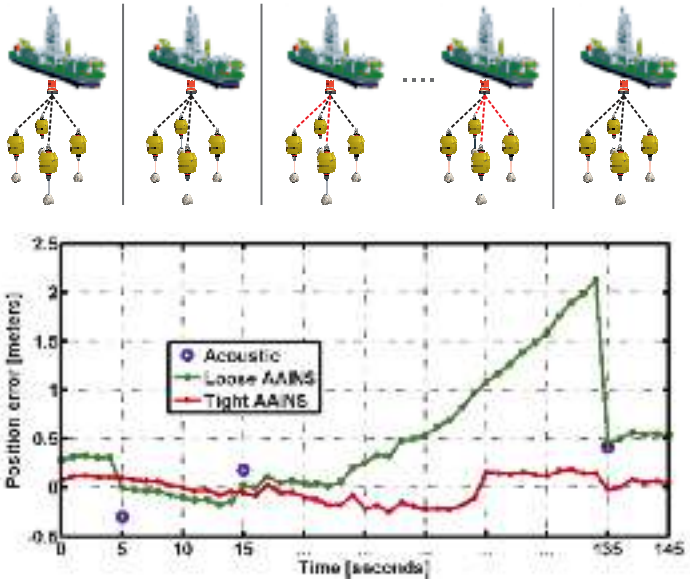


Figure 2 Acoustic positioning, loose and tightly integrated INS in conditions of noise and aeration. A dotted red line in the vessel illustrations above indicates a failed acoustic measurement.

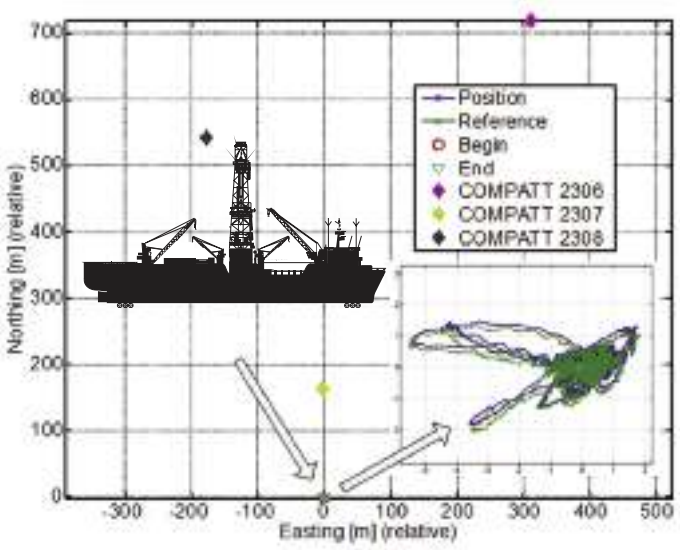
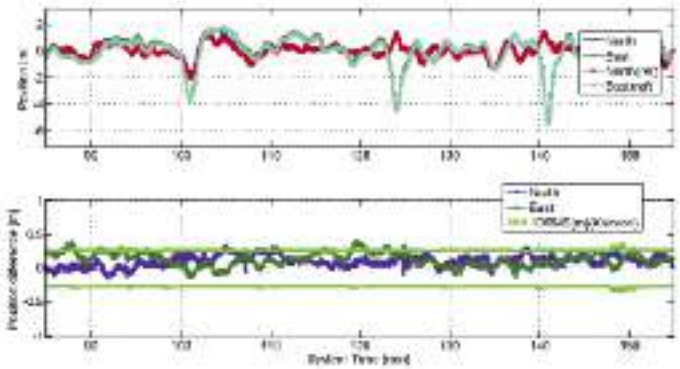


Figure 3 Three transponders, 1,720 metres water depth, four second acoustic update rate (operation outside of array). **Figure 4** INS positioning performance as compared to reference GNSS. 1DRMS ~0.2m. INS perfectly follows true vessel motion.



repeatability in water depths beyond 3,000 metres (relative to the seabed transponder array).

Improved robustness

Tight integration also offers much increased robustness during periods of acoustic degradation as illustrated in Figure 2. From the 15 second mark and continuing for 120 seconds until 135 seconds, only a few acoustic measurements are available per acoustic cycle. This prevents standalone acoustic positions from being computed and hence the loosely integrated solution enters free inertial drift (2 metres drift in ~ 2 minutes) until acoustic positioning is restored. The more robust tightly integrated solution makes full use of the reduced set of USBL acoustic measurements and the effect is just a slight decrease in accuracy. Due to tight system integration, the Kalman filter gets direct access to a rich set of low level quality metrics created by the acoustic transceiver's wideband digital signal processing and so can better assign weights to the acoustic measurements and eliminate outliers.

Deep water operational results

Figures 3 and 4 show Sonardyne DP-INS results from operational use onboard a deep water drillship. Despite using just three transponders as compared to the standard five for a stand-alone LUSBL acoustic system, the performance and DP weighting is close to state-of-the-art GNSS.

Figures 5 and 6 show Sonardyne DP-INS results obtained in November 2013 onboard another ultra-deep water drillship operating in 2,700 metres of water. The solution remained operational at about 1 metre accuracy despite being down to just two transponders. The acoustic update rate was just 12 seconds (prolonging battery life) with the transponders deployed within easy ROV reach at less than 10 degrees off the vertical. This previously unheard of level of robustness and operational efficiency is only possible via tight integration. Using three or (preferably) more transponders is recommended for DP drilling applications. However, this example shows how robust accurate positioning will typically carry on even if one transponder is lost.

Bring it all together

Tightly integrated acoustic-inertial navigation provides accuracy,update rate, robustness and hence DP weighting that is on par with state-of-the-art GNSS (GPS) when operating within a conventional LUSBL array of transponders. The massively increased performance from tight acoustic-inertial integration can also be used to reduce the number of transponders and the acoustic update rate. This extends the battery life of seabed equipment and reduces operational cost. The reduced amount of acoustic signals in the water also simplifies simultaneous operations (SIMOPS). Pre-calibrated USBL transceivers with mechanically integrated INS are available. Their use saves vessel time and reduces the risk of down time since a transceiver can now be replaced without the need for a lengthy system calibration. **BL**

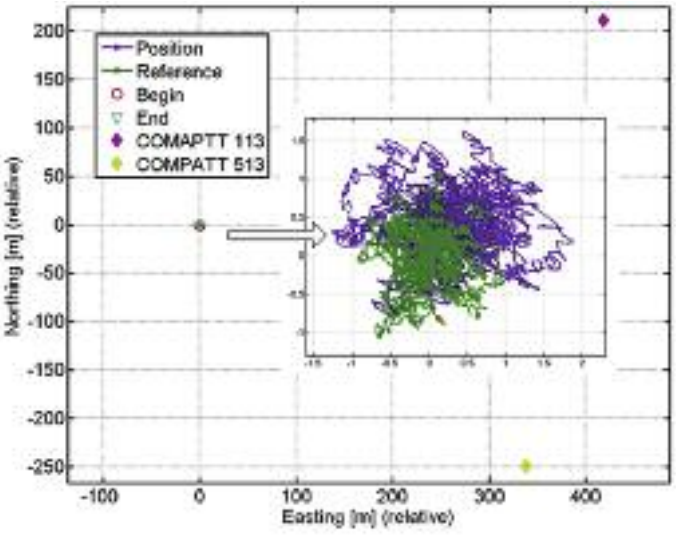
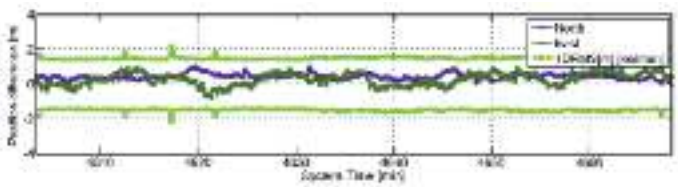


Figure 5 Two transponders deployed within ROV reach at <10 deg off the vertical, 2,700m water depth, 12 second acoustic update rate. **Figure 6** INS positioning performance as compared to reference GNSS. Expected 1DRMS accuracy ~1.5m, actual positioning accuracy <1.0m (1DRMS).



Construction Survey

Product Focus: Fusion LBL

Pick any offshore field developed in the last 35 years and the chances are Sonardyne's Long BaseLine (LBL) acoustic positioning equipment has played a part in its construction, from installing structures and tracking ROVs to conducting spoolpiece metrologies. Fusion 6G is the company's sixth generation LBL platform, evolved to meet users' requirements for software that is powerful yet simple to use with subsea hardware that can be configured for many different applications. **Edd Moller**, Global Business Manager for Construction Survey and **Peter Major**, Survey Manager, pick out the top reasons to invest.

