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Cover: Edgetech's pole-mounted 6205s2 bathymetry/side scan sonar

DEVELOPMENTS

POWERNAP

Shell has announced production at the PowerNap subsea development in the US Gulf of Mexico. It has an estimated peak production of 20 000 barrels of oil equivalent per day (boe/d). PowerNap is a tie-back to the Shell-operated Olympus production hub in the prolific Mars Corridor.

PowerNap's three production wells are produced through a single insulated 19-mile flowline with high-pressure gas lift capability.

BAY DU NORD

Canada has given the go-ahead for Equinor's $12 billion Bay du Nord that lies 500km off the Newfoundland coast. Equinor and partner Cenovus Energy have not yet made a final investment decision on whether to build the project, but the Norwegian firm said it welcomed the ministry's decision.

The Bay du Nord project would involve building a floating platform to drill an estimated resource of 300 million barrels of light crude.

YELLOWTAIL

ExxonMobil has made a final investment decision for the Yellowtail development offshore Guyana after receiving government and regulatory approvals. The company's fourth and largest project in the Stabroek Block, is expected to produce approximately 250 000 barrels of oil per day starting in 2025.

Yellowtail production from the ONE GUYANA floating production storage and offloading (FPSO) vessel will develop an estimated resource of more than 900 million barrels of oil. The $10 billion project will include six drill centres and up to 26 production and 25 injection wells.

SICCAR POINT

Siccar Point Energy has been acquired by Ithaca Energy. This will add the Schiehallion and Mariner fields to Ithica's portfolio. Siccar Point also has an interest in the producing Jade gas field. Additionally, the transaction will include the Cambo and Rosebank fields, two of the largest undeveloped and most strategically important discoveries in the UK North Sea.

The PowerNap field will be developed from Mars

The Prosperity FPSO left dry dock in March. It is a sister ship to the vessel which will be used on Yellowtail

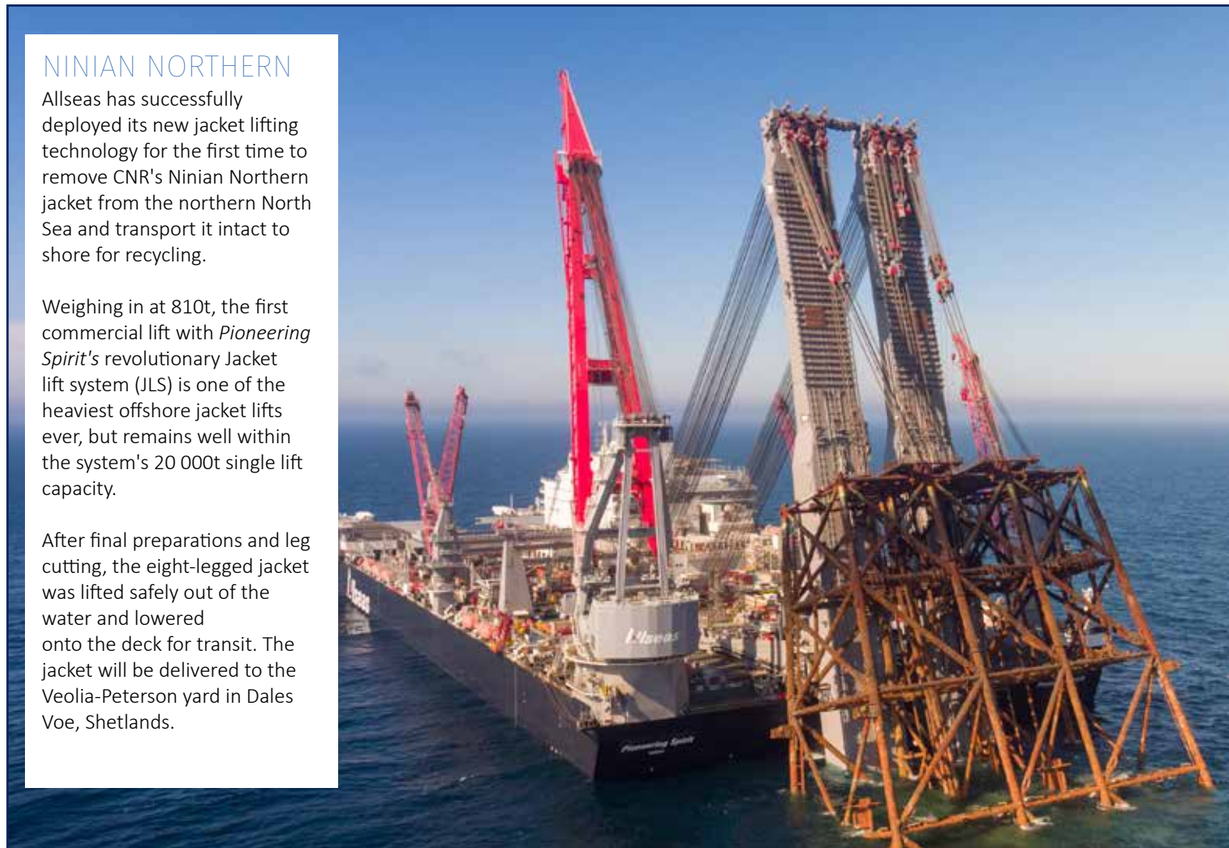
The Bay du Nord project

NINIAN NORTHERN

Allseas has successfully deployed its new jacket lifting technology for the first time to remove CNR's Ninian Northern jacket from the northern North Sea and transport it intact to shore for recycling.

Weighing in at 810t, the first commercial lift with *Pioneering Spirit's* revolutionary Jacket lift system (JLS) is one of the heaviest offshore jacket lifts ever, but remains well within the system's 20 000t single lift capacity.

After final preparations and leg cutting, the eight-legged jacket was lifted safely out of the water and lowered onto the deck for transit. The jacket will be delivered to the Veolia-Peterson yard in Dales Voe, Shetlands.



SEAPIX-R 3D VOLUME SONAR

NOAA NEFSC has tested iXblue's SeapiX 3D volume sonar in the Block Island windfarm off the coast of Rhode Island, the first commercial offshore wind farm in the United States.

The objective of the evaluation was to observe and monitor the pelagic ecosystem often overshadowed by the demersal and benthic communities in the windfarm areas.

As offshore wind farms will soon be an important component of the New England and mid-Atlantic seascape, novel methods to survey and monitor the animals that reside or migrate through these areas will become necessary as they are a critical component of the life history of many commercially and ecologically important species.

Moreover, limited capability to physically sample the biota with capture gear in and around offshore wind farms will necessitate using alternative sensing solutions to monitor the pelagic ecosystem.

Active acoustic technologies like iXblue's SeapiX 3D volume sonar can survey large areas quickly and efficiently to map spatio-temporal distributions and estimate abundance and biomass.

SeapiX is the first compact civilian system comprising a dual Mills Cross multibeam sonar transducer offering complete control to fishermen and fisheries researchers. Its transducer generates several simultaneous multibeam transmissions and acoustic processes to yield quantitatively and qualitatively impressive measurements of the marine environment. This solid-state 3D multibeam sonar which operates at 150 kHz, brings new insights to the scientific community for the evaluation and the monitoring of marine environments and can provide real-time full 3D biomass assessment.

WINGHEAD

NORBIT Subsea recently supplied multiple Winghead multibeam survey systems to Xocean. This enables ultra high resolution shallow seabed mapping. With fully integrated and tightly coupled multibeam survey systems, the Winghead will be mounted on the fleet of uncrewed surface vessel platforms.

Xocean recently undertook an environmental survey of the seabed in collaboration with Dundalk Institute of Technology (DkIT). This is the first time an uncrewed vessel has operated in Irish waters and represents a major step forward in reducing the carbon footprint associated with offshore survey operations.

To-date Xocean has delivered over 100 projects globally for some of the world's largest companies. Ireland is fast-tracking the development of its offshore wind sector in line with commitments to increase offshore wind capacity to 3.5GW as part of the government's ambitions to deliver 70% of electricity from renewable sources by 2030, as a result of the 2019 Climate Action Plan.

RENEWABLES AGREEMENT

Heerema Marine Contractors has been selected as a strategic supplier by Equinor /bp to develop the Empire Wind and Beacon Wind projects. HMC will enter into a Strategic Supplier Agreement for the transportation and installation services of wind farm foundations and offshore substations for the US East Coast projects.

This will cover a firm period of seven years. Throughout this period, Equinor, bp as 50% joint venture partner, and Heerema will collaborate as exclusive partners in the preparation and Jones Act compliant execution of the projects. Empire Wind and Beacon Wind will produce 2.1 GW and 1.2 GW of renewable energy

Heerema Marine Contractors wind transportation/installation

LAB ON A FISH

How do fish react to human-made infrastructure such as turbines and dams? How are they responding to climate change? These questions prompted researchers at Pacific Northwest National Laboratory (PNNL) to develop what has been described as a new fitness tracker for fish.

This 'Lab-on-a-Fish' is a biotelemetry tag that simultaneously monitors the health, behaviour and environment of fish or small aquatic species.

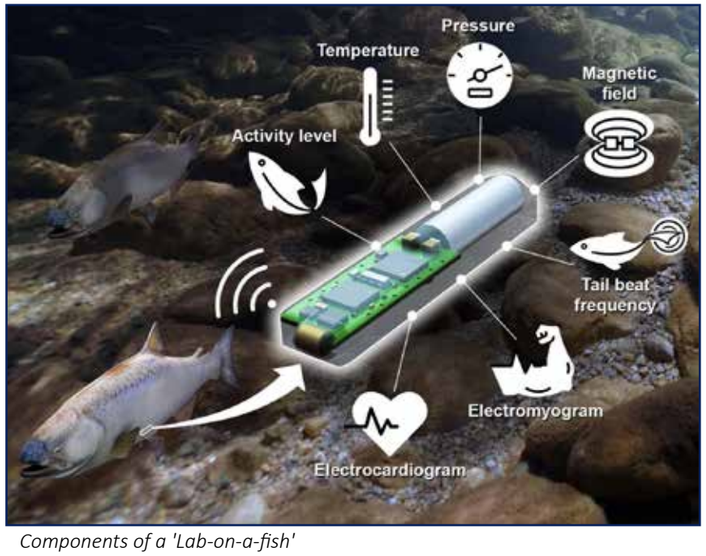
"This first-of-its-kind device uses multiple sensors to wirelessly track what a fish experiences in real-time," said Daniel Deng, Laboratory Fellow and mechanical engineer at PNNL.

His sensor development team collaborated with the battery team lead by Jie Xiao, a Laboratory fellow and chemist.

"The device, a type of biosensor, can simultaneously collect data about a fish, including its location, heartbeat, tail movement and burned calories, as well as the temperature, pressure, and magnetic field of its surrounding environment," said Deng.

"From this data, we can learn what stresses fish out and thus help scientists and managers understand the impact of climate change and infrastructure development on ecosystem health and, in turn, inform future management and conservation strategies."

Deng was inspired to develop this to help tackle a common challenge for hydropower projects—fish passage. By US law, some hydropower facilities must assure that migratory fish species, such as salmon, are able to bypass dams and swim upstream to the rivers where they reproduce.



Components of a 'Lab-on-a-fish'

This not only allows scientists to monitor fish passage success but also to identify whether the fish have encountered any physical stressors at specific points along their journey.

Historically, fish tags have been limited by the number of sensors that can be put into one device without negatively affecting fish behaviour or device longevity. Deng's device however, weighs 2.4 grams and is about the size of a pen cap. It can collect data for up to eight months.

This biosensor is surgically inserted under skin near a fish's rear dorsal fins. As the fish swims, a wireless receiver picks up the sensor's telltale beeps. This means scientists can study smaller species for a longer time than possible before.

Once scientists retrieve the data from a wireless receiver or the device itself, a series of machine learning algorithms can help them tease out patterns among all the measurements. They say that it offers something much needed in conservation and aquaculture.

Deng and his team are already developing the next-generation Lab-on-a-Fish, which tailors the device to specific user needs related to hydropower, conservation, and aquaculture.

In the future, this technology could help monitor a range of aquatic and terrestrial species, expanding its use and utility.

This work was supported by the Department of Energy's Water Power Technologies Office.

FAULT-FINDING IN AUSTRALIAN WATERS

C-Kore Systems successfully completed a fault-finding in Australian waters.

The Cable Monitor units helped the operation run smoothly by providing quick and accurate measurements of insulation resistance for the subsea system.

C-Kore Systems has a range of subsea testing tools used globally by operators and contractors on both fault-finding operations and new installation campaigns.

The tools are easy to deploy and are operated without the need for C-Kore personnel being present, providing rapid and accurate feedback. This combination of simplicity, accuracy and reliability introduces significant operational savings to testing campaigns.

Subsea systems

The Subsea Manager for the Australian operator commented, "We were very pleased how well the operation was performed. As the C-Kore units are so easy to use and provide quick, accurate results, they have become an integral part of our operations."

@ OCEANOLOGY 2022

SEABED LANDER

Marine technology company OTAQ showed its latest Seabed lander – ostensibly a sled containing cameras and lighting for taking images of the seabed. It incorporates a stainless steel frame to allow other ancillary cameras and equipment to be fitted as well as a telemetry unit to communicate with the surface via standard survey coax cables.

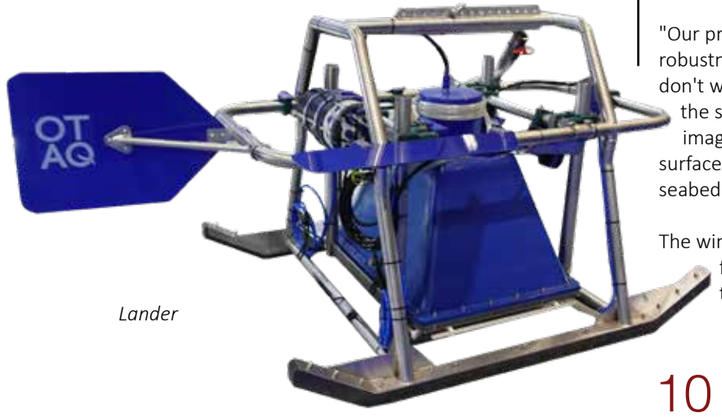
The system on show, however, was also fitted with a clear water lens.