FUSION 6G: BE



Trusted Solutions

Decades of development and experience

Fusion 6G is the net result of nearly four decades of LBL experience. Over this time, the development of 'best practice' techniques and proven computations deliver exceptional subsea positioning performance no matter how deep, how shallow or how complex the task is.

Specifying Sonardyne LBL offers the lowest risk solution encompassing the best performing technology, free consultative help and a 24/7 global support network. The success of Fusion 6G is testimony to the abundant wealth of knowledge and experience available throughout Sonardyne that directly contributes to the success of clients' subsea projects.



Precision

The most precise at any depth

Regardless of water depth, the precision of Fusion 6G is the same and far exceeds other surface installed positioning systems such as USBL. This allows field developments to be planned to the same specification in deep and shallow water, safe in the knowledge that the highly accurate Wideband 2 acoustic signals found inside 6G hardware will allow for the precise installation of subsea structures, ROV tracking and accurate acoustic metrologies.



Multiple Applications

It can do anything you want

Using the same equipment, it is possible to perform any project ranging from wide area subsea positioning through to highly accurate metrology measurements. LBL arrays of 6G 'Compatt' transponders can be used for positioning vehicles such as ROVs while mobile transponders can be placed on oil and gas structures to provide positioning and other information such as structure heading, pitch and roll or any other variable that needs monitoring. LBL arrays are also used for seabed settlement studies and pipe and cable touchdown monitoring where descent rate is an important factor.



Scalability

As big or as small as you need it to be

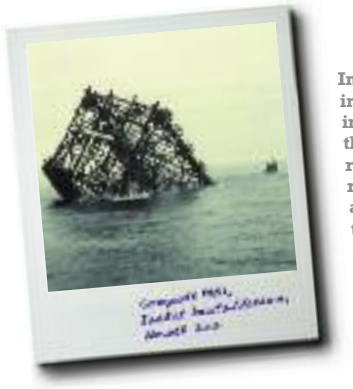
6G LBL seabed arrays can be scaled to suit any project. Array transponders can be placed in seabed tripods in order to obtain centimetric positioning for tasks such as metrology and structure installation. Alternatively, they can be deployed on floats to a set height above the seabed that makes a compromise between accuracy and distance. Compatts deployed on strops can easily range over 3,000 metres between themselves and provide positioning to less than 50 centimetres at the same time. This accuracy allows for most field wide positioning tasks whilst reducing the number of seabed transponders. Even fewer transponders can be used by using SPRINT, Sonardyne's acoustically aided INS system.



Vessel Topside

Flexibility to interface with any transceiver

As all Sonardyne 6G transceivers use the same communications language, it is simple to interchange between ROVNav 6, Dunker 6 or HPT USBL transceivers. Each transceiver can be easily interfaced with Fusion 6G depending on the



In 1979, Sonardyne introduced Compatt - an intelligent transponder that had the capability to make direct baseline measurements for rapid array calibration. Over the next 35 years and six hardware generations, Compatt has had a direct impact on every major field development project around the world.

ST IN THE FIELD



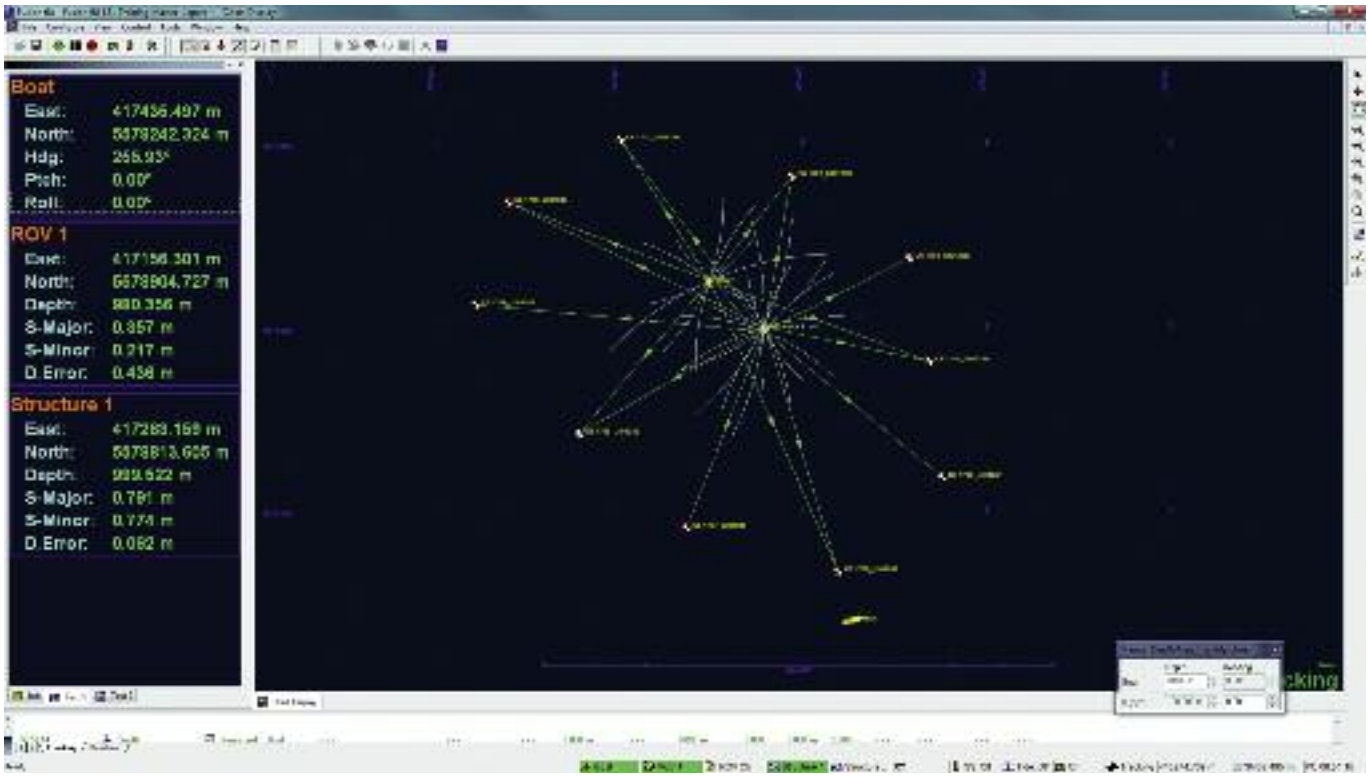
Compatt 6s stand ready for deployment. Wideband 2 technology enables faster, more efficient solutions for applications such as spoolpiece metrology (above) and subsea structure placement (right). (Below) Recognised as the industry standard tool, there is a worldwide pool of skilled and experienced LBL operators and surveyors. This ensures LBL projects are well mobilised and subsea tasks are carried out correctly and efficiently.





Construction Survey

Product Focus: Fusion LBL



Sonardyne's tried and tested Long BaseLine positioning software, Fusion 6G, is successfully controlling many construction survey projects from complete field-wide positioning to precise acoustic metrology campaigns. Fusion 6G is also being operated to control multi-user LBL arrays enabling up to five ROVs to be positioned in a single LBL array simultaneously.

subsea operation. Additionally, Sonardyne seabed LBL transponders also support the HPR400 acoustic signal architecture which allows them to be calibrated using USBL systems available from other manufacturers and suppliers.

6 Trained Workforce

People already know how to use it

With thousands of people having passed through the Sonardyne Training Academy, there is a readily available pool of highly skilled and experienced LBL operators. This ensures LBL equipment is well mobilised and projects are carried out correctly and efficiently. Procedures are well understood, techniques have been finessed and jobs can be planned safe in the knowledge that skilled offshore personnel will carry them out.

7 Sonardyne Wideband® 2

The signal technology behind Fusion 6G

When exclusively using 6G hardware, operators have access to the latest Sonardyne Wideband 2 acoustic navigation and telemetry options.

Signal quality metrics are calculated for all received Wideband 2 acoustic signals and all this information is reported as part of the range or telegram message. Users can then be confident that power and gain settings are correct and that the direct signal has been detected, reducing risk for acoustic metrology operations. Additionally, these figures can be used to optimally weight an acoustically aided INS. With the extra signal length and data bits in a Wideband 2 signal, the effects of multipath are clearer to mitigate against.

8 SPRINT

Full or range-aided LBL

Fusion 6G is fully compatible with Sonardyne's SPRINT INS system. As a manufacturer of both INS and LBL components, only Sonardyne can provide such a tightly coupled solution. With its ease of use and class-leading performance, SPRINT INS can use either the full Fusion 6G solution or just the ranges from the LBL network in order to reduce the number of seabed transponders. Although it is possible to navigate from only a single transponder, it is only with two or more ranges that system redundancy can be used to provide confidence of the INS position.

9 Version 1.12 Software

Now available for Windows 7

Fusion 6G builds on Sonardyne's renowned LBL software application to provide support for the latest generation acoustic instruments. In maintaining a familiar front end software interface along with fully proven wizards to command subsea hardware, the switch to 6G can be considered a low risk process for existing users

Fusion LBL has recently undergone a large software development campaign to migrate it to the Windows 7 platform. In addition, features such as full multi-user setup and operation, auto transponder discovery mode, automatic power and gain, interface to the NSH control hub and remote access to the scripting tool will soon be available. The latest Fusion LBL software upgrade can be found at www.sonardyne.com or via support@sonardyne.com. However, version 1.11 is still available for those running Windows XP or do not require the latest features.







(Clockwise) 6G Configurator allows the user to view and adjust the properties of a 6G instrument once they've been acquired using an iWand test device (top right). Gyro-Compatt 6 combines a LBL transponder and AHRS in a single subsea housing. RovNav 6 is a vehicle-mounted LBL transceiver used to command Compatts.



Sonardyne Fusion 6G LBL – More features at a glance

- Faster setup using high speed telemetry commands
- Data storage and retrieval in Compatt 6 such as installed array co-ordinates
- Real time signal diagnostics for critical application QC
- Faster to calibrate using simultaneous baseline calibration
- 500+ non-interfering unique addresses for field-wide simultaneous operations

10 Tried and Tested

Independently verified by customers

The full least squares computations within Fusion 6G used for network adjustments have been mathematically proven to be the most effective way of calibrating subsea arrays. It offers full user control over setting the positions, depths and ranges with their estimated errors, full outlier rejection and the ability to correct for mistakes such as incorrect sound velocity. The generated calibration reports can be easily checked to allow for timely QC of LBL operations.

11 LBL Transponders

From Compatt to GyroCompatt

Fusion 6G can interface with a wide variety of transponders to provide the flexibility for users to select the exact instrument level they require. Options range from Compatt 6 transponders with standard depth sensors, to those that include other sensors such as sound speed sensors and inclinometers. The top specification GyroCompatt 6 integrates an LBL transponder and ring laser gyro in the same subsea housing for heading measurements, inertial grade pitch and roll along with high accuracy DigiQuartz depth sensors and more. (See page 4 for more transponder options).

12 Faster to Set-up and Calibrate

It's become easier, not harder

New simple telemetry commands such as 'Get', 'Set' and 'Sense' have removed the previously complex configuration process for setting up Compatts on the seabed. This means that there is a reduced requirement for training for operators as the complexity is now incorporated into the instruments and not the software. In addition, Sonardyne's new hand held acoustic transponder test and configuration device, iWand, allows for the easy set up of equipment in the workshop, on the back deck of a ship or on ROVs and subsea structures before they are deployed.

13 Multi-user Operations

Sharing single arrays

The development of multi-user functionality has been proven to allow multiple vessels and vehicles to use the same Compatt transponder array. Each Compatt has four subscription channels in addition to its common interrogation frequency, effectively making for five Compatts in one unit. Each transponder also maintains its 6G USBL interrogation channel and a HPR400 channel for third party USBL systems. Multi-user is already available in 6G hardware with full functionality in Sonardyne USBL systems being rolled out.

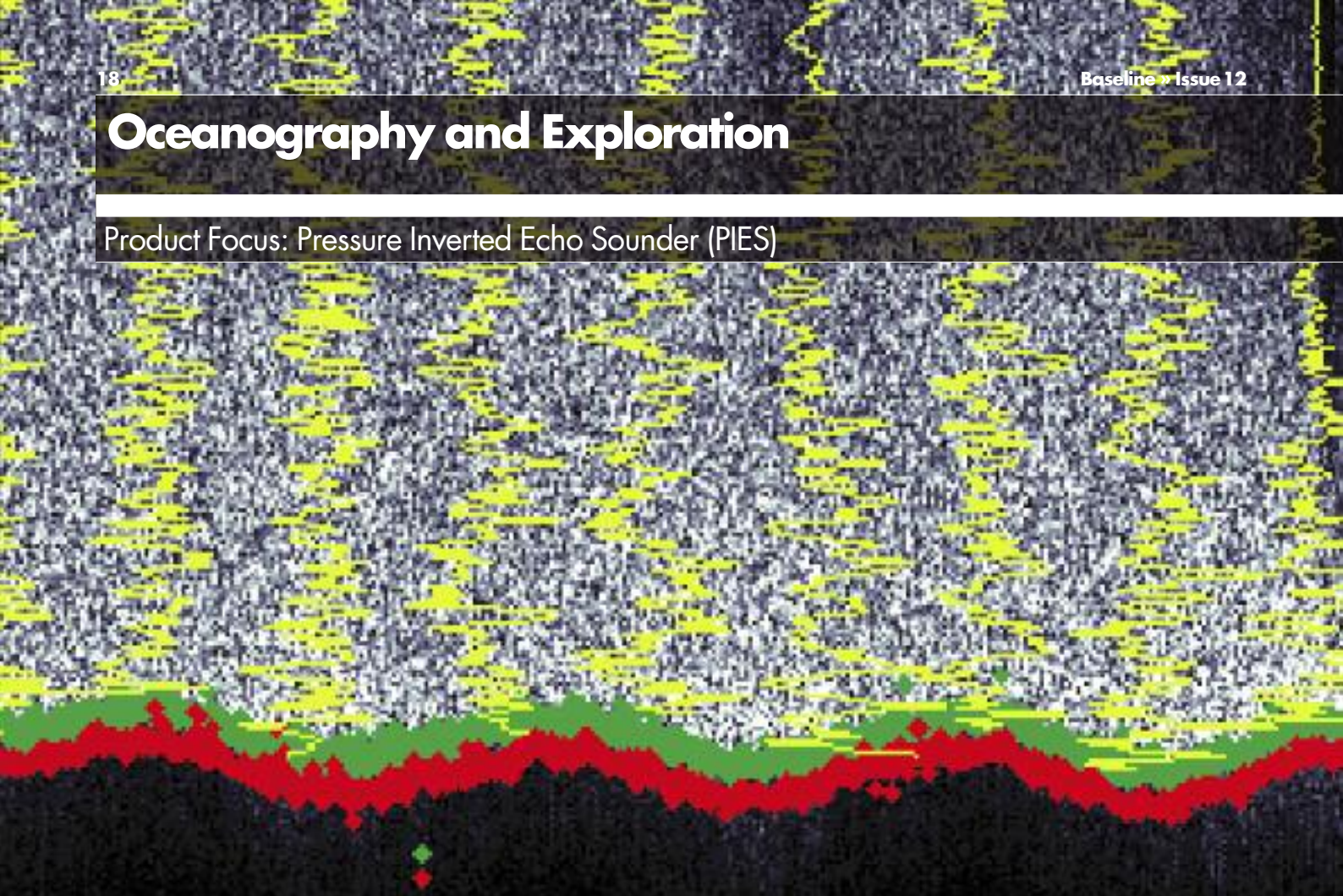
14 Support and Training

24/7, 365 days a year

Sonardyne supports, and supplies spares for, current and previous generation products meaning that 5G and 6G generations are fully supported. Investing in Sonardyne 6G means that in years to come, your equipment will still be working hard for you. As products near the end of their life, Sonardyne works closely with clients to ensure they have a simple, cost-effective upgrade path, keeping technology current throughout the lifespan of all projects. From planning, consultancy and custom engineering through to delivery, Sonardyne is available around the clock to support every project. **BL**

Oceanography and Exploration

Product Focus: Pressure Inverted Echo Sounder (PIES)



CHALLENGES MEASURING SOUND SPEED? PIES TAKES THE PRESSURE OFF

Sonardyne's track record in the development of wirelessly connected subsea instruments that position, monitor and communicate, meant the creation of an instrument to assist with reducing seismic variability and better understand the physical processes occurring in our oceans was a natural progression. Baseline takes a closer look at PIES and explains how measuring water velocity with a high degree of accuracy and repeatability sheds new light on survey data.

OFFSHORE EXPLORATION is heading into ever deeper water as many shallow reservoirs gradually move towards the end of their useful production lifecycles. Many deep water reservoirs are also geologically complex and require an increasing number of high quality seismic surveys to provide information on the changing structure and, ultimately, to maximise productivity.