"In turbid or very muddy waters, the camera can't always recognise details on the seabed," said Dr. Harry Rotsch, OTAQ's Technical Director "One effective way to improve visualisation is to point the camera through a chamber filled with clear water. "

At the top of the chamber is a high specification DSLR stills camera which points down through the glass-bottomed clear water filled tank. Valves on the side allow the tank to be emptied and filled quickly.

At the most recent Ocean Business show in Southampton, OTAQ showed the Lander it supplied to the Unique Group. The lander incorporated a variety of new inspection products, such as the very high-resolution stills cameras, Eagle IP180 video cameras and Eagle IP LEDs. The Lander system can also be configured to carry other third-party supplied inspection and monitoring equipment.

Two models will be produced with a shallow-water version rated to 300m and a future deep-water version rated to 4000m, available for rental and sale exclusively through Unique Group's worldwide office network.



Lander

WINCH

There are a number of ways to collect data through the water column . One way is to use gliders or floats that submerge and return, collecting data along the journey. The downside is that they tend to drift with the currents.

Another method is to lower sensors from moored buoys. The downside of *that* method is that the surface floats always reside in the highest energy part of the water column and are often subject to impact from the waves and winds. Furthermore, they are always very visible and detectable. This is often acceptable but there are applications in which invisibility and undetectability is a benefit.

The solution is a subsea winch that sits on the seabed paying out a line with a sensor pod or frame attached to a floatation body.

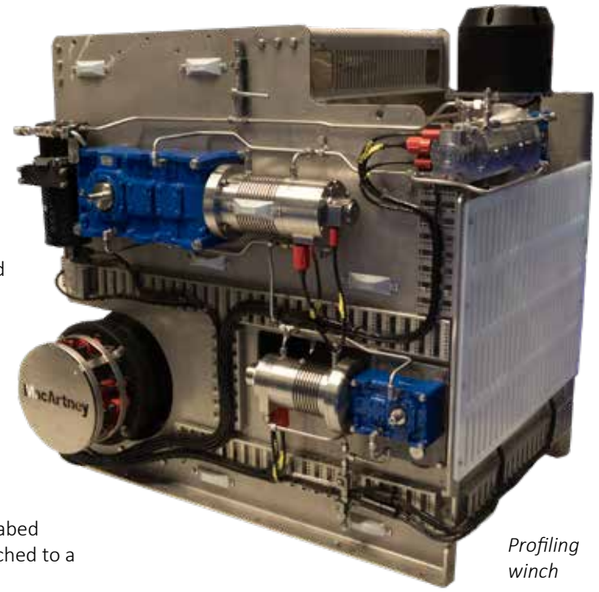
Some years ago, MacArtney produced such a seabed winch but have not often exhibited it. The exception was at the Oceanology show.

"This is a growing market," said Lars Jørgensen, Head of Product Management at MacArtney. "This model holds 750m of cable and is rated to 750m water. We have sold about six of these and they are a useful addition to our portfolio.

"If you imagine the tethered buoy rising upwards, at some point it will pierce the surface and move up and down with the waves. At the subsea drum, it is important not to have any slack cable as this may affect the spooling, so we have installed a simple tension system.

"Our principal market is for naval operations where robustness and reliability is at a premium. The forces don't want to disclose what they are being used for or the sensors they are putting on but there are many imaginable uses. By putting a satellite antenna on the surface buoy, it could have could be used to connecting seabed equipment with a remote base."

The winch can be equipped with slip rings to allow data from the buoy to allow a two-way data feed. It has the advantage of stealth. It can be left on the seabed



Profiling winch

quite inert, but engaged on demand. A sonar can be placed in a specific horizon such as a SOFAR channel, but quickly removed after transmitting or receiving information. It can either be run on a battery package or given suitable existing infrastructure, could be tethered to land.

There are many other civil applications such as being part of an ocean observatory. Putting can put on sonars and physical oceanography sensors like CTDs, ADCPs can provide useful profile data.

The winch can be additionally equipped with steel-armoured and PUR jacket cables. A fleeting or spooling arm places the line on the drum. The primary structure is stainless steel with adonised aluminium bottles

"It is a fully electrically driven winch with compensation oil for the three gear boxes and three motors," said Jorgensen.

LUMA PROJECT COMPLETED

Ashtead Technology has successfully completed its first significant subsea monitoring project using Hydromea's LUMA high-speed through-water wireless optical modems since signing a global rental partnership last year.

The project saw Ashtead provide its Autonomous Structure Monitoring Systems, which were each integrated with LUMA optical modems, to complete an underwater installation monitoring work scope for subsea and offshore wind contractor, Havfram, in the Norwegian North Sea.

The work scope included the provision of ten Autonomous Structure Monitoring Systems, two for each suction anchor template.

An additional four Autonomous Structure Monitoring Systems were used to monitor the installation of a range of subsea structures.

The Structure Monitoring Systems were configured for autonomous independent operation, communicating data to one of the installation ROVs.

Ashtead used LUMA optical modems to enhance the accuracy of the data collected, ensuring maximum performance of the system.

LUMA products are claimed to be the smallest, lightest, lowest power consuming subsea optical modems available that provide high-speed and high-bandwidth wireless communication at depths of up to 6000m with remarkably low latency, even in the murky waters of the North Sea.

Ashtead has rolled out the use of LUMA technology in all of its offshore energy global construction and O&M projects.

LUMA model

SAILDRONE

Last march, Saildrone signed a contract with Sulmara Subsea to deploy *ten* Saildrone Voyager uncrewed surface vehicles (USVs). These will perform survey operations around the world for the offshore energy sector.

One of the largest single orders for unmanned vehicles, they will be operated from remote operation centres in Glasgow, San Francisco, Singapore and Saildrone's new ocean mapping headquarters in St. Petersburg, Florida. The contract also establishes a joint working group to drive the adoption of low-carbon USV-based survey and inspection.

There are three Saildrone platforms.

The smallest is the 7m long solar and wind-powered *Saildrone Explorer*. This can move at an average of 3kts and carry out operations for over a year without having to return to port. So far, Saildrone's Explorer fleet has sailed over 750 000 nautical miles from the Arctic to the Antarctic and spent more than 17 000 days at sea in the harshest ocean conditions on the planet

The middle of the range and the newest addition to fleet is occupied by the 10m-long *Saildrone Voyager*. It carries a payload for survey operations including high-resolution multibeam echosounder and Innomar SBP systems. It is the only survey USV that can deliver long-duration IHO-compliant multibeam mapping surveys and ocean data collection at depths up to 985ft (300m).

The *Voyager* contains a diesel-electric power system which means that the normal 4kt speed can be accelerated to 5kt or even 8kt at a sprint. The vessel not only includes radar and cameras, but also a 150m profiling winch.

At the top part of the range is the majestic 22m-long *Saildrone Surveyor*. This can reach sprint speeds of 10kt with an endurance of 180 days. It incorporates a 500m profiling winch and the vessel is capable of IHO-compliant multibeam mapping down to 23 000ft (7000m).

At the Oceanology show, Principal Engineer Dave Peacock explained how the Sailrone Explorer worked.

"At the top is a rigid sail which is balanced by a keel. This provides the main locomotive power. There are solar panels on the sail and upper deck which generate electricity for the sensor electronics.

The bottom of the keel has a bulbous body. The front is filled with lead ballast while the rear houses sensors. On the upper surface is a Seabird SBE37 CTD and dissolved oxygen sensors while the leading edge contains a Teledyne RDI 300kHz ADCP. Fish biomass can be measured by a Simrad WBT Mini. The bathymetrey system is also housed at the vessel's lowest point.

For shallow water work, Saildrone normally houses a single beam Airmar DT800 while in deep water, it typically carries a Teledyne Ecotrac E20 or a Simrad WBT Mini.

Around halfway between the bulbous keel and the deck is a small propeller. This is used for harvesting energy rather than propelling the vehicle. This is replaced by an actual thruster on larger models which helps the Saildrone move when there's no wind. These engines are also connected to a generator to charge the batteries.

The larger models also include a fuel tank although this is much smaller compared to a vessel of similar capability.

On the main deck body is a NOAA PMEL ASVCO$_2$ sensor for the measurement of atmospheric and dissolved pCO$_2$. It also contains the Dual GPS aided inertial measurement unit and a Vaisala Barocap PTB210 for determining barometric pressure.

MAST

Around halfway up the sail, there is a cross spar and tail.

"The tail controls the movement of the wing," said Peacock. "Moving the tail will efficiently cause the rest of the wing to rotate into the wind and generate the sailing power.

At the very tip is a Rotronic HC2- S3 air temperature and relative humidity sensor, incorporating a radiation shield.

Behind this is the LI-COR LI-192SA which measures photosynthetically active radiation. Underneath is the Heitronics CT 15.10 IR pyrometer which measures skin temperature.

"That is not the skin of the vessel that it measures" explained Peacock – "it's the micron- thickness skin of the air/sea boundary layer that is very interesting to oceanographers.

"Think of a cup of coffee. The skin holds heat but if anyone blows over the surface, it releases thermal energy and the cup cools rapidly. The air-sea boundary is small but plays a disproportionate role in the thermo regulation of the oceans."

At the at the very top is an octagonal body which is the smart camera array.

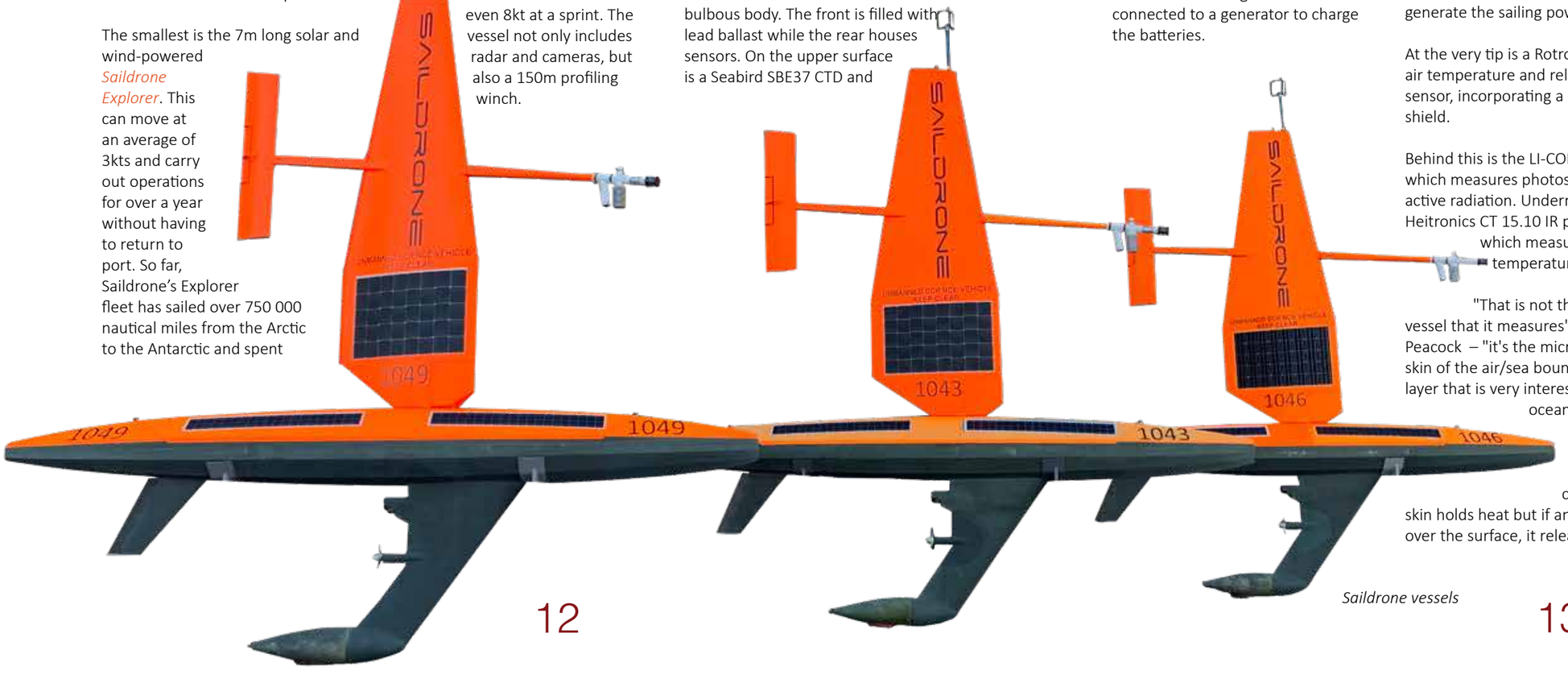
"The 360 deg high-resolution optical cameras can use machine learning to identify vessels from illegal fishermen, small fast boats or tankers," said Peacock. "It can detect sea ice and sea birds, giving a situational awareness

GULF STREAM

A group of three Saildrones are presently sailing through the Gulf Stream to collect critical, in situ data that will help scientists improve weather forecasts and carbon accounting.

This mission is being led by scientists from the University of Rhode Island (URI) and the European Centre for Medium-Range Weather Forecasts (ECMWF). The ocean drones will brave some of the harshest ocean conditions on earth collecting data in areas that traditional crewed ships cannot tolerate.

The Gulf Stream has a significant impact on both weather systems and the global carbon budget, but collecting data from the area is extremely challenging. The Global Carbon Budget 2021, released at COP26, uses ocean carbon uptake estimates generated by models and sophisticated statistical methods that fill gaps where they have been unable to collect in situ data.



Saildrone vessels

and as well as relay the sea state to our pilots while we're sailing.

"We have a regular connection with the cloud which allows us to control the vehicle. Data is logged at a high rate on the vehicle, lower resolution data gets relayed regularly via satellite to home base, for navigation as well as our payload data.

"The Saildrones can collect data at much higher spatial resolution than what satellites are able to see, allowing them to identify fine features like fronts and eddies.

"As opposed to moorings, they can also be dynamically re-tasked to sail to new operating areas, as well as sail back to port to offload high-resolution data or be serviced.

"At the very top, near the AIS transceiver, is a very accurate ultrasonic anemometer which logs very accurate wind speed. We're measuring not just the horizontal wind we typically think of on the water, but also the fine-scale vertical wind speed. "

Eddy covariance (sometimes called Eddy Flux) is a method to directly observe the exchanges of gas, energy, and momentum between air and sea, and is an important tool in understanding how heat is handled by the oceans.