Marine seismic acquisition is typically conducted using either several kilometre long streamers towed behind a surface vessel or by using seabed cables or nodes which are physically placed above the reservoir before shooting commences. These surveys can last from a few weeks to a few months and are often repeated as part of a reservoir surveillance programme at intervals ranging from several months to a number of years depending on the level of detail required.

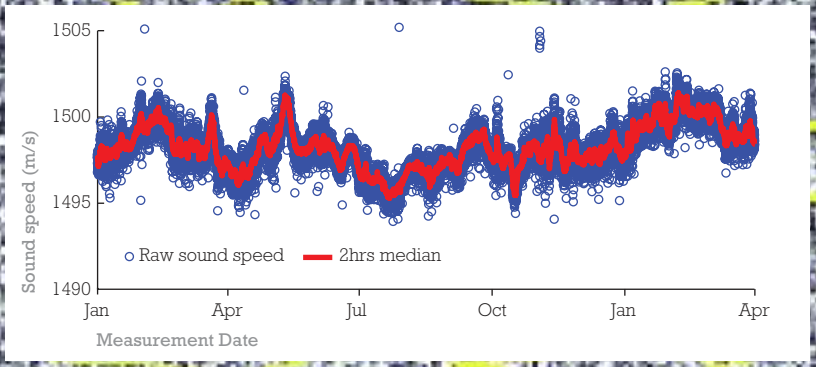
Repeatability, repeatability, repeatability

Obtaining high quality images is often hampered by variations in the process of repeating the same seismic acquisition multiple times. This variability comes in many forms including changes to the geometry between the source events (shots) and the receiver positions (streamers, cables or nodes). Environmental differences such as the weather, currents and tides also affect the speed at which seismic pressure waves propagate through the water column.

This speed is known as water velocity by geophysicists who go to great lengths to ensure it is well characterised during each acquisition and across multiple surveys to improve the quality of the surveillance imagery and minimise uncertainty in the reservoir description.

The traditional method for measuring water velocity is to use a sound velocity probe repeatedly deployed through the water column from a surface vessel. This method is often considered suboptimal due to the variable deployment locations, the daily (or longer) intervals between measurements and that the probe does not always travel





through the whole water column all the way to the seabed. A further limitation is the requirement for the vessel to remain stationary whilst each data set is collected. If repeated many times, this becomes a time consuming and costly exercise.

With these limitations in mind, in 2010 Shell geophysicists Paul Hatchell and Kanglin Wang approached Sonardyne with the challenge to develop a self-contained instrument that could be deployed on the seabed and left to autonomously measure the average water velocity over several months or even longer without any intervention. The result is PIES – Pressure Inverted Echo Sounder.

Signal processing

Measuring the water velocity using PIES involves sending an acoustic signal from the seabed which is reflected off the water-air interface (the waves act as multiple scatterers) and receiving the energy back again at the seabed. Special embedded signal processing detects the energy coming back and estimates the total travel time, measures the depth i.e. distance (using highly precise depth sensors) and so calculates the average water velocity of the entire water column as it varies with time.

PIES can be placed on the seabed by ROV or freefall deployed from a surface vessel. Once in position, it autonomously measures water velocity at defined intervals and records this data internally for wireless upload to an acoustic transceiver deployed over the side of a vessel. At the end of the survey, each PIES unit is collected from the seabed by ROV or it can make a floating ascent to the surface by activating its integral acoustic release mechanism.

Once processed, the user has access to a continuous and highly sampled time history of average water velocity as well as tidal history throughout each survey or even across multiple surveys, supporting the ideals of seismic surveillance.



"The ability to capture a complete time history of water velocity variations during our surveys is incredibly beneficial when it comes to minimising the variability in Shell's reservoir surveillance activities," observes Paul Hatchell. "PIES now plays an integral part in many of our surveys as the data it gathers helps us to obtain better seismic images which leads to a better understanding of our reservoirs."

The benefits offered by PIES are now being recognised by other leading oil majors who are evaluating units deployed in the North Sea and West Africa.

Understanding our oceans

Supporting seismic surveys is not the only application for PIES. The continuous measurement of average water velocity and its inherent variability provides information that helps oceanographers to better understand the physical processes that occur in the deep ocean. This can range from the way in which sea currents transport energy around the planet and the nature of underwater weather fronts through to the dynamics of the atmosphere ocean coupling.

For this, Sonardyne has developed a long endurance version of PIES which, depending on the measurement interval configured, can remain on the seabed for up to five years. The novel design of the instrument ensures that it always lands on the seabed in an upright position, making it quick and easy for users to deploy off a small boat without the involvement or expense associated with a survey vessel and ROV.

Data can be uploaded on demand via a built-in acoustic modem or at the end of the survey period when the unit floats back up to the surface and is recovered. **BL**

Subsea Asset Monitoring

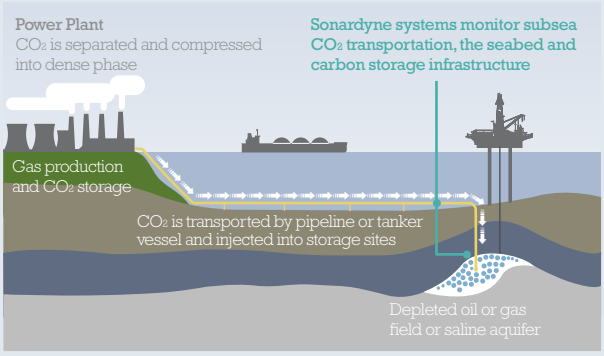
Environment

SONARDYNE TO KEEP WATCH OVER CO_2 STORAGE SITES



What is CO_2?

Carbon dioxide (CO_2) exists in Earth's atmosphere as a trace gas at a concentration of 0.04 per cent by volume, as of 2014. Very large amounts of CO_2 are also produced when gas, oil or coal is burnt. The burning of carbon-based fuels since the industrial revolution has rapidly increased the concentration and this cannot be offset by plant photosynthesis.



Carbon Capture and Storage (CCS)

Carbon Capture and Storage systems capture waste carbon dioxide gas from fossil fuel power stations and large industrial sources such as steel and cement works and transports it to a storage site, injecting it underground and preventing it entering the atmosphere.

In the UK it has been estimated that there is a subsea geological storage capacity for at least 70 billion tonnes, enough for 150 years of CO_2 emissions at 2010 rates.

Monitoring Technologies

ALDS Sonardyne's Automatic Leak Detection Sonar (ALDS) can continuously monitor for CO_2 leaks from infrastructure and the seabed around injection wells. ALDS is designed to monitor more than one billion cubic feet of seawater, with 360° of coverage from a single sensor location, operating without the need for skilled sonar operators to monitor the system.

Solstice is a side scan sonar designed for long endurance AUV operation with low power consumption and wide swath coupled with high capability on-board processing. This allows focused mapping of the seafloor and automated detection and alerting of leak like anomalies.

AMT Autonomous Monitoring Transponders (AMTs) allow intelligent power control and automated acquisition and storage of data from integrated sensors such as CO_2 sniffers, sound velocity, salinity and dissolved oxygen. The data is time-stamped and logged internally for recovery via the integrated high-speed acoustic telemetry modem. This autonomy allows measurements to be made over a long period of time and data to be uploaded to autonomous vehicles patrolling the area.

The development of a UK-based North Sea Carbon Capture Storage Industry is an important element in the Government's initiative to significantly cut greenhouse gas emissions by 2050. Following Sonardyne's announcement of its participation in a new Energy Technologies Institute consortium, **Graham Brown**, Divisional Director – Oil and Gas at Sonardyne investigates the project's objectives and how Sonardyne's technologies can assist in the subsea monitoring of these Carbon Capture Storage sites.



OVER THE LAST few decades we have become increasingly aware of the impact that we collectively have on the health of our planet. Many positive efforts have been made, such as cleaning up our rivers and segregating our domestic waste for recycling or composting; these are things that are obvious to us, things that we can see. However, there are waste products that we can't see and carbon dioxide (CO_2) is one of these. The World Bank estimated in 2010 that every person in the UK emitted 7.9 tonnes of CO_2; this is a staggering 494 million tonnes for the country as a whole. What does 494 million tonnes really mean? How can you imagine it? It is more than twice the amount of waste that goes into landfill every year in the UK.

More contentiously to some, science has shown that our emissions of greenhouse gases are having an impact on us, as Al Gore eloquently concluded in his film "An Inconvenient Truth":

"Each one of us is a cause of global warming, but each one of us can make choices to change that with the things we buy, the electricity we use, the cars we drive; we can make choices to bring our individual carbon emissions to zero. The solutions are in our hands, we just have to have the determination to make it happen. We have everything that we need to reduce carbon emissions, everything but political will..."