"It is also typically very hard to measure because when wind hits a bluff body it can lead to flow distortion and turbulence," said Peacock.

"We've specifically designed the Saildrones to keep the anemometer away from possible disturbances so they can measure wind up high and very cleanly."

SOUTHERN OCEAN

The saildrone has proved itself able to withstand very harsh environments.

In 2019 a vessel circumnavigated the Southern Ocean. In pre-testing, the winds and waves destroyed the sail structure. This causesd the designers to retrofit a smaller, squat, more square rigged version.

The winds in the Southern Ocean are typically unidirectional, so the sail was always positioned with the wind at its aft.

Last year, off Puerto Rico, a Saildrone sailed through the Category 4 Hurricane Sam to collect critical weather and ocean data – something far too dangerous for human-crewed missions. This would later be crowned the strongest hurricane of the year.

Scientists especially wanted to find out what happens when hurricanes undergo rapid intensification (when with the peak wind speed increasing 35 mph in the within 24 hours.)

Saildrone in the Southern Ocean

They discovered that less saltwater near the surface and saltier water at deeper layers act like a barrier, restricting colder, more salted water to mix to the surface when storms pass.

The result is a layer of warmer water near the surface which provides more energy and more fuel for the hurricane.

WIRE WALKER

At the recent Oceanology 2022 show in London, RS Aqua exhibited Del Mar Oceanographic (DMO)'s novel Wirewalker vertical profiling system.

"Collecting underwater data along a vertical profile is a very good way of determining change over any given period of time," said RS Aqua principal, Martin Stemp. "Numerous systems exist but the Wirewalker must be one of the most economic."

"One common way of gathering profile data is by the use of sophisticated drifters of gliders. While these mechanisms are extremely useful, particularly over a wide range of water depths, but a feature is that they characteristically drift and this may or may not be a useful property."

Drifters work by some sort of bladder system where the units sink until they reach a given depth at which, a valve opens, possibly accompanied by a weight movement to alter the centre of buoyancy. The result is that the devices will then rise back to the surface. As they do so, sensors incorporated into the body will record various parameters. These systems are successfully employed across the globe.

Their movement is limited by energy stored within the battery, although the life of a profiling float is around 4 years. They are also weight-sensitive and this effectively limits the number of sensors it can physically incorporate.

The Wirewalker is a very cost effective and more versatile alternative to an autonomous profiling float for vertical data gathering," said Stemp "It is powered simply by the oscillatory movement of the waves."

The Wirewalker Profiling System consists of a profiling body attached to a length of wire, suspended from a surface float and held taut by a weight. The system can be deployed as-is for “free-drifting” Lagrangian style deployments, or it can be tethered to the seabed to keep it moored in place.

The ingenious part of the Wirewalker device, however, is how the profiler platform utilizes surface waves to move up and down the wire.
“The wire runs through the slightly buoyant profiler," Said Stemp. "When engaged, a cam connects the profiler to the wire so that as the float/wire moves on the downward part of the wave, it drags the profiler downwards.

"When the wire starts to move upwards, however, the cam automatically releases. The profiler body remains stationary while the float pulls the wire upwards through the body and the cycle recommences. With this ratchet system, the profile makes its way down the wire until it reaches the turnaround bumper.

"At this point, the cam fully releases, allowing the profiler platform to decouple from the wire and to float freely up to the surface at around 0.5 m/s.

Typical round trip profiling rates average about 10m/min, which equates to around 100 000m profiled per week.

Profiling ranges up to 500m deep are commonplace; however, 1000m deep profiles are possible with capable instrumentation and high density buoyancy.

Enabled by its continuous rapid profiling, the real strength of the Wirewalker is in the data. Measurements from a single user-defined sensor suite are transformed from simple one dimensional time series, into 2D depth-time images, where a wealth of information and clear insight into the conditions of the upper ocean can be visualised.

RS Aqua is the sole distributor of the Del Mar Oceanographic Wirewalker in the UK.

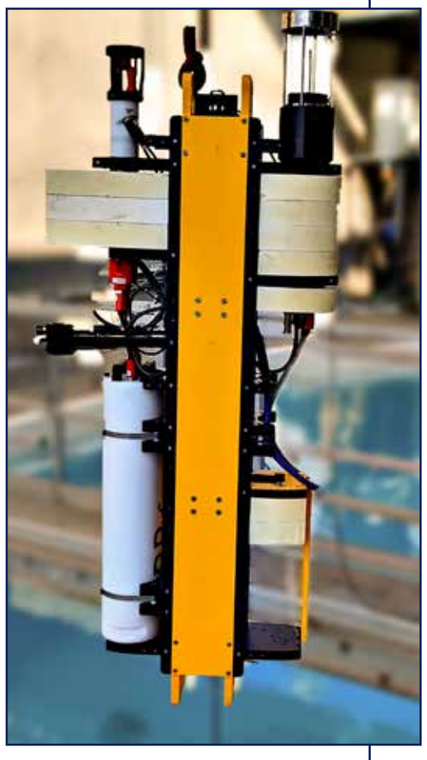
PROFILER

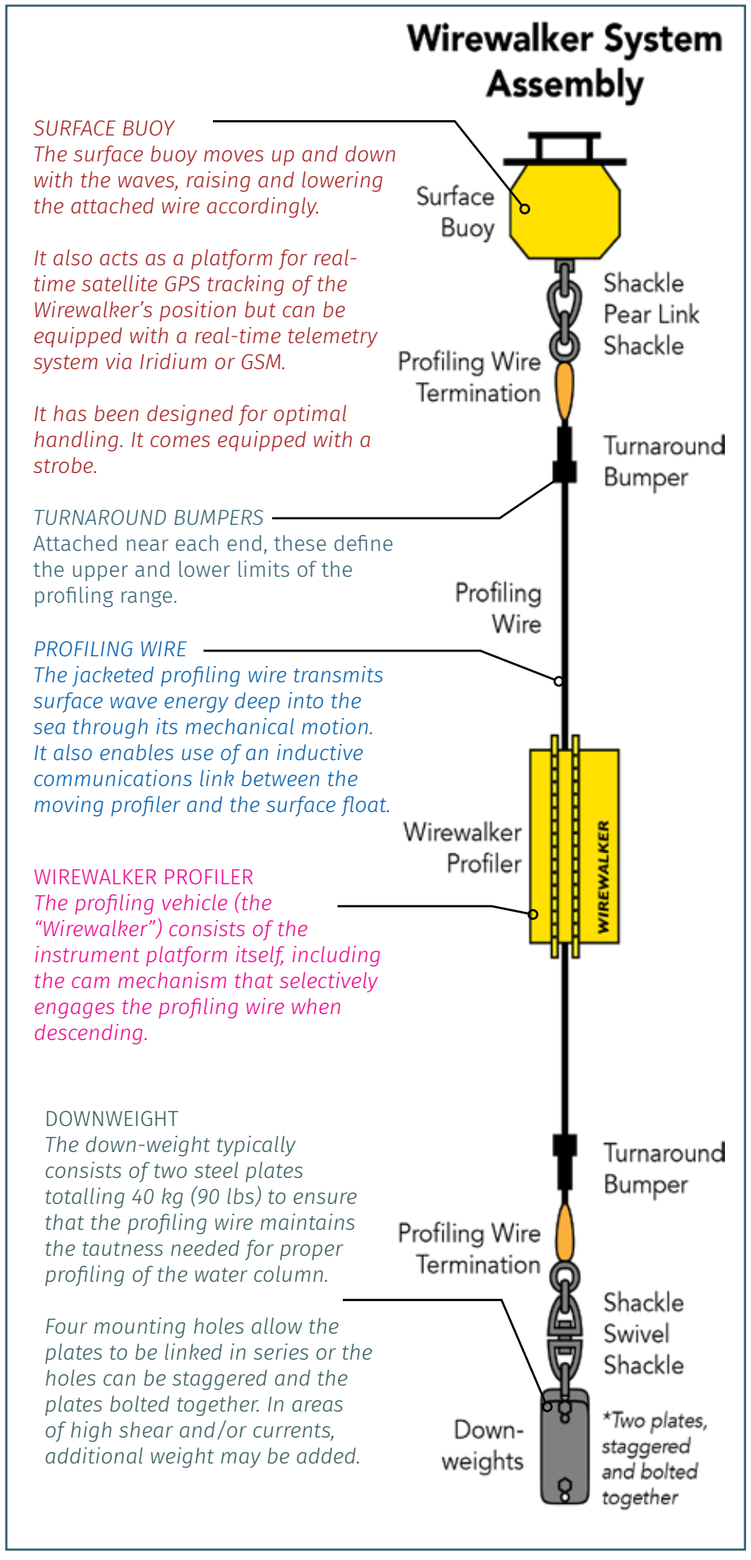
The profiler houses a configurable set of oceanographic sensors. The movement requires no electronics or battery power for propulsion. Any on-board power is exclusively used to extend the duration of the integrated sensing payload.

Sensor suites are easily tailored to meet application needs; achievable though a modular design and simple ballasting.

It also has a configurable set of depth rated foam blocks to set the positive buoyancy.

Various foam densities are available and define the depth rating of the profiler (300m-1000m). The profiler is outfitted with asymmetric cowlings that give it a leading and trailing edge as they align the profiler body into the current.





REMOTE MARINE SURVEY

By Richard Hill, International Business Development, EdgeTech

Those that recently visited Oceanology International (2022, London) or followed related social media posts will have recognised the number of active USVs offering capabilities equivalent to the crewed systems typically used for inshore/ nearshore geophysical survey projects.

Helping to achieve this requirement, EdgeTech showcased its latest edition of its 6205 MPES bathymetry/side scan sonar product series – the 6205s2, together with the latest edition in the 3400 sub bottom profiler product series – the 3400-OTS (over-the-side).

At the exhibition L3-HARRIS was conducting on-water demos with its C-Worker-5 USV. EdgeTech was keen to promote the ability of these two sonars two work either independently or harmoniously with each other in a tightly integrated manner.

MPES: TECHNOLOGY UNIQUE TO EDGETECH SONAR

Historically, swath bathymetry systems have been categorised into one of two groups: Phase Discrimination Bathymetric Sonars (PDBS), which are based solely on interferometric techniques, and Multi Beam Echo Sounders (MBES), which use beam-forming techniques. This distinction, however, has become increasingly blurred over time.

"Our hybrid MPES approach, capitalises on the capacity of both technologies while overcoming the limitations of each," said Richard Hill, International Business Development, EdgeTech. "Remote marine survey will only be as effective as their payloads, and that's where the updated products from EdgeTech stand out.

"Having listened to the unfolding needs of the marine science community, we have recently made available on the 6205s2 sonar a new game-changing sonar frequency combination—850kHz and 1600kHz—optimized for compact vehicles operating in shallow water or in close proximity to the seafloor.

"The new high frequency combination delivers high resolution side scan sonar imagery at both frequencies, as well as MPES bathymetry at 850kHz. "

MULTIPLE PHASE MEASUREMENTS

MPES technology forms the basis for all EdgeTech bathymetry products. It uses ten channels in the receive array to derive up to nine phase difference measurements per side, and these multiple phase measurements provide a number of benefits when resolving for the seafloor soundings.

The increased channel count provides information to acquire mean and standard deviations for each sample so as to statistically filter out dual echo (or multi-path) contaminated samples, and so ensure that the data collected are less contaminated by noise and more robust.

"There is a high channel count in each transducer," said Hill, "which allows MBES-like beamforming to help focus the energy at the nadir to create a denser data set in this region. EdgeTech's MPES was the very first of its kind to produce clean, wide swath coverage while maintaining real acoustic data at nadir with a data density that remains almost constant from nadir to the outerswath.

Coverage within the nadir region of the sonar swath is crucial to capitalizing on the efficiency gains of PDBS systems, or the equivalent but more costly dual head MBES systems."

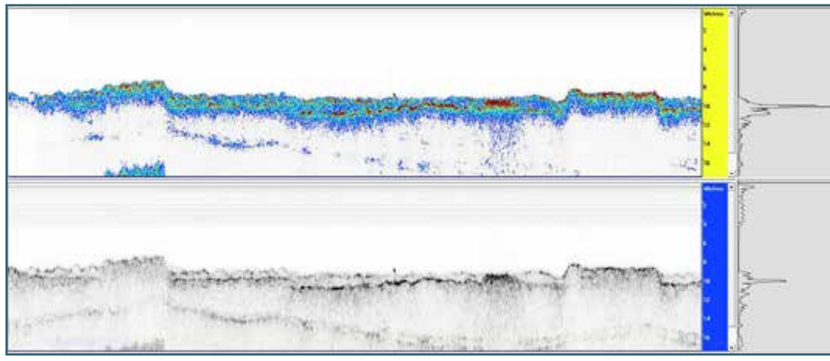
"With the integration of EdgeTech's Full Spectrum CHIRP technology signals, the MPES sonar is able to exceed the IHO SP-44, NOAA, and USACE specifications for Feature Detection and Bathymetric Point Data Uncertainty."

540kHz side scan sonar high resolution imagery

EdgeTech's next generation MPES transducer design, which includes dedicated full length transmit and receive arrays for both high and low frequencies, enables operators to collect ultra-high resolution and accurately geo-referenced side scan imagery without interference or loss of resolution.

"This additional information is key for shallow water surveys as it can mean the difference between deleting data as water column noise and recognising real objects," said Hill. A motion-tolerant side scan is also available as an additional data set should the operator prefer to use it in post processing.

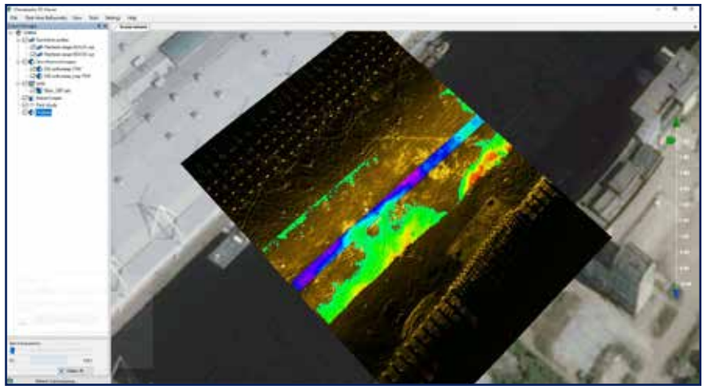
"Customers have noted that the frequency combination lets the user get full high-resolution side scan sonar at 1600kHz over 30m per side, while getting wider coverage from the 850kHz and its co-registered bathymetry at the same time and which can include nadir gap coverage."



3400-OTS results illustrating the dual-pulse ability

SBP REAL-TIME REFLECTION COEFFICIENT MEASUREMENT

The 3400-OTS transmits wide band Frequency Modulated (FM) pulses using EdgeTech's proprietary 'Full Spectrum CHIRP technology'. The system uses flat multi-channel hydrophone array to generate high resolution images of the sub-bottom stratigraphy and provides excellent penetration in various bottom types.



3400-OTS data alongside 6205 sonar results

The 3400-OTS receiver array is segmented for standard sub-bottom profiling operations or *pipeline mode* for optimal location and imaging of buried pipelines or cables. Using the real-time reflection coefficient measurement uniquely allows users the ability to collect complex 'analytic' data using linear system architecture to measure sediment reflection and analyse sediment type.

Additionally, the system has discrete transmit and receive channels allowing for continuous data collection resulting in a high ping rate particularly important for construction and pipeline surveys.

"A further distinct advantage with an EdgeTech sub bottom profiler is that its Pulse Library makes it possible to select tailored FM pulses for different survey applications," said Hill "The 3400-OTS system comes as a complete package including EdgeTech's DISCOVER acquisition software, although it can easily be

interfaced to popular 3rd party survey software.

"As one recent customer noted: 'it's certainly a frequently used feature for us, to be able to make a few test survey lines and on-the-fly, to change the pulse type whilst we run the sonar in a flip-flop mode. Straight away, this allows us to see the pros and cons of different pulse types in relation to the nature of the seabed material of the project site.

"When it comes to simplifying the integration and minimising the operational training for USV projects, it is good to get three high resolution data sets from one and the same equipment manufacturer when possible"

This is now achievable when the 3400 sonar head is connected to the 6205s2 sonar head. This allows the bathymetry /side scan sonar/sub-bottom profiler data to be transferred to the single top unit. The sonar control and data display is managed by one version of DISCOVER.

"The icing on the 'simplified installation' cake, is to also fit the 6205s2 with an OEM RTK GNSS/INS unit, thus taking care of the time/position/attitude data that's required by an integrated seabed mapping system" said Hill.

NADIR GAP-FILL FOR SIDE SCAN SONAR

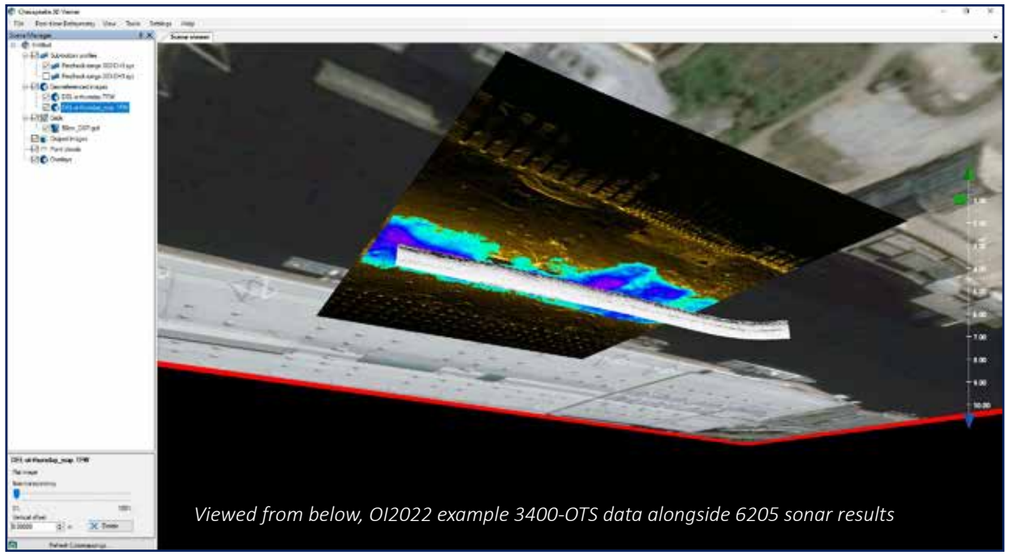
The traditional side scan system with port and starboard channel has a space between them when viewing the data. Once bottom tracked, the two sides get stretched to form a filled area. However, the imagery at and close to nadir means that identifying targets is difficult and any shadows from them are small.

Standard operations would include running additional survey lines offset from the original line to fill in the data at the nadir area.

"This is a decent solution but one that comes with a penalty," said Hill. "A full survey line needs to be run to fill an area that might be just a few meters wide (a function of the height above the seabed of the sonar).

"The recent Gap-Fill innovation from EdgeTech, delivers the ability to see the nadir gap from both the left and right sides, providing shadows from either direction, as well as in a three- dimensional aspect in the nadir gap.

The shadows are perpendicular to the vehicle's path and consistent with traditional side scan methods, enabling easy interpretation of data. The gap fill data in the 6205s2 system is coincident with the side scan data and is therefore, geospatially, exactly the same.



Viewed from below, OI2022 example 3400-OTS data alongside 6205 sonar results

AVOIDANCE SONAR

Woods Hole Oceanographic Institution has pioneered a new obstacle avoidance pipeline for Autonomous Underwater Vehicles (AUVs) using the Impact Subsea ISS360 Imaging Sonar.

The pipeline is intended to provide a reduced form factor, lower power requirement and a more cost effective solution than traditional approaches.

The team successfully utilised the ISS360 Imaging Sonar integrated with a REMUS 100 AUV and demonstrated automatic obstacle avoidance capability with the new pipeline.

The Software Development Kit (SDK) which is freely available for the ISS360 Sonar was used to provide a simple direct integration of the sonar to the vehicle.

Ben Grant, Managing Director, Impact Subsea further added 'The ISS360 is a highly compact, low power consumption sonar with impressive range and resolution capabilities.

The ISS360 provides a powerful imaging sonar capability for underwater ROV & AUV applications.

The pioneering work conducted by WHOI is very exciting to see and we have very much enjoyed supporting their team with this development'

AUV Imaging Sonar

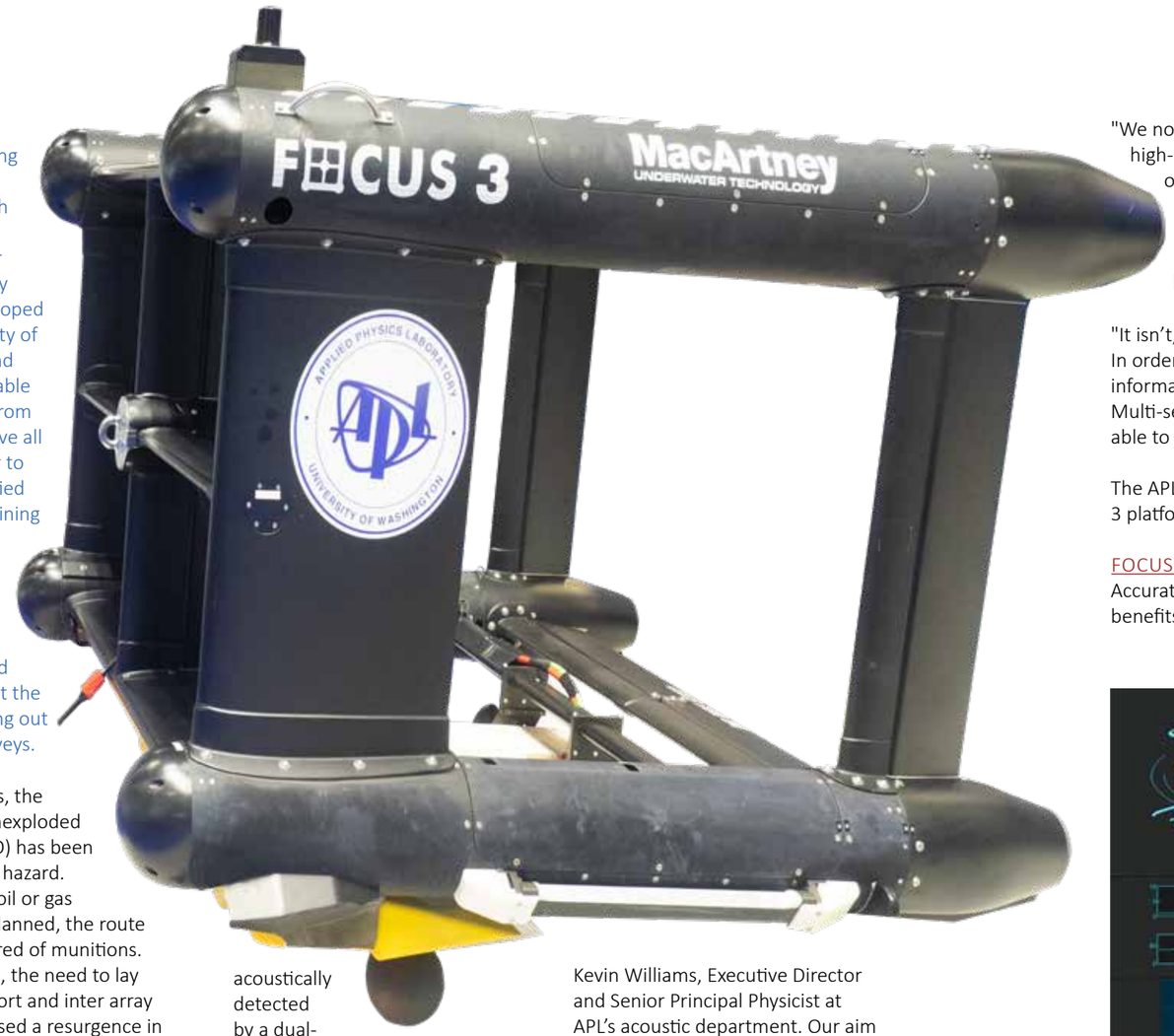
MICRON GEMINI

Tritech has released the new Micron Gemini combining the Micron and Gemini product families. The designers say that it is the smallest multibeam sonar on the market. It offers an extremely cost effective, powerful real time imaging sonar in the body of the Gemini 720im.

With greatly improved image quality, a 90-degree horizontal field of view and 50 m range, the Micron Gemini offers cost effective obstacle avoidance and navigation for small ROVs and AUVs, as well as utilisation with Tritech's Diver Mounted Display system (DMD).

Combining product families

GETTING INTO FOCUS



A new sub-bottom mapping system based on an EdgeTech synthetic aperture sonar (SAS), driven by software developed at the University of Washington and carried by a stable tow platform from MacArtney, have all come together to produce a unified way of determining buried objects from cables and pipes to mortar shells and other UXO. This could significantly cut the costs of carrying out wind farm surveys.

For many years, the presence of unexploded ordnance (UXO) has been a recognisable hazard. Every time an oil or gas pipeline was planned, the route had to be cleared of munitions. In recent years, the need to lay numerous export and inter array cables has caused a resurgence in this demand although importantly, at a much lower cost base.

Underwater object detection has become a subject of interest to the engineers at the University of Washington Applied Physics Laboratory (APL-UW), particularly with regard to pipe tracking and explosive detection. They recognised that unburied targets could be acoustically detected by a dual-band EdgeTech 2205 sonar but for sub surface detection, they began to look at quite a mature technology- the EdgeTech Buried Object Scanning Sonar (EBOSS) sediment-penetrating 3D synthetic aperture sonar (SAS).

“A characteristic of the EBOSS is the intensive computational burden associated with beamforming,” said Kevin Williams, Executive Director and Senior Principal Physicist at APL’s acoustic department. Our aim was to develop code to reduce this computational load.

“Technology has progressed since the first EBOSS was developed, in particular the ability of data processing software and a graphics processing units originally developed for the high-end gaming sector, to deal with 3D volumetric data in real time.

"We now have tools such as mosaics, high-resolution volume renderings of specific targets, and extraction of acoustic features such as target impulse response information that can be used for UXO classification.

"It isn’t, however, all about software. In order to physically capture this information, we needed a highly stable Multi-sensor Towbody (MuST) vehicle able to carry multiple sensors."

The APL selected a MacArtney FOCUS 3 platform.

FOCUS 3

Accurate acoustic imaging technology benefits from a very stable platform because it does not nearly require the same amount of motion compensation to place the sonar at the desired location- within one tenth of a wavelength," said Williams.

“It is probably safe to say, that the system just wouldn’t work without the stability provided by the Focus 3."

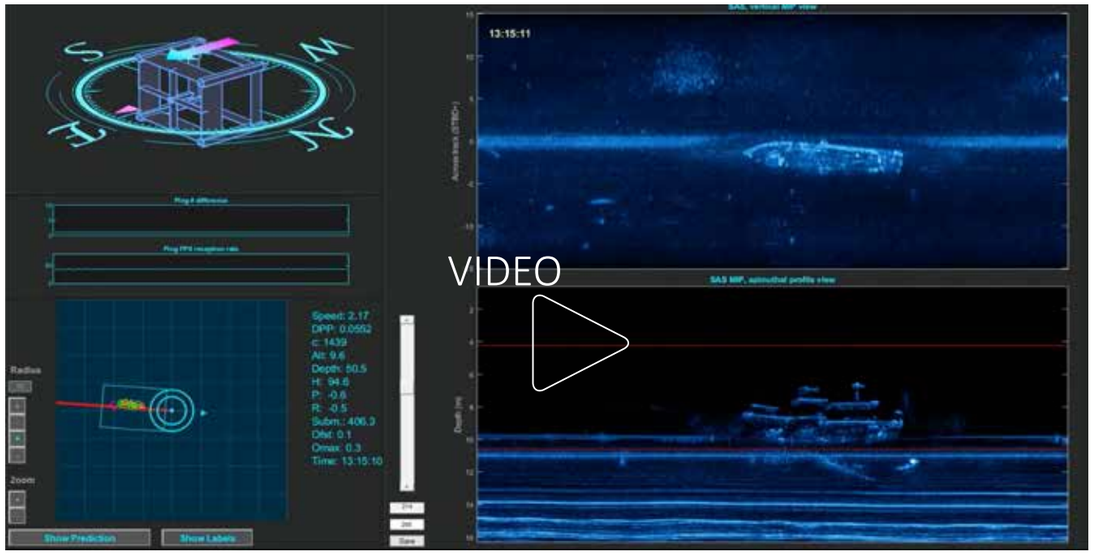
This towbody can be powered and controlled from the surface and gather data relayed in real time via its NEXUS multiplexer. Included on the vehicle is a Doppler velocity log (DVL), inertial navigation system (INS) and a sound-speed sensor to help the synthetic aperture beamforming.