In the UK there has been a concerted political will to make that change and this was enacted in the 2008 Climate Change Act which established the world's first legally binding climate change target; the key aim being to reduce the UK's greenhouse gas emissions by at least 80% from the 1990 baseline by 2050. This has been followed up with

Subsea Asset Monitoring

Environment





(Left) Members of the consortium gather around the NOC's Autosub LR which is being modified to carry the required sensor payload. (Right) AMTs will be interfaced with specialist sensors to monitor changes in the water chemistry around storage sites.

a dedicated programme of research and development funded by the Department of Energy & Climate Change (DECC), including a £1billion commercialisation competition to support practical experience in the design, construction and operation of commercial scale Carbon Capture and Storage (CCS) and a £125 million, four year co-ordinated research, development and innovation programme. According to the International Energy Agency (IEA), CCS has the potential to reduce carbon dioxide emissions from fossil fuel power stations by as much as 90%, and could contribute up to 19% of global carbon dioxide mitigation by 2050.

Storage in the North Sea

CCS captures waste carbon dioxide from large industrial users such as steel and cement works or fossil fuel power stations. It is then transported to a storage site, injecting it underground where it will not enter the atmosphere. In the UK, these proposed storage sites are deep underground, underneath the seabed of the North Sea in depleted oil and gas reservoirs or saline aquifers. The aim of this huge science and engineering effort is to mitigate our contribution to global warming and ocean acidification by preventing the release of large quantities of CO_2 into the atmosphere. In the UK it has been estimated that there is a subsea geological storage capacity for at least 70 billion tonnes, enough for 150 years of CO_2 emissions at 2010 rates.

In the context of the Northern part of the North Sea, locking away this CO_2 could have an additional benefit of maximising the recovery of oil from existing reservoirs as an additional Enhanced Oil Recovery (EOR) method. The CO_2 is injected into, or adjacent to, producing oil wells where it mixes with the oil, reducing the viscosity and increasing the pressure, allowing the oil to flow more easily and quickly through the reservoir. This could significantly improve the total recovery.

The ETI

The Energy Technologies Institute (ETI) is a UK based company formed from a partnership between six private sector member companies – BP, Caterpillar, EDF Energy, E.ON, Rolls-Royce and Shell – and public funding by the DECC and the Department for Business Innovation and Skills through the Technology Strategy Board and the Engineering and Physical Sciences Research Council (EPSRC). The ETI was formed to accelerate the deployment of projects to meet the UK's energy targets and is focused on enabling deployment of technology; taking ideas proven in the laboratory through to a point where they are ready for full scale demonstration.

Working together

Sonardyne is working with Fugro GEOS to lead an ETI funded project which will demonstrate an underwater system capable of monitoring a storage site to identify if leakage is occurring. The project is being delivered by a consortium including the National Oceanography Centre (NOC) and British Geological Survey (BGS), Plymouth Marine Laboratory (PML) and the University of Southampton (UoS). This project is built on the firm foundations of the QICS (Quantifying and monitoring potential ecosystem impacts of geological carbon storage) four year research programme which was funded by the Natural Environment Research Council (NERC) in the UK, with support from the Scottish Government. Its purpose was to improve understanding of the sensitivities of the UK marine environment to a potential leak from a CCS system.

Working with all the partners in the consortium, Sonardyne will be developing the Concept of Operations (CONOP) and guidance for operators on implementing and conducting the monitoring of subsea carbon stores. To support this, experts in our partners PML, BGS and NOC are producing computer models of CCS sites to simulate various

"The challenge set by the ETI is the development of an entirely new capability in the MMV of undersea CCS sites."

Anthony Gaffney
Managing Director,
Fugro Geos

"Effective monitoring provides potential operators with the confidence to make key economic decisions on storage options."

Den Gammer
CCS Strategy Manager, ETI

"CCS is an important technology; providing confidence that CO_2 is safely stored is vital to the technology's success."

Sarah Mackintosh
Office of CCS, DECC





(Left) A standard ALDS deployment frame similar to those that will be deployed in the North Sea. (Right) Performance testing of ALDS resulted in successful detection within two minutes of leak initiation.

failure scenarios to optimise sensing system design for giving the public and regulator confidence that no leakage has occurred.

Although there are many existing technology components which can detect CO_2 in a marine environment, there are no integrated, cost-effective and commercially available systems which can reliably record and report anomalies caused by leakage of CO_2 into the sea above a store site. This need to introduce robust monitoring of underground CO_2 storage sites is in response to legislation such as the European Union's directive on CO_2 storage. This requires any store operator to monitor for potential leaks and examine whether any leak is damaging the environment or human health.

Reducing the risks

Monitoring of the seabed is to be conducted on a risk based process. Potentially higher risk leakage areas include the injection wells and any associated subsea infrastructure; such sites could suffer from failures from a variety of causes such as corrosion or impact and result in localised leakages. There are also other sites, for example abandoned, but capped, wells connected by the same reservoir. The wide area over the entire top of the reservoir is generally considered a low risk area.

The highest risk areas are likely to cumulatively comprise a relatively small area, some several thousand square metres of seabed and its overlying water column. In these locations, autonomous monitoring instrumentation such as Sonardyne's AMT will be interfaced to specialist point chemical and physical sensors such as CO_2 sniffers, sound velocity, salinity, pH and dissolved oxygen content sensors to monitor changes in the water chemistry.

To detect small leakages these sensors are generally reliant on being 'in the flow' and may only cover small areas. To increase area coverage around the higher risk locations, it is proposed to use a combination of active and passive sonar techniques. Sonardyne has developed and tested ALDS, an active sonar for hydrocarbon leaks which has a proven ability to detect and alarm on very low flow rate leaks of less than one litre per minute at ranges of 750 metres. The QICS programme also showed the potential for passive acoustic detection to quantify leak rates and Sonardyne is working closely with the Institute of Sound and Vibration Research at the University of Southampton to develop this technique.

Current research and evidence shows that leakage is highly unlikely. However, if CO_2 did escape from the reservoir, it would be difficult to predict exactly where it would reach the seabed. This is where very long range AUV technology, such as that demonstrated with the NOC Autosub Long Range programme, and commercially available Autonomous Surface Vehicles (ASV) could prove to be very cost-effective options for patrolling the entire reservoir. The choice between AUV and ASV is based upon water depth, with an ASV only generally suitable for very shallow water operations as a sensing platform. However, some ASVs have been proven in long duration demonstration projects (see Baseline 11) and have acted as seabed to shore communications relay stations. In deeper water, a very long endurance AUV can be used to patrol the wide area; NOC's Autosub LR is being modified to carry a sensor payload to detect chemical and physical variations in the properties of the seawater together with Solstice, a low power, high resolution side scan sonar with bathymetry to take images of the seabed to assess it for defects related to leakage and map any anomalies.

CCS technologies may have a significant role to play if the UK and other countries are to meet their obligations with respect to reducing the amount of CO_2 released into the atmosphere. Sonardyne's work in this area together with its consortium partners and the ETI, will give a good framework for store operators to conduct marine monitoring, measurement and verification activities to ensure the store is behaving as expected. **BL**

"We are confident we can develop an accurate, efficient and robust monitoring system for North Sea CCS."

Graham Brown
Divisional Director, Oil and Gas

Sonardyne
SOUND IN DEPTH

"We are delighted to be involved in this project. It has the potential for a new UK industry to de-carbonise future energy generation."

Ian Wright
Director Science & Technology, NOC

Keen to learn more about CCS and the ground-breaking project Sonardyne is involved with?

Search 'CCS' on the Sonardyne website or scan this QR code. Our press release has links to related sites and articles.

Case Study

SS Central America shipwreck



The *SS Central America* sunk during a hurricane in 1857, carrying an estimated 5,200 newly minted $20 gold pieces.

Excavating the Ship of Gol

Lost for 131 years, 160 miles off the coast of South Carolina, the *SS Central America* sunk in 1857 after being caught in a monstrous hurricane. Known as the 'Ship of Gold' due to the large shipment of valuables she was carrying, the 280 foot long wooden-hulled, copper-sheathed paddle steamer now lies in water depths of approximately 2,200 metres (7,200 feet).

For more than a century, the ship lay undiscovered on the seabed until 1988 when the Columbus-America Discovery Group found her using the Remotely Operated Vehicle (ROV) *Nemo*. At the time of sinking, the *SS Central America's* cargo contained a large quantity of newly minted 1857-S Double Eagle gold coins and gold bars, ingots and nuggets mined and produced during the California Gold Rush. The loss of the abundance of wealth in the storm triggered the financial crisis and the Panic of 1857, leading to a brief but severe economic depression in the United States.

Initial recovery operations began in 1988 and lasted until 1991, with less than 5% of the ship-wreck investigated during this time. After years of litigation with the insurers of the cargo, the majority of the recovered gold and artefacts were sold to private buyers for millions of dollars. Since then, salvors have not returned to the site for more than two decades. Until now…



When Odyssey Marine Exploration, Inc. a pioneer in deep-ocean exploration was awarded the exclusive contract to conduct an archaeological excavation and recover the remaining valuable cargo from the *SS Central America* shipwreck, the project team knew that ROV positioning accuracy would be vital to the mission on this historic project. ''After reviewing several deep-ocean companies, the court-appointed receiver selected Odyssey for the project based on our cutting-edge technology and specialised expertise in conducting deep-ocean archaeology. ROV positioning accuracy is key to our ability to deliver the precise work demanded by the receiver and the court,'' said Andrew Craig, Senior Project Manager for Odyssey Marine Exploration. Having set sail in April 2014, the team on board the R/V *Odyssey Explorer*, Odyssey's archaeological platform and recovery vessel, are using Sonardyne's SPRINT Inertial Navigation System, Long BaseLine (LBL) and Ultra Short BaseLine (USBL) technologies to acquire accurate and precise positioning of Odyssey's ROV, *ZEUS*. The repeatability of the LBL acoustic positioning is vital for *ZEUS* to conduct detailed multibeam and photomosaic surveys in addition to conducting a thorough



***ZEUS* is positioned using SPRINT and Ranger systems.**



SPRINT is using acoustic aiding from both Ranger USBL and Fusion LBL to position *ZEUS*.



Sonardyne positioning technology has been used on the *Odyssey Explorer* for many excavation and recovery projects.

d; the SS Central America

archaeological excavation of the site.

A Ranger USBL tracking system is used to provide acoustic aiding to the SPRINT system installed on *ZEUS* during descent and ascent through the water column to the wreck site. On arrival at the wreck site, SPRINT switches to acoustic aiding from a Fusion Long BaseLine (LBL) array. The deployment of six Compatt transponders on the seabed working in conjunction with SPRINT provides deci-metre positioning of ~0.12 – 0.15 m for *ZEUS* that is precise, accurate, and repeatable. ''The utilisation of the SPRINT system has dramatically increased the quality of our subsea positioning and directly contributed to our ability to perform deep water marine archaeology to the highest possible standards.''

Sonardyne's Ranger and SPRINT systems are designed for the USBL tracking and inertial navigation aiding of subsea vehicles. Ranger is a high performance, survey grade USBL acoustic positioning system designed for ROV/towfish tracking operations and dynamic positioning (DP) reference. The system chosen is capable of tracking multiple targets at ranges of up to 6,000 metres and is compatible with a wide range of transponders. Ranger can calculate the position of the subsea target – in this case, *ZEUS* – by measuring the range and bearing from a vessel-mounted transceiver to an acoustic transponder fitted to the ROV.

''The utilisation of the SPRINT system has dramatically increased the quality of our subsea positioning''

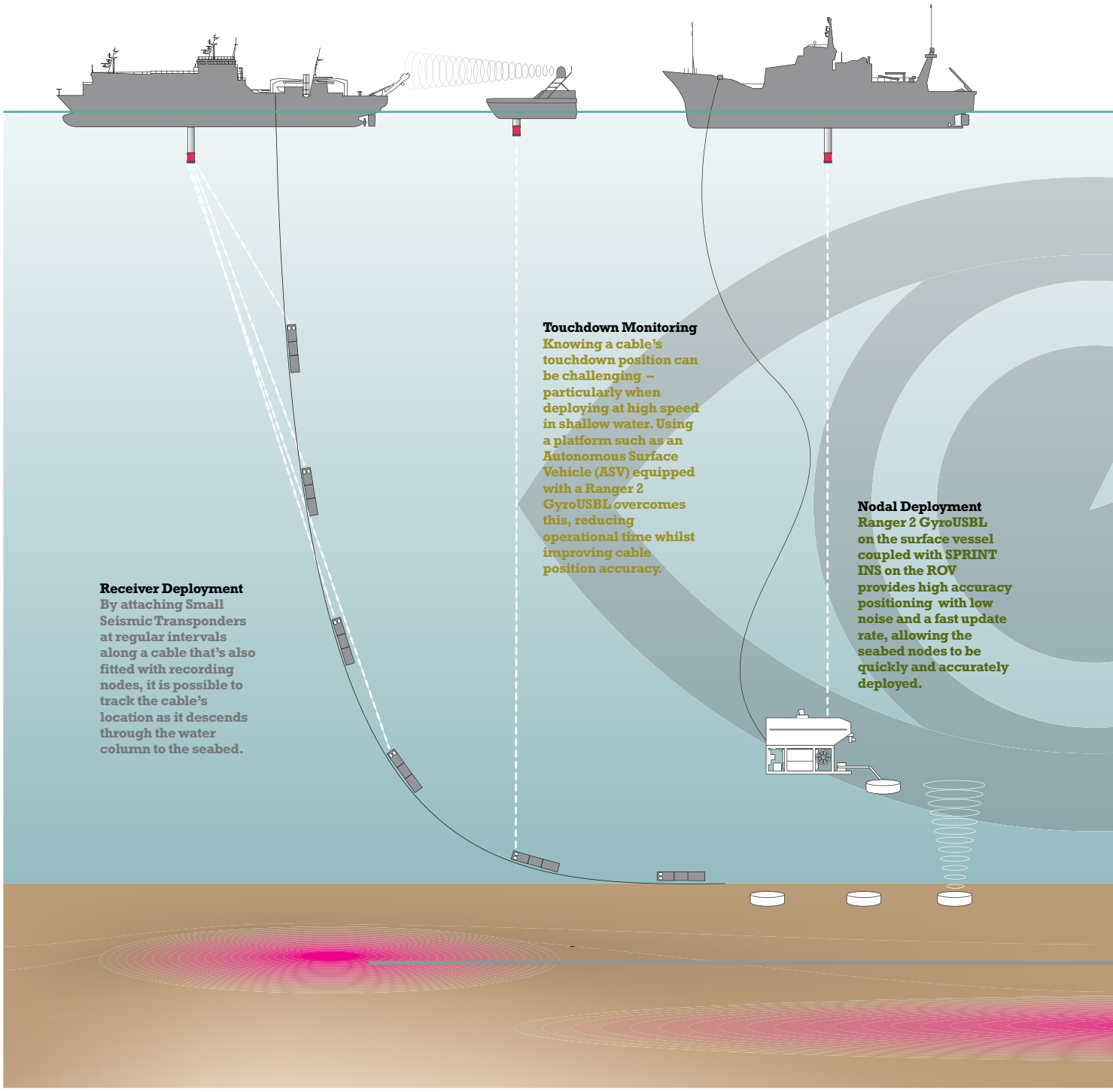
SPRINT INS is an acoustically aided inertial navigation system for subsea vehicles which makes optimal use of acoustic aiding data from USBL and LBL positioning. The SPRINT final position is also enhanced through the aiding of other sensors such as a Doppler Velocity Log (DVL) and a DigiQuartz depth sensor. This improves position precision, short term accuracy, reliability and integrity whilst reducing operational time and vessel costs, extending the operating limits of USBL and the efficiency of LBL. The additional integrity of the INS significantly reduces delays during periods of challenging subsea acoustic conditions with the output update rate allowing for greater subsea vehicle control.

''We've used Sonardyne technology on many of our excavation and recovery operations over the years for vessel positioning and subsea vehicle tracking,'' commented Andrew. ''Using SPRINT, we are able to manage the real time navigation and positioning of *ZEUS* using USBL-aided INS whilst also collecting data from the LBL array that has been deployed. In previous operations, INS positioning has been very robust and saved us time in numerous ways with our survey tasks so we look forward to the same operational efficiency during the excavation of the *SS Central America*.''