“The FOCUS 3 also includes a dual-antenna GPS for determining heading and position when surfaced while heading, tilt, altitude and pressure/ depth sensors", said Hans-Jorgen Hansen, MacArtney’s Sales Director, Ocean Science. “We use it for control and navigational feedback in order to know the position of the body at all times, with high accuracy.

SONAR

"The EBOSS is a very powerful tool, allowing us to use frequencies of 5 to 25KHz so we can penetrate deep into the sediment," said Williams."It can image 3m below a sandy seabed although this can be increased to 12m in soft sediment.

“The tow speed itself is not critical



On the top view is the plan view and below, the elevation showing the buried cable in the 20cm–60cm of sediment although it is possible to see even deeper. On the right side is a compass to show that the Focus 3 is flying flat and stable. In addition to the objects it is also possible to look at greater environment.

but from experience, have found 4kts to be optimum. At that speed, the Focus 3 is really stable," said Williams.
"We have flown it faster but to do so, it is necessary to increase the ping rate. We have found the sweet spot at 60Hz which translates as a ping every 3-4cms and this allows us to resolve images of one inch (2.5cms). One of the reasons we limit the sonar to 60 Hz is that we need to ensure the sonar does not overheat."

"The stability of the Focus 3 towbody means that we can safely fly at 5m above the seabed in order to look deep into the sediment," continued Hansen. "This height allows a 20m swath. In many applications such as using it to track a pipeline, however, this is not critical.

"As we fly higher, say at 10m, we don't get such a good resolution but benefit from a 40m swath. Flying higher, is that it very much increases the swath at a rate of four-to-one so at 15m height, we could ping it at 30 Hz and benefit from a 60m swath.
"The Focus 3 is very manoeuvrable and the integral wings allow it to fly a steady altitude above the seabed, but also enables it to move side to side.

This effectively means that the Focus 3 can move at 50m either side of the pipe and still have the it within the field of view. Having 100m to play with circumvents any navigation issues."

All the information can be streamed up to the wheelhouse to provide navigational information on the seabed bathymetry while keeping track of the cable.

"Because of the little vehicle motion we are able to process the SAS information in real time which in turn adds to the ability to use it," said Williams. "Looking at images on the fly has great benefits, especially tracking buried cable.

POST PROCESSING

The APL has developed a data-driven, feature-based navigation refinement algorithm to augment the onboard navigation sensor suite and improve the navigation precision.

"An important feature of post-processing is the accurate fusion of data from different scans," said Williams."The number of non-overlapping acoustic images can be often a determining factor for the accuracy of an image. As a result data fusion relies on pixel-scale navigation precision.

"This *renavigation* enables the features captured by various observations from different scans to be accurately aligned. It also results in significant improvements to mosaic data products as these can undergo speckle reduction and significant signal-to-noise ratio improvements when fusing data together from different scans.

Following the sonar run, the data taken from various passes can be assembled to create a very high fidelity three dimensional image.

"The post processing systems we have developed not only allow us to cut the image and effectively visualise it in slices like medical tomography scans," said Williams.
"In one test project, we were able to see internal structures in a ship sitting on the seabed.

We could not only cut the image sideways forward to aft but also port to starboard. We could then grab a cube from the model and rotate it. In this way, we could see the decks but also two stairways of between them."

Recovering the Focus

In addition, high resolution spectral processing can be used for UXO identification and classification, and that is the area that the group are really interested in.

"We are getting about an inch resolution so for larger items, we are getting a lot of pixels on target and that helps to the final classification. We can classify structures about 8 inches long and three inches in diameter. We can look at a variety if shapes

"A medical ultrasound of the UXO target is very useful in identifying the shape of the object but the more difficult challenge, and something we see as a very useful diagnostic tool, is to discover what happens as it is hit with sound.

"These frequencies literally cause metal bodies to resonate is like ringing the bell and that oscillation allows us to match frequency responses from a database in post processing and allows us to classify the target. This library is in active development. Each target has its own signature so it is possible to tell if the body is dense or not.

"From the interference patterns, we can actually use it to identify the target better than if we had just its shape.

INVERSION

When doing a UXO survey along a desired path, by far the largest area surveyed will be clear.

"From the EBOSS, we can determine the sound speed and density of the sediments. This provides information on the lithology and gives information to the geotechnical group to provide information on if there are hard layers, how large an area do they cover and how deep.

COST SAVINGS

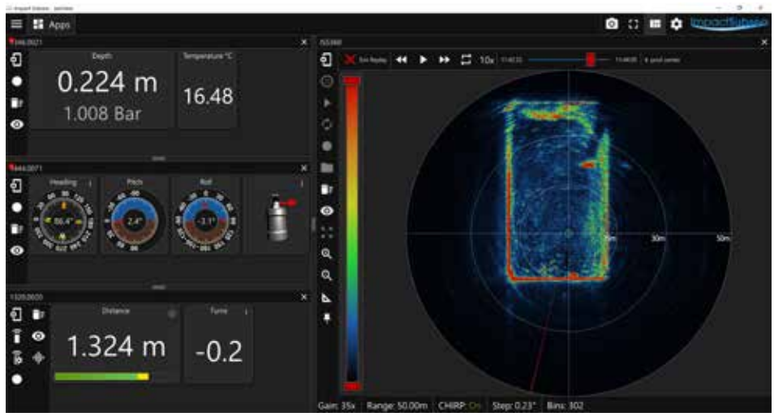
"A conventional UXO detection procedure is to fly a magnetometer over an area and look for responses. These are listed in priority and divers or vehicles are then sent to look at and intervene with at these targets in detail. This part of the operation is *very* expensive.

Any method of detecting and classifying targets with greater accuracy can dramatically reduce overall costs, potentially by an order of magnitude."

V3

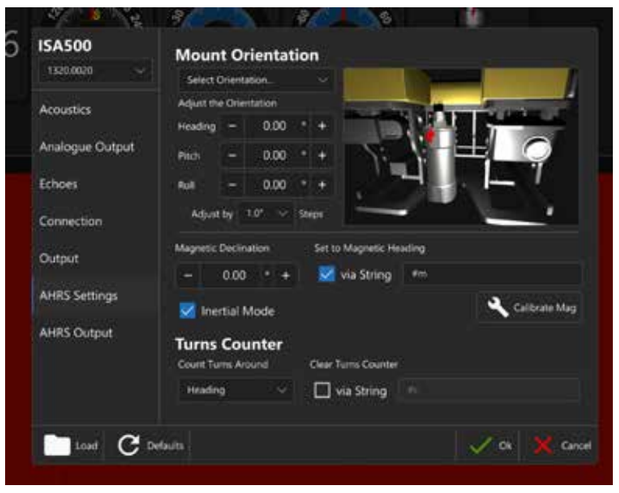
IMPACT SUBSEA HAS ENHANCED ITS SOFTWARE AND FIRMWARE TO SQUEEZE MORE CAPABILITY FROM ITS ROV & AUV SENSORS

When not developing some of the smallest ROV and AUV sensor packages on the market over the last few years, the engineers at Impact Subsea have been busy working on the third generation of seaView software to support the range of Altimeters, Attitude and Heading Reference Systems, Depth Sensors and Sonars.



Above: V3 Software can be used for multiple sensors

Below AHRS Set up. The software now has a turns counter



The launch of seaView V3 is accompanied by the release of a third generation of sensor firmware which dramatically opens up new capabilities in the sensors themselves. It provides a powerful platform for existing Impact Subsea sensors and future sensor developments.

V3

seaView V3 allows a single or multiple Impact Subsea sensors to operate simultaneously from a single application.

"The visual display has been enhanced to provide an even better user experience," said Impact Subsea's MD, Ben Grant, "with a cleaner interface allowing individual sensors to be shown at a time or multiple sensors together".

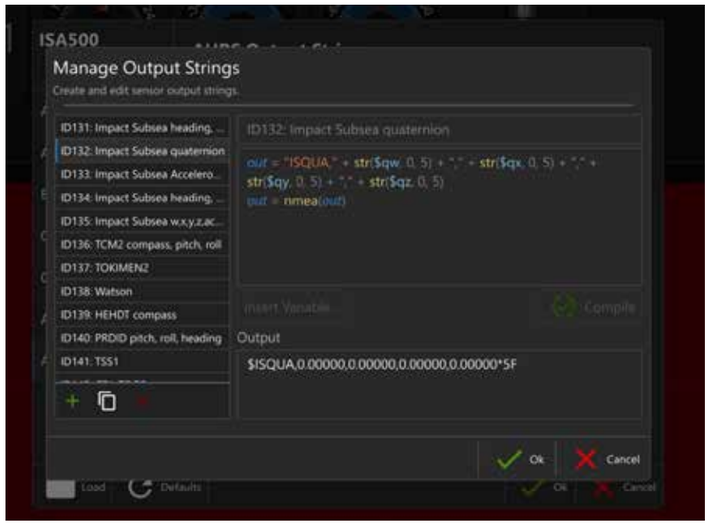
"With V3 comes the ability to automatically detect any sensor that has been physically connected to the computer. The user no longer needs to deal with communication port allocation or configuration of required baud rate – this is handled automatically by the software. Sensors are automatically displayed on screen as soon as they are connected.

Once connected, simply double-tapping on the sensor icon takes the user directly to the application to look specifically at all the raw data. One reason that enhanced visualisation is particularly useful, is that the underwater sensors can now provide more information than they previously did.

All sensors are fully software configurable, with seaView V3 providing a clear process to set up and configure sensors to suit specific requirements. For example, V3 allows for custom output strings to be created, where users can add new formats of ASCII output strings to a sensor's firmware.

This enables quick integration of sensors into existing platforms and software applications by the user, without the need to redevelop systems or request additional support from Impact Subsea.

"As an example, when our Altimeter is working underwater, the user is now able to receive information such as the altitude above the sea bed, the temperature of the sensor itself, its heading, pitch, roll and a real-time moving 3D model," said Grant.



Output string generator – used to create user defined output strings from the sensors

"A turns counter feature has also been added for all Impact Subsea sensors enabled with the integrated Attitude and Heading Reference System. This is ideal to keep track of umbilical loops in ROV operations, or other applications where the rotation of an underwater asset requires monitoring.

Impact Subsea's altimeter was traditionally limited 10 pings per second. The company has now opened it up so it is now able to output 100 pings per second, range dependent. This very fast update rate is useful, for example, when part of the sensor package to control an ROV. The higher ping rate can assist the control system and make the vehicle more stable.

It also has the ability to receive multi echoes. This allows the user to look at multiple targets within a beam. It will show the range to each target by a single ping.

FIRMWARE

"We've done a lot behind the scenes and in particular, written a whole new generation of firmware for our sensors," said Grant.

"Re-writing some of the firmware has resulted in more efficient utilisation of our hardware, focussing on the capabilities of each sensor. This has allowed the altimeter, for example, to take more readings per second, and improve its heading pitch and roll stability and accuracy.

"The altimeter for example, has a dual core processor in it," explained Grant. "Traditionally all the acoustics and the heading pitch and roll instructions were shared between the two. We have now modified the arrangement with one core dedicated to the acoustic side and the other, to the heading pitch and roll.

"For the pitch and roll side, this has particularly allowed us to improve this stability and accuracy. At the same time, looking at the at the acoustic side we were able to streamline the output and it was this that allowed more readings per second.

"While this is good for stability and onboard control systems it is particularly useful for bathymetric surveys. This means that in a single beam survey, the sensor can ping a lot faster, allowing more data to be gathered.

"Our depth sensor has always achieved a survey grade accuracy 0.01% of full pressure scale, but we found that most of the sensors were quite capable of doubling the accuracy, so we've introduced a new calibration method and can now offer accuracy to 0.005%," said Grant.

"For certain applications such as deflection monitoring, where the user needs a very high precision, high accuracy depth measurement, this becomes much more attractive."

The 'inversion reset' capability in Impact Subsea sensors has been further enhanced: Three inversions within 10 seconds of power on sets the sensors to RS232; Six inversions, sets it to RS485. This allows sensors to quickly be configured to suit the required communications interface.

This gives a good platform for the next generation of sensors.

"We already produce the world's smallest sonar" said Grant, "but we're now looking towards developing even higher resolution imaging sonars.

Our vision for future sonars would utilise the same tried and tested electronics stack but we envisage the boot end to be about twice as wide. This will provide a very narrow angular resolution to obtain high accuracy imagery at longer ranges.

"Currently, the maximum distance between the sonar and the target is 90 meters. This is achieved by a 2.3 deg beam. By the time it gets to, say, 90m away, the actual beam is quite wide and this dictates the features that can the sonar can differentiate between. Right now we get fantastic resolution imagery close in; down to 2.5mm range resolution from our ISS360 sonar.

"The ISS360 has established itself as a core sensor on underwater vehicles – from observation to workclass vehicles. We look forward to expanding the ISS360 range of sonars to add enhanced angular resolution" concluded Grant.

MINE DISPOSAL

Estimates put the number of explosives in the waters surrounding the UK at around 100 000t.

In recent years, this unexploded seabed ordnance has become increasingly challenging for developers laying pipelines and cables for the renewable energy industry.

The most common method of ordnance disposal is to detonate devices *in situ*. The downside of this approach, however, is that underwater explosions can generate large noise and the shockwaves are able to propagate through the water, potentially causing irreversible damage to cetaceans and sea creatures many kilometres away from the blast epicentre.

The explosions from high-order detonations also release chemical waste toxins and into the water.

This has prompted underwater ordnance clearance company EODEX to offer a low-order deflagration technique. This allows the explosive part to be rapidly burnt without causing the whole munition to explode.

Standing in front of a British A Mk 12 Ground mine, used as an anti-submarine and anti-vessel weapon, Steve Vernon, EODEX Operations Director, explained.

"The A Mk 12 weighs about 1000kg and contains a huge amount of explosive," he said. "Running along the inside is a coil rod that detects magnetic signatures of vessels passing over it.

COMPONENTS

There are three basic parts to a mine. The first is the detonator. This extremely sensitive device is the start of the detonation process and passes explosive power to a slightly less sensitive explosive booster. This in turn initiates the main charge, either Amatol, TNT or a mixture of both.

"For disposing of such a mine, once any of these three key elements are removed," said Vernon, "the detonation process has been broken, rendering the UXO unable to function as designed. Our methodology for a low-order disposal operation focusses on disrupting this explosive train and making the weapon no longer viable as a danger.

"Classic floating mines, with sensors protruding along their periphery, are designed to blow up a hole in whatever they might happen to impact.

Influence mines work in a slightly different way. The ground mine could be laid either from a ship or from an aircraft by means of a parachute. These would lie on the seabed and wait for vessels to pass over.

If the mine detected a magnetic signature from the right class of vessel, it would detonate, creating a huge gas bubble underwater, known as a 'Bubble Pulse'. This reaction was sometimes enhanced

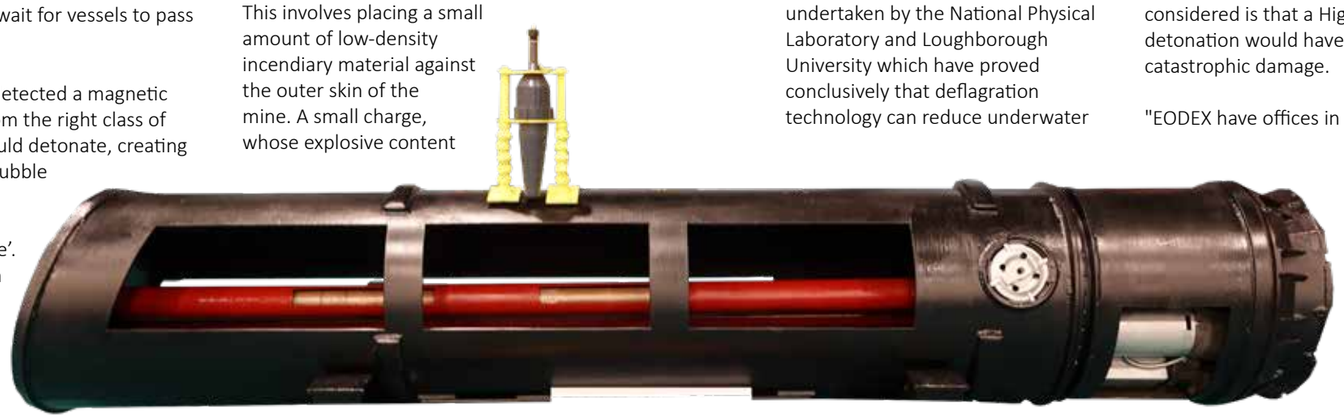
SC 250 Air-dropped bomb

by the addition of aluminium in the explosive mixture.

"As the gas bubble rises to the surface, the decrease in ambient pressure causes the molecules to expand and so the bubble increases in volume. For the ship floating on the surface with no water to support it as the bubble breaks surface, the vessel collapses. In combination with the shock wave from the explosion, this breaks its back. This can sometimes cause a large vessel to sink in a matter of minutes."

Instead of placing an explosive donor charge next to the nuisance munition to either detonate or destroy it, Eodex use an approved low order deflagration solution developed from years of military usage and manufactured by Alford Technologies.

This involves placing a small amount of low-density incendiary material against the outer skin of the mine. A small charge, whose explosive content is measured in grams not kilograms, forms a very high-temperature plasma jet.



"When this inverts, it forms a plasma slug like a molten bolt," said Vernon. "This pierces the case and ignites the explosives inside the bomb or the mine. This burns at a very high heat intensity.

"The explosives inside the mine are very oxygen-rich and once the burning process starts, the materials are quickly consumed in a matter of microseconds. This burning process gives off gases which build up considerably and, overpressure the steel container splitting the case

"Once the case splits, there is an inrush of water which quenches the heat. There might be a small residue of explosive left over but they're quite safe."

Airdrop bombs are often heavier with skins of 2-3ins, and these require slightly larger deflagration charges.

TRIALS

The work follows BEIS trials undertaken by the National Physical Laboratory and Loughborough University which have proved conclusively that deflagration technology can reduce underwater noise from UXO disposal to a mere fraction of what would be experienced from the traditional high order method.

"We recently carried out the second phase of a government trial in Denmark on a number of live Mk 6 Ground mines," said Vernon.

"It was previously understood that if the deflagration process is carried out on a completely intact UXO, it maintains the burning process for longer. It has now been proven that, it doesn't matter if it's slightly broken open or degraded because the explosives are still consumed/ incinerated enough to render the UXO safe.

"Last year, the Polish Navy blew up a 5.5t Tall Boy bomb designed to penetrate concrete submarine pens. For this unique disposal there was quite a long pause, about four to five seconds, which we knew was the bomb deflagrating.

"This resulted in a limited explosion that barely rattled windows 100m away but the important fact to be considered is that a High Order detonation would have resulted in catastrophic damage.

"EODEX have offices in Portsmouth, Bognor Regis and Aberdeen and have just opened an office in Rhode Island USA. Our reasons are fairly clear, the US coastline has numerous munitions from US naval operations and whilst not as common as in European waters there are even munitions from exchanges in WWII.

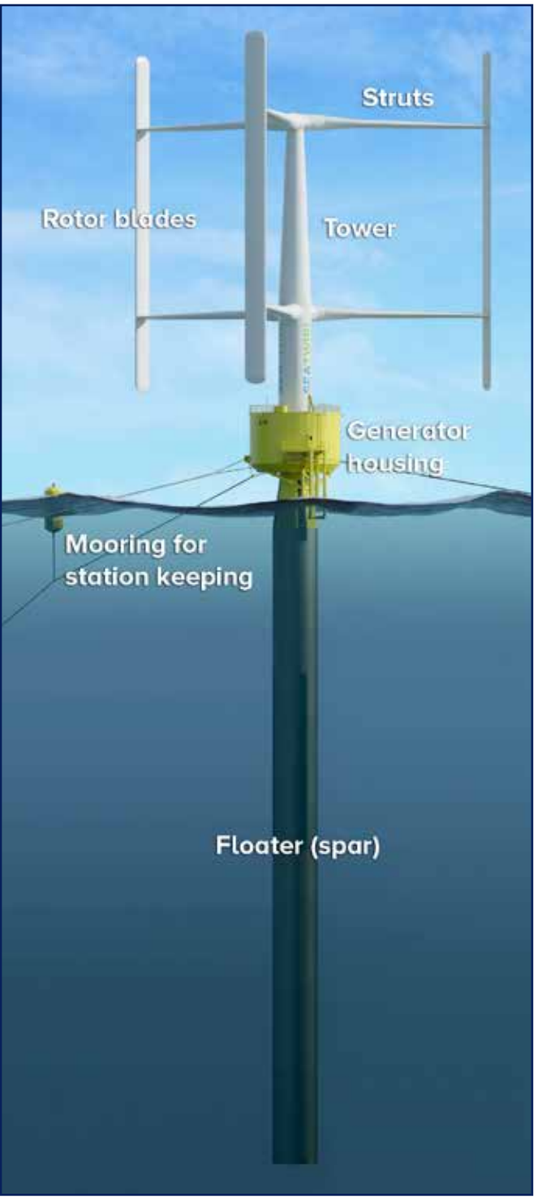
"It is known that the Eastern Seaboard is a migratory stretch of water for a number of sea creatures, making the use of EODEX's gentle disposal methods essential a game changing capability for safely removing any munitions prior to any offshore construction works taking place
.
"We would normally be contracted by a marine service provider or tier one contractor to carry out the whole investigation, survey and UXO disposal phases of a project.

"For the survey part of our work, we would subcontract this to a company that employed equipment such as magnetometers or sub bottom profilers to enable the compilation of a target list of items to be further investigated. The process of relocation and identification allows us to exploit these targets.

"Non UXO is dealt with as scrap and confirmed UXO dealt with using EODEX's environmentally gentle disposal system, using divers or ROVs."

SEA TWIRL

SEA TWIRL



Components of the Sea Twirl

SeaTwirl has obtained approved concession in Norway for installation of the Company's S2x floating wind turbine in Bokn Municipality, Norway. The application pertains to the installation of a 1 MW S2x unit, a vertical-axis turbine.

SeaTwirl's wind turbines use a vertical axis wind turbine that can harness wind energy independent of wind direction. The wind turbine and the floater (spar) are fixed together and rotate as one unit.

The only static (non-rotating) part of the wind turbine is the generator housing, which is moored to the seabed keeping the turbine in position.

The loads on the single bearing located inside the generator housing are relatively low, as the over-turning moment from the turbine is transferred through the vertical spar.

SeaTwirl's wind turbines have a lower centre of gravity and inherently a more stable than horizontal-axis wind turbines because the generator and all parts that require maintenance can be placed under the turbine but above the water. Importantly, the turbines are easily accessed which reduces service costs.

SeaTwirl's unique system ensures lower manufacturing costs, lower lifecycle costs (i.e., reduced need for service and maintenance) and thus a lower overall cost.

This is especially important for offshore structures. SeaTwirl turbines can be sited in areas that are currently out of reach for many conventional monopile offshore wind turbines (that are limited to a depth of about 60m). This means that the turbines be sited where winds are stronger and more reliable.

Research and scientific reports also suggest that vertical-axis wind turbines have a very high structural limit and can be built larger than horizontal-axis wind turbines.

SeaTwirl, together with Marin Energi Testsenter AS (MET) applied for a concession period of five years.

The installation site for S2x is planned to be located in Boknafjorden, northeast of Lauplandsholmen. The test site -previously a fish farm-is located approximately 700m off the coast in water depths of up to 130m.

It is planned that S2x will be connected to an existing onshore transformer substation, and it has been confirmed that there is sufficient capacity in the transformer substation to handle the power generated. SeaTwirl has already reported that Haugaland Kraft will purchase the electricity produced.

While seemingly a new company, the company recently marked its 10th anniversary.

SEAWIND

Seawind's twin-bladed turbine Image: Seawind

A novel two-bladed inspired by the rotor dynamics of helicopter blades is at an advanced stage of development. According its manufacturers, the Swedish company Seawind, its two-bladed turbine will be 25% cheaper to install and operate while generating about the same amount of electricity as a 3-blade version. The first turbine is scheduled to be installed in 2024.

In order to generate as much power a possible, turbines have to adjust their exposure by changing their pitch. If the wind is too powerful, they turn the blades to spill wind.

Seawind's system however, is based on teeter hinge which adjusts the entire rotor head like on a helicopter. This eliminates the need for a complex blade pitch mechanism, a source of failure in many turbines.

A radar measures wind speeds feeds this information to the system The designers have increased the length of the blade by 5m to compensate for the fact that there are only 2 blades.

The twin blade system has a number of advantages, particularly that the reduction in the number of blades makes it cheaper to fabricate and easier to install. The two blades also results in lower air resistance so the blades can rotate faster.

Its mechanism has fewer moving parts. The mechanisms are simpler, fewer failure sources, and parts are readily available in the open market which also reduces costs and makes systems easier to maintain. Simplicity should also reduce times between maintenance.

DRILLED PILES

Later this year, the DEME Group will complete installing the 80 foundations for the Saint Nazaire offshore wind farm. Located over rocky seabed, this will be the first commercial scale project installed in French waters for bespoke subsea piling drill system developed in association with commercial tunnelling company Herrenknecht

One problem with installing any structure on the sea bed, is keeping it there. Sometimes very fast underwater currents can impact on the sides of a structure to destabilise it but equally problematic, is that the sea bed around the underwater structure can erode and often wash away, removing the support. That is why inflexible offshore turbine foundations are very important, especially in the high energy environments associated with many wind farms.

The industry has largely solved this problem by driving very long steel monopiles deep into the sea bed as part of the turbine structure. One drawback with this is that hammering down on a pile driving creates a significant amount of noise.

The smaller 2.820m dia OFD system produces a 3.140m dia hole. The drilling head turns at up to 14 rpm and the 400 kW drive produces a nominal torque of 708 kNm. The 13.5m machine weighs 100t

Left: A typical application

In recent decades, there have been concerns that the vibrations affect the migration paths of curious whales and other marine mammals. The piling installation industry has responded by developing a variety of noise suppression and other sound insulation systems, bubble curtains and other ways to minimise the escape of the noise.

There are some areas, however, where difficult ground conditions make it low-energy pile driving impossible.

Drilled piles are not unknown in terrestrial civil engineering projects but some of the offshore piles are up to 7m diameter. This prompted tunnelling experts Herrenknecht OFD (Offshore Foundation Drilling) by to develop a mechanised solution that increases the feasibility of offshore projects requiring deep foundations.

The company has essentially modified its tools to drill though the monopolies and down into the bedrock to achieve a suitable foundation.

“Like horizontal tunnelling machines, this technology uses a full-face drilling system but directed vertically downwards," said Dr. Marc Peters Head of Business Division Energy, “We have developed two basic machines – one for smaller and one for larger diameter piles.

“The process commences with the casing or foundation pile being held firmly by a pile gripping unit on the platform structure or crane and calibrated in its vertical position.

"The OFD machine is then lowered *inside* the foundation pile or casing and fixed with the help of a locking system which keeps the drilling machine in position. All supply lines as well as data cables and discharge line are permanently connected between the machine and the surface."

Shortly after the drilling wheel starts to rotate, excavating a hole of the same diameter as the *inside* of the pile, overcutters are extended underneath the foundation pile. These under-ream the casing to give the hole a diameter even greater than the *outside* of the monopile.

As the cutting wheel rotates, the excavated soils are transported up to the surface to prevent it being re-ground. Depending on the installation method, the monopile is gradually lowered – either mechanically or by the force of gravity, – simultaneously with the advance of the cutting wheel.

The lowering speed is controlled by the drilling operator, with hydraulic cylinders being used to measure the downforce on the cutting wheel.