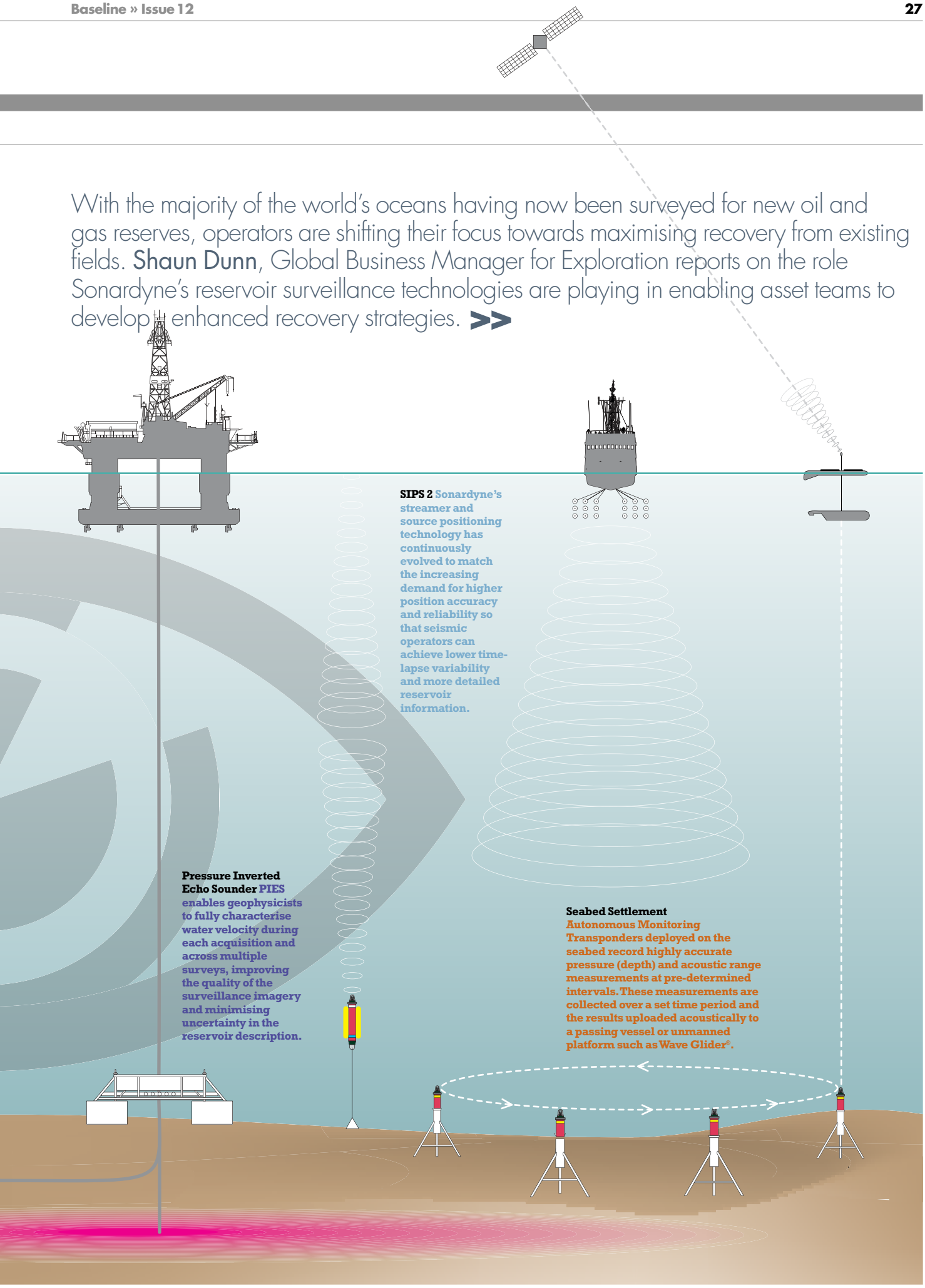
Exploration

Technology: Tracking, Positioning and Monitoring

A SEISMIC SHIFT IN RESERVOIR SURVEILLANCE



With the majority of the world's oceans having now been surveyed for new oil and gas reserves, operators are shifting their focus towards maximising recovery from existing fields. **Shaun Dunn**, Global Business Manager for Exploration reports on the role Sonardyne's reservoir surveillance technologies are playing in enabling asset teams to develop enhanced recovery strategies. >>



Exploration

Technology: Tracking, Positioning and Monitoring

FOR MANY YEARS, vessels have explored the oceans looking for new fields and reservoirs. The majority of geographical regions and sedimentary basins have now been explored with reducing volumes of untapped conventional resources available to be discovered, most notably for giant and super giant fields in excess of 500 Mmbbls (million barrels) reserves. There are a few exceptions in places such as the Arctic and the very deep water regions of the Gulf of Mexico and the South Atlantic margin, but accessing these reserves is fraught with technical uncertainty, risk and high cost per-barrel extraction; these regions are increasingly commercially challenged and are currently rendered unappealing.

For this reason, the continuing trend for upstream oil and gas companies is to extract the maximum benefit from their existing fields and spend less time searching for new prospects. This is driving a steady increase in the development and deployment of reservoir surveillance techniques for a more detailed understanding of the distribution of hydrocarbons in producing reservoirs, leading to the development of recovery improvement programmes.

A variety of surveillance tools and techniques are available but one of the primary methods remains the application and use of repeated seismic acquisition across a reservoir throughout its production lifecycle. The resulting data from these time-lapse surveys is used to monitor the reservoir and fluid movements over production time. To detect what are often quite subtle changes, it is imperative that repeated surveys are conducted with minimal variation. Minimising geometric differences between source and receiver positions is one way to reduce variability; another is the careful monitoring of environmental variables including water velocity and tidal height. This can be conducted using Sonardyne's Pressure Inverted Echo Sounder (PIES) which monitors two-way travel time through the water column whilst simultaneously measuring pressure at the seabed. See page 18 for more information on measuring water velocity using PIES.

The vast majority of exploration projects are still conducted using streamer-based acquisition but geophysicists generally agree that the most reliable reservoir surveillance requires seabed recording equipment to minimise variation between surveys and enable repeatability of data acquisition. With this method, seabed receivers are stationary and provide the highest possible definition time-lapse reservoir imagery. It is therefore unsurprising that there is a steady increase in seabed seismic acquisition activity with service providers competing to offer high definition imagery using seismic nodes deployed on the seabed.

For many years, Sonardyne has supplied acoustic and inertial equipment that supports streamer, node and source positioning operations. This technology continuously evolves to match the ever increasing demand for higher position accuracy and reliability so that seismic operators can achieve lower time-lapse variability and generate more detailed reservoir information.

Seismic source positioning

In non-permanently deployed seismic systems the receivers are deployed in one of two ways. Norwegian seismic acquisition expert Magseis uses thousands of small autonomous nodes attached to long steel cables. This node and cable combination is deployed from the surface vessel and forms a grid pattern of receivers on the seabed, ready for the survey to begin. It is vitally important that the cables are laid in the correct positions to avoid becoming entangled with subsea infrastructure and to ensure good repeatability between surveys.

For these projects, Magseis uses Sonardyne's Small Seismic Transponders (SSTs) attached near the nodes at regular intervals along the cable and positioned by a Ranger 2 system with a Lodestar GyroUSBL transceiver. With this, it is possible to track the cable's position as it descends through the water column to the seabed. Using Ranger 2 GyroUSBL, it is possible to simultaneously track hundreds of SSTs, providing highly accurate real-time information to ensure the





Image: Magseis ASA 2014

(Above) The use of Sonardyne SST transponders and Ranger 2 USBL to position hydrophone ground stations results in considerable savings in vessel time as only one overhead pass of the cable is required to position the transponder. (Below) Sonardyne's GyroUSBL transceiver fitted to an ASV will allow cable touchdown points to be accurately monitored.









(Above) An AMT configured for reservoir surveillance is prepared for deployment. Alongside it is HPT, a combined USBL transceiver and high speed modem that will be used to recover logged data during the survey. (Below) SPRINT is an acoustically aided inertial navigation system that improves the accuracy, reliability and integrity of ROV operations.

cables meet their target locations.

One remaining challenge of surface vessel based positioning is the ability to accurately track the laydown position of the cable when it is landing far behind the vessel - such is the case when deploying at high speed in shallow water. To overcome this, an Autonomous Surface Vehicle (ASV) equipped with the same Ranger 2 GyroUSBL system will, in future, be able to track the touchdown point during deployment, resulting in reduced operational time whilst improving cable position accuracy.

In deeper water or when surveying in close proximity to subsea infrastructure, several seismic nodes are lowered to the seabed at a time, where ROVs are then used to deploy them in their final position. In contrast to cables, these nodes are not positioned directly but instead by tracking the ROV position as it uses its manipulator to plant the node on the seabed. Position accuracy is still vitally important but with hundreds of seismic nodes in a typical array and each having a finite battery life before recharging is required, speed of deployment is also critical.

In this case, the Sonardyne Ranger 2 GyroUSBL system installed on the surface vessel is coupled with SPRINT technology on the ROV along with external inputs from Doppler Velocity Logs (DVL), depth and sound speed sensors. When used in combination, this system provides extremely high accuracy position information with low noise and a fast update rate, allowing the ROV to deploy nodes quickly and accurately, ready for surveying.

Reservoir settlement monitoring

Another reservoir surveillance tool quite separate from seismic acquisition is settlement monitoring. Years of oil extraction without appropriate and effective recovery mechanisms can cause the pore-pressure of the oil bearing rock to decrease, often reducing its ability to support the layer of rock above it (known as the overburden). The result is that the overburden layer can sink, causing a small but detectable settlement of the seabed by a few centimetres per year. Examples of this are the chalk fields in the Norwegian and Danish sectors of the North Sea where sea floor foundering as a result of high production rates has required costly retrofitting and remediation of seabed tethered production facilities.

Sonardyne's settlement monitoring technology consists of large arrays of Autonomous Monitoring Transponders (AMTs) and Fetch long-life sensor logging nodes deployed on the seabed for several years. They take highly accurate pressure (depth) and acoustic range measurements at pre-determined intervals. These measurements are repeatedly collected over a set time period (up to several years) and the results uploaded acoustically to a passing surface vessel or ASV/USV and forwarded to geophysicists for analysis.

One such system was deployed in 2011 at Shell's Ormen Lange field in the North Sea. The array consists of over 200 AMTs spread over a wide area where every few hours, each transponder wakes up and takes pressure measurements and acoustic ranges between other transponders in the array before going back to sleep. To date, this array has made over 250 million observations resulting in over half a Gigabyte of sensor data uploaded to either a conventional surface vessel of opportunity or unmanned surface vehicle for onward transmission to Shell analysts for processing. With this system it is possible to detect movement in offshore fields of just a few centimetres per year or better, providing highly insightful surveillance data about the status of the underlying reservoir.

The way forward

It is generally accepted that geophysicists will spend more of their time interpreting reservoir surveillance data as oil and gas companies strive to maximise recovery from producing fields to offset poorer than expected exploration successes.

Increasing the quality and amount of this information is a never ending quest for offshore exploration and production companies. Sonardyne is constantly striving to improve its product portfolio to help with this seismic shift in reservoir surveillance and stay at the forefront of this critical area of subsea technology. **BL**

International

News from our Regions Around the World

UK – Aberdeen



Barry Cairns VP Europe and Africa

Building the team

To strengthen the support we give to clients and their subsea projects, we've added two new members to our commercial team. Will Padden is relocating from our Houston office so is already a familiar face to many, whilst Dan Williams joins us with over 10 years' experience in the offshore and hydrographic market.

Market-wide growth

Sonardyne 6G technology is constantly in demand for drilling, construction, survey, IRM and decommissioning operations, but just recently we've seen a big increase in demand from the geophysical community for our reservoir surveillance solutions. Read more on page 26.

Regionally, East Africa is becoming particularly active with the team having identified many opportunities where our 6G platform can make a significant impact.

Our commitment to working closely with each market sector proves that Sonardyne truly is a 'one stop shop' for all Life of Field, subsea positioning and telemetry products. ■

Brazil – Rio das Ostras



Richard Binks
Offshore Business Development Director

Orders and installations

Whilst matters 'on the pitch' have dominated Brazil's headlines, offshore it's been business as usual. Two long awaited Petrobras Geodesia ROV support vessel contracts have been awarded to Subsea 7, resulting in large spreads of 6G USBL and LBL equipment.

DP-INS data

Installed DP-INS systems on rigs and vessels in the region have been providing us with some exciting data. A dual DP-INS system on the P23 has shown system accuracy average of 25cm from the GNSS position in 1,100 metres of water with the system also easily identifying and riding out GPS scintillation excursions.

Our subsea inertial system, SPRINT, is also enjoying success with a number of survey companies now using it to navigate ROVs supporting field construction and intervention activities.

Safety and training

I mentioned in my last regional review that we were working towards OHSAS 18001 accreditation. Well I'm delighted to say that we have now achieved this goal; you can read more on page 7. We're proud to know that our staff, contractors and visitors are working in an environment where the highest safety standards are upheld. ■

USA – Houston



Simon Reeves Senior Vice President

Discoveries and development

The Gulf of Mexico remains a very active region with no apparent slow down in exploration and field developments. Some analysts are predicting a sizeable increase in rig installations over the next 18 months. This has resulted in some large scale project enquiries from the oil and gas majors looking to either purchase outright or purchase-to-lease equipment to support their operations. Asset monitoring and BOP control technologies are high on their lists.

Going deeper

Pushing into deeper water is another trend we've seen emerging. Traditionally the preserve of the ocean research community, many oil and gas projects are now specifying equipment rated beyond our popular 3,000 metre rating. The arrival of our new 7,000 metre depth rated WMT has therefore been a welcome addition to our USBL product line-up. ■

SE Asia – Singapore



Anthony Gleeson Vice President

Our big birthday

It's been 21 years since Sonardyne Asia began trading. Since those early days of a team of two working in a shared office, we've grown to 15 people delivering a full-service operation from a purpose-built base in Loyang. With Technical Sales Manager, Vincent Chua, now joining the team, we are now better placed than ever to satisfy our customers' needs and their subsea projects. Watch this space for news of our formal celebrations planned for later in the year.

Working down under

Our technology has also evolved over the years from Compatt 3, 4 and 5, to of course 6G – developed to meet the challenges of deeper water and more complex field developments. In Australia, 6G is proving the technology of choice for pipeline inspection and subsea metrology operations.

Talking technology

Technology seminars run by our Survey Support Group continue to prove popular across the region. They provide the ideal forum to present the capabilities of our technology and to discuss specific projects. Let us know if you'd like an invite to our upcoming events. ■

Help & Advice

THE KNOW HOW

Our highly experienced product specialists are available to help you maximise the performance from your Sonardyne technology. Get in touch by emailing: support@sonardyne.com



Recovered it? Now check it

Here are our top tips for keeping your subsea hardware in pristine condition. Just remember that before carrying out any general maintenance, you should read the Warnings and Cautions in the manual relating to your instrument.

Begin by thoroughly cleaning the unit in clean fresh water to remove all accumulations of salt, sand, silt and marine growth. Do not use abrasive brushes or sharp tools as this will damage the protective coating and increase the risk of corrosion. Clean the anodes with a nylon brush, checking to make sure there is sufficient zinc remaining. Replace if necessary. Dry the unit with a lint free cloth. Where fitted, check the Pressure Relief Vent Valve is pushed home. A protruding valve indicates an internal build up of pressure so refer to the section in the manual relating to Operation of the Pressure Relief Vent Valve before going further. Inspect the surface finish for any signs of corrosion such as flaking, cracking or delamination. Inspect all cables and connections for signs of abrasion, cracks or splits. Check the guard for distortion. Inspect the rubber boot on the transducer for signs of splitting. Contact your local Sonardyne office for spares, repairs or advice.

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We hold stock of Compatt 6s fitted with a wide variety of sensor endcaps. Please can you advise us how often the sensors need to be calibrated to keep them in spec?

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It's vitally important that the performance of your endcap sensors is regularly checked. Check depth and sound velocity sensors annually whilst inclinometers and temperature sensors should be checked every two years. Our regional service centres are equipped to perform these specialist checks and re-calibrations, for a fast turnaround of your equipment.



Video: How to inspect O-rings

You'll find them in every subsea instrument we manufacture – o-ring seals. They may seemingly ordinary and unimportant, but without the correct maintenance and care, they can allow water to leak in to your subsea instrument and cause it to fail. In many cases, the product will be ruined beyond economical repair.

Our video tutorial explains what to do every time you open up a Sonardyne product that uses o-rings seals. The advice is common to all Sonardyne products that use o-rings from ORTs, DORTs and LRTs, through to DPTs, Compatt transponders and ship-mounted transceivers. To watch the video tutorial, head to our YouTube channel or scan this QR code.

Are your shackles the weak link?

One of the most vital parts of an instrument can often be the simplest. In the case of a transponder fitted with an acoustic release mechanism, it's the shackle connecting the unit to its mooring.

The shackles we supply are of the highest quality, fully certified and manufactured from super duplex stainless steel to offer high strength and excellent corrosion resistance.



You'll need a new shackle each time you re-deploy so it can be tempting to fit cheaper alternatives. However, based on the unfortunate experiences some of our customers have reported, we'd strongly advise against it. Our message is protect your instrument, protect your survey data and fit the best.

Sonardyne
SOUND IN DEPTH

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6G. NOW WINNING ACCOLADES ONSHORE AS WELL AS OFFSHORE.

6G technology has positively impacted offshore operations wherever and however it has been deployed, saving users' time and reducing risk. Speak to us and discover how it will benefit your next project.



THE QUEEN'S AWARDS
FOR ENTERPRISE:
2014

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