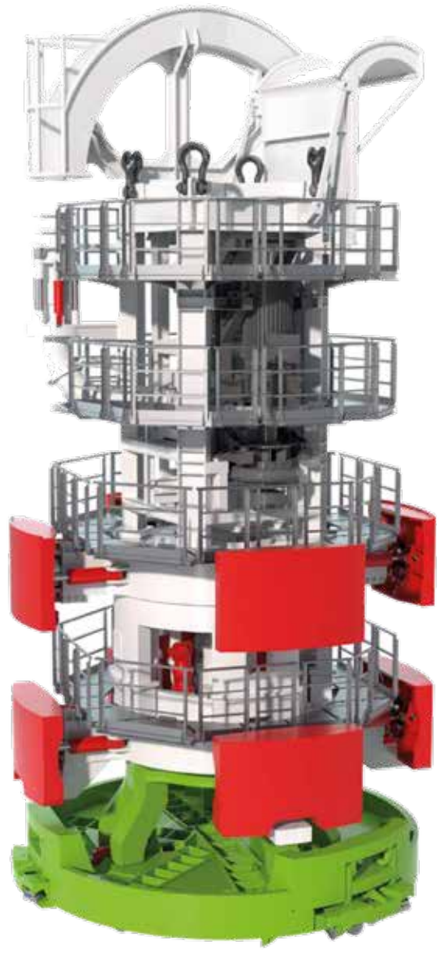
When the final depth is reached, the overcutters are folded back in and the locking system is disengaged. The machine is is then smoothly lifted out of the foundation pile or casing and placed into the seafastening system on the platform structure.

In a final step, the overcut has to be grouted with offshore grout material and connected with the surrounding geology.

“We first developed the OFD machine to drill pin pile foundations for jackets and tripods. The larger diameter OFD machine for the installation of the entire monopile incorporates many of the lessons learned from that project.

The only main stipulation is that the foundation pile must have a constant diameter through which the OFD machine can be recovered although the system can accommodate a pile that is slightly conical.

This customised drilling technology tailored to foundation diameter and specific project conditions.



The larger 7.05m dia OFD system produces a 7.7m dia hole. The drilling head turns at up to 5.9 rpm and the 1600kW drive produces a nominal torque of 5,362 *kNm. The 15m machine weighs* 350

Top Right: A typical application

CPT 101

Knowing the soil strength can ensure that the substrata is competent enough to support heavy seabed infrastructure such as pipelines, cables or structures that may be imposed on it. Perhaps the most common method of determining soil strength is the Cone Penetrometer Test (CPT).

The technique is based on pushing an instrumented cone vertically into the ground at a continuous velocity and force.

CPT Probe

The varying degrees of resistance offered by the soil is measured by the sensors in the tip.

Behind this resistance cone is a 100mm long outer friction sleeve. These sensors provide information on the shear strength, density and deformability of the soil.

Most cones also incorporate a pore water transducer which measures the water pressure in the soil. It can be used to record the ground water response as the cone is pushed into the soil. Gamma ray sensors may be added to some cones to reveal sediment density.

Directly measuring cone resistance, sleeve friction and pore pressure also allows other derived parameters such as friction ratio, excess pore pressure and effective cone resistance.
From these readings, geotechnical engineers can infer soil classification, internal friction angle, relative density, undrained shear strength and behaviour type.

But how is the CPT probe physically delivered into the seabed? One such is to use a rig.

DRILLING RIG

Many companies employ heave compensated geotechnical drill ships for site investigation including coring operations at given depths. In addition to sampling, attaching the CPT probe on the end of the drillstring and gradually lowering it into the bottom of the already-drilled hole can take deep formation measurements.

SEABED RIG

An alternative to drilling in *very* deep waters is to use a self-contained seabed drilling unit. This is lowered down from a support vessel to carry out geotechnical operations remotely. This includes push-sampling.

ROVCONE

For relatively small operations such as route surveys, subsea developments, drill cuttings pile surveys, decommissioning surveys and for locations which may present access problems, one option is to deploy lightweight CPT systems held in the manipulator arms of a free-flying work class ROV, or trenching machines etc.

This can still deliver 1000kg push force at penetrations limited to say 10m. One such, Bluefield Geoservices' ROVCone, incorporates a wire-free (acoustic) real-time communications between the

Bluefield Geoservices' ROVCone

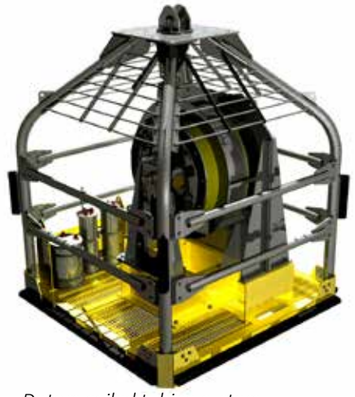
penetrometer and the ROV which eliminates cabling, reduces snag hazards, and speeds up installation and removal to/ from the ROV.

The most common method for delivering the probe, however, is a compact Subsea CPT device deployed onto the seabed from a vessel via an A-frame or crane, either over the side or alternatively, through a moon pool.

COILED TUBING

One of the most versatile Seabed CPT systems is based on coiled tubing. The tubing is taken off a storage reel and fed between one or two wheel drives. This effectively straightens the tubing while allowing it to pushed vertically downwards into the soil. In many applications, these are extremely cost effective tools.

The principal advantages is that they are simple, particularly compact and very easy to deploy. The downside, however, is that any ability to push down into the soil is limited by the



Datem coiled tubing system

stiffness of the tube. Excessive resistance can cause the tube to buckle or deviate away from the vertical. Nevertheless, it can penetrate around 10m.

Applications requiring a more powerful or deeper penetration may require a stiffer rod-based systems. They can be used in water depth of up to 1500m and penetrate up to 80m below the surface.

RODS

A common system is based on connecting together, metre-long rods and introducing them into a port at the top of the top of the seabed system. As it unit is lowered by winch through the water to seabed, new rods are sequentially added to the end of the disappearing main rod.

The deeper the required penetration into seabed, the greater the number of rods have to be connected.

Alternatively, once made up, the rods are sometimes held in a support mast at the top of the body.

GEOMIL MANTA

In order to get a coherent reading, the probe must be pushed at a continuous speed and force to get a coherent reading. Geomil Equipment's Manta seabed cone penetration testing system feature a novel hydraulic continuous drive system (CDS).

"Its features a drive chain equipped with diameter 36 – 55 mm gripper pads which hold the rod tightly to prevent it from slipping,"said Ed Smit, Sales Manager at Geomil.

"It can be pushed down at a constant pressure-compensated speed up to a maximum 28 mm/s. When retracting the rod, there is also a 80 mm/s fast system. Because of the design, it is the only seabed CPT system which can also push casing"

The 2.5t seabed units be increased to 28t due to ballast plates attached between the body the skirt. This provides a mass necessary for the CPT to push against but can be adjusted when projects only a limited reaction force.

The Manta 200 can achieve penetration depths up to 80m while imparting a downward force of 200kN- optionally 250kN.

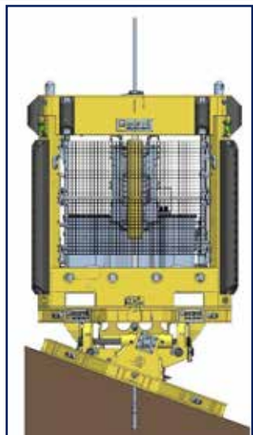
The base has a dimension of $4m^2$. If set on an undulating seabed but still push vertically downwards, it can be attached to a Levelling frame. The automatic levelling system handles slopes up-to 20 degrees.

Data is viewed in real time as with a conventional CPT. Data, communication and power are all handled by the umbilical.

Top: The Manta Seabed CPT,

Mid: Chain gripper system

Right: Levelling frame



When it lands on the seabed, single or more normally, contra-rotating wheels driven under a self-tensioning mechanism, push these rods into the seabed by means of friction.

The downside with this system is that downhole resistance can overcome the friction of the wheels pushing the rod downwards with the result that the wheels slip and the cone stalls or moves in a stick-slip manner.

CONTINUOUS DRIVE SYSTEM

See Box (Overpage).

ST RODS

Having to continually add metre-long rods to the push-system can be cumbersome. Water currents impacting against the line may affect the smooth journey of the cone.

One solution is to use ST rods "This describes a series of smaller articulated rods connected together," said Fearn.

In early March, Bluefield completed the inaugural job with its new newly-delivered 100kN ROSON-ST Seabed CPT System. This test verified the ability of the seabed to support a subsea template in the Norwegian sector of the North Sea.

"Think of a necklace of bicycle chain in which all the links are 40cm or so. These are articulated enough to be able to be wrapped around a drum.

"These hinged links, however, have another property. They have a secondary bayonet design that when twisted, the individual components can be interlocked to produce a stiff body.

After doing so, the SingleTwist-Rods (hence the ST-) have a form a solid CPT string with a push/pull/buckle performance equal to a string of standard CPT rods. There are structurally strong enough to push the cone from shallow depths up to 50m."

"It can be used for projects from shallow to ultra-deep water and comes as a fully integrated unit to enable operations in even the harshest of offshore conditions," said Fearn. The ROSON-ST does not require any external CPT string support, assuring optimal safety, fast deployment and high productivity.

It is suitable for 50 m penetration at water depths up to 4,000 m. The ST-Rods are mounted on the ROSON-ST seabed system in one of two states, twisted or untwisted.

SEISMIC

In recent years, analysis of monopile foundations has uncovered potential stability issues. This is due to the constant impact on the structure form the currents and waves below the sea level, and from the wind itself. Coupled with this, is the cyclic movement generated from the turbine itself as the blades turn.

It was discovered that the monopile foundations can be subject to liquefaction, where the sand grains and the ground water surrounding them, essentially separates. This consequently no longer provides vertical support to the pile body. Seismic systems can be used to measure this bearing capacity.

A seismic add-on module is installed behind the CPT cone. This consists of an array of receivers, normally accelerometers or geophones, typically in a uni-axial or tri-axial array.

Meanwhile, a waveform generator, typically a simple hammer striking a plate but alternatively, a hydraulic piston is installed near the seabed CPT. This creates a seismic wave for downhole detection.

The waves that propagate through the soil produce a profile that can be compared with computer models and then you can better make an estimation of the bearing capacity of the soil.

GULF OF MEXICO , GARDEN BANKS 142

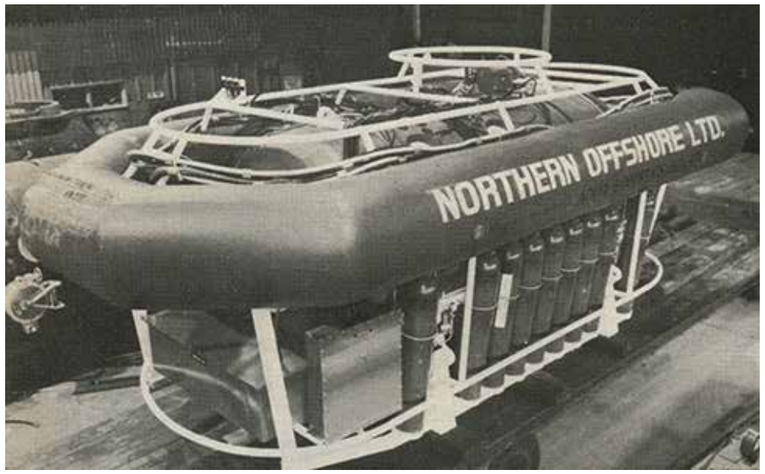
ATP had two fields nearing the end of their life on Vermillion 389 and 410. The platforms were only 7 years into their 20 year life when the reservoirs started depleting quicker than expected.

They also had two new fields on Garden Banks 142 and Ship Shoal 358. A happy coincidence... except the older platforms lay in 365ft waters while the new finds were in 419 and 542 ft water depths.

Instead of scrapping the old and building new jackets, ATP installed a tripod plinth on Garden Banks and a 4-pile plinth on Ship Shoal. These made up the height difference to allow the platforms to be re-used.

RESCUE CHAMBER 1978

Northern Offshore's 12-man hyperbaric rescue chamber used to support Elf Aquitaine's Frigg field. It was designed by Aqua Logistics international.



SHELL'S AUGUR TLP

Installed in a record breaking water depth of 872m.

NORTH ALWYN 1985

The 18 500t North Alwyn A jacket was installed after three day to from RGC Methil. Because of the 25kt winds and 3m waves, it took 8hrs from launch to touchdown.

The design of the jacket was carried out by a joint venture of CJB Earl and Wright, and French contractor Sofresid. Following CJB Earl and Wright being split up, the work was taken over by John Brown offshore

Anotable feature of the jacket was the buoyancy tubes. The buoyancy required on the jacket during upending and launching was normally provided by buoyancy tubes fitted inside the temporary pile guides along each leg. This resulted in a large number of small diameter pipes which had to be removed before the piles could be driven.

For this, John Brown opted for a smaller number of large diameter tubes which doubled as pile guides and only removed along with the ordinary pile guides once piling was completed. There were 14 tubes 3m diameter and approximately 80m long

CLIPPER 1989

The Jack ups Rowan Gorilla IV and Santa Fe Monarch working simultaneously over Shell Esso's Clipper wellhead platform

BLUE WATER 3. BRAZIL 1976

Sister rig of the Blue Water 1, the industry's first semisubmersible drilling rig dating back to near 1962.

OCEAN ODYSSEY

In 1988, the Ocean Odyssey following a well control incident. Fire ripped to the semisubmersible leaving it badly damaged. After the flames were extinguished, the rig was towed to Dundee. Inside the derrick, the workers discovered bent drillpipe in the set back area which collapsed In the intense heat

PETROJARL 1, GLITNE 2000

The Petrojarl was owned by Petroleum Geo-Services (PGS) under its Golar Nor subsidiary. Golar Nor also owned the Petrojarl Foinaven. Both were passed to Teekay (A company set up in 1973 by Torben Karlshoej, whose initials it its name) when the company acquired Golar Nor.

PGS won the contract to produce Statoil's $100 million Glitne field in 2000

BEATRICE B

Cleveland Offshore's finest!

Britoil's Beatrice Integrated deck positioned onto the jacket with a world record 3412t lift. This beat the record set two years earlier in 1981 when the Shell Fulmar SALM buoy was lifted by 142t. The jacket was built by RGC Offshore in Methil.
The 1470t accommodation module, built by Gotaverken Arendal was was then lifted in place

VEGA 1986

The articulated mooring column at Italy's Vega field.
It had a steel gravitational base consisting of four 9m diameter vertical cylindrical tanks. This supported a 9m diameter 125m long vertical column weighing 1800t. This was divided into 5 watertight compartments.

RAVENSPURN

Operated by Hamilton brothers, Ravenspurn North was fabricated in 1989. Before this, there had been eight British and 10 Norwegian concrete structures but none stood in waters less than 100m deep. The smallest of them consumed 125,000 tonnes of concrete, the largest three times that amount.

By comparison Ravenspurn used 23,500 tonnes. Uniquely it was built entirely in the dry.

The structure was built 15 months for £15 million, estimated to be 25%

SEAWATCH 1985

Today, Relatively inexpensive data boys brimming with microelectronics float in the worlds ocean to gather various types of oceanographic and meteorological data such as wind speed, direction, pressure, humidity, temperature, wave height and period. In 1985 however this same information was gathered by a new floating device called the Seawatch.

At the time, there were small data boys on the market , but these suffered from a number of drawbacks including environmental damage loss and particularly theft. At the other end of the scale, there were much larger and expensive data boys weighing up to 100 tonnes.

Thorn EMI electronics' Seawatch was especially suited for gathering data in areas such as West of Shetland. The buoy's hull was fabricated of steel reinforced GRP ballasted with concrete. The 3m diameter buoy was suitable for applications from shallow waters to use in depths of 4500m. While the larger buoys had to be towed, the SeaWatch could be carried on the deck of a vessel.

Yours for £60 000

SNORRE 1991

The 16 tethers that hold own the Snorre TLP, terminate on the seabed in four concrete gravity templates. Each template consists of 3 cells. These were installed in 1991. The yellow cones protect the tether latch compartments.

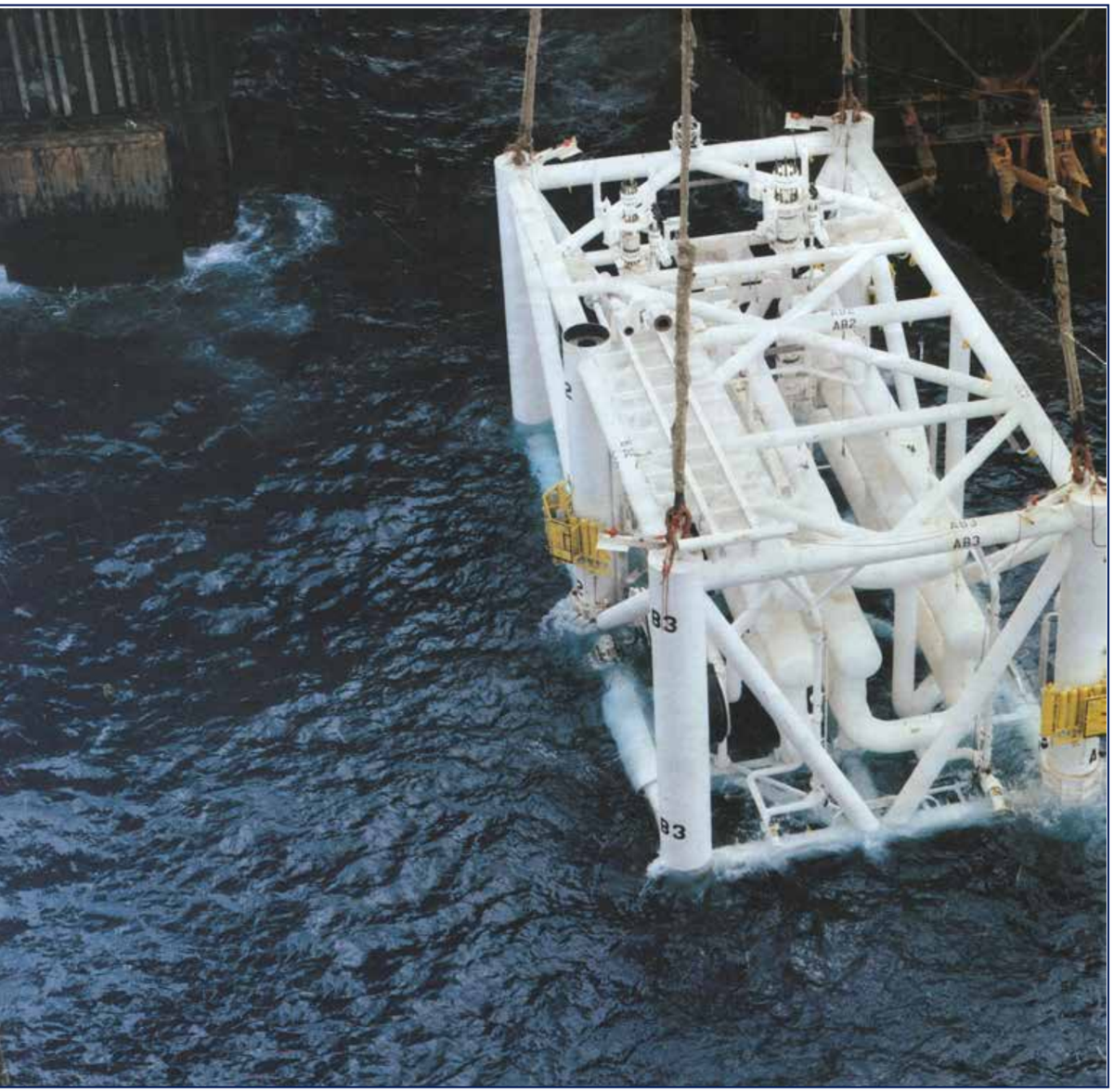
STATFJORD B

At the time, the world's heaviest tow.
The displacement was 825 000t and the deck weight was 40 000t

UMC

The Underwater manifold complex (UMC) being held by a tug before being submerged.

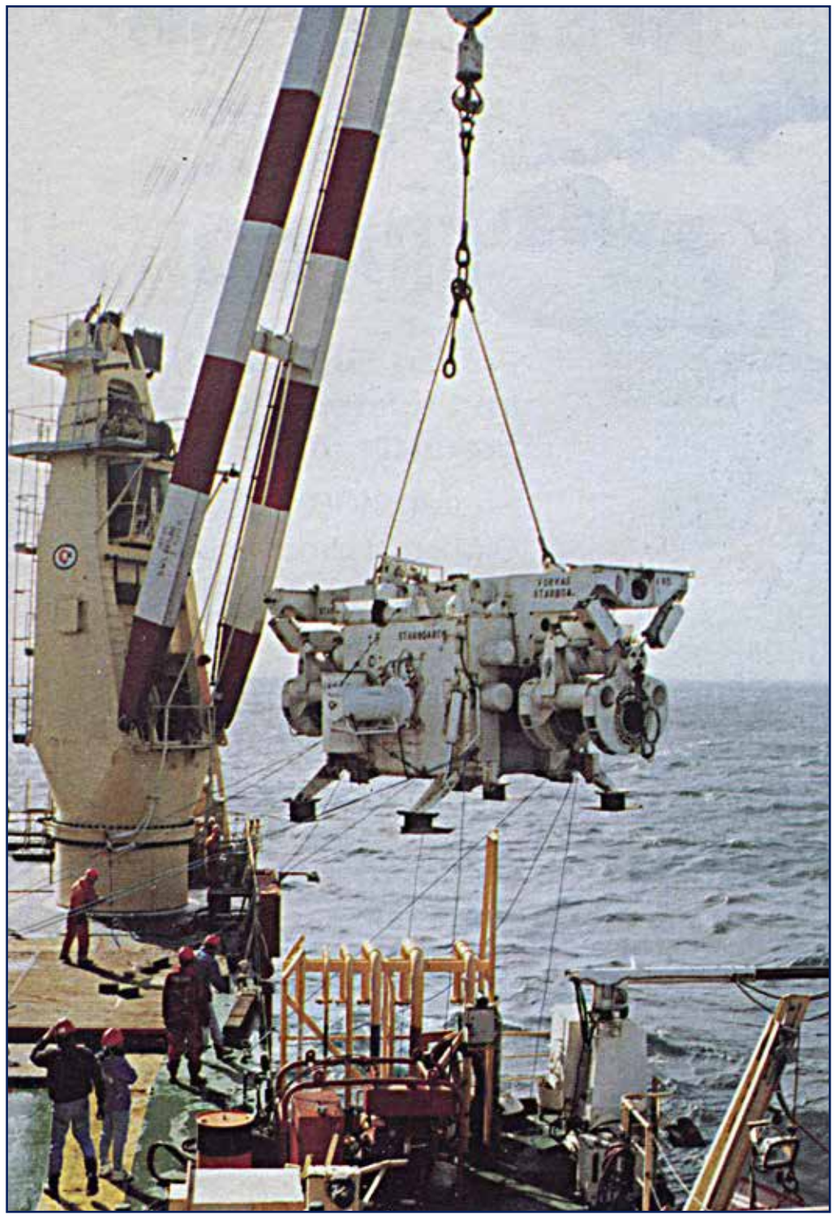
Shell deployed the UMC on the Central Cormorant field as a testbed for technologies and future deepwater developments. These included flexible pipe and multiplexed electro-hydraulic controls.



TEXACO TARTAN

The subsea slugcatcher being placed next to Texaco's Tartan platform. This stopped the multiphase gas and liquid wellstream from causing damage.

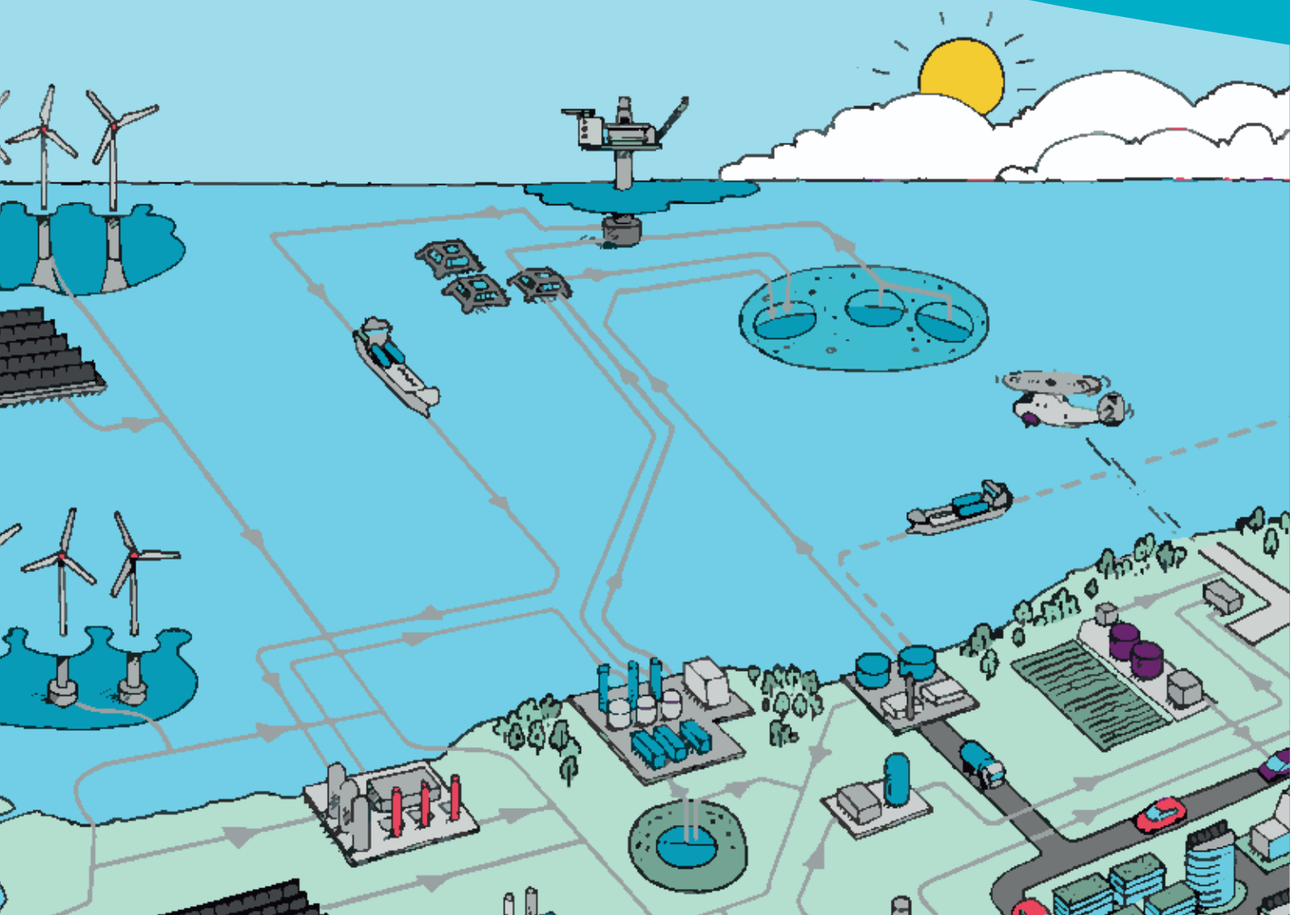
The 640t structure was placed 8m from Tartan by the sscv Hermod
The crane vessel then moved to the Highlander satellite field to install the Wellhead Protector template.



THOR 2 1991

In 1991, the world's first fully diverless hyperbaric welding system completed trials off Scotland. The Thor 2 (TIG Hyperbaric Orbital Robot) could operate in water depth down to 450m which meant it could work anywhere in the North Sea.

it was designed and tested by Comex in Marseille and was a advanced version of the company's THOR 1 welding system which was itself used on Total's Alwyn North export line in 1986 performing the first offshore connection using automatic welding.



SEADOG

The tracks allow it to move along the sea bed
It was launched in 1982, built by Slingsby Engineering for British Telecom. The 22t vehicle was capable of operating in 274m. The buoyancy came from 4 ballast tanks filled with air/water. It could excavate a 30-90cm trench in 3kt currents

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