FAST DIGITAL IMAGING

As industry prepares to manage its Covid 19 response, many businesses have been forced to review the way that they operate. This is particularly true within the underwater survey sector.

In the recent past, some offshore operators have begun to embark on major initiatives for increasing automation. Automated systems are highly accurate and reliable while the lower carbon footprint and the reduced exposure of humans to potentially dangerous environments are very appealing. Indeed, the sudden desire to decrease offshore manning has become particularly topical with many looking for alternatives after finding it difficult to travel.

One of the most human-intensive underwater operations is subsea inspection. This, however, is vital in order to ensure that the condition of structures, particularly pipelines, retain the necessary integrity. Over the decades, routine monitoring has shifted from being carried out by divers to using underwater vehicles, particularly ROVs. Unfortunately, the requirement for surface vessel support can make the operation very expensive.

Already, many are turning from remote to autonomous vessels and vehicles. Not requiring the same degree of surface support, these can traverse along the pipeline at greater speeds as they record images. The downside of autonomous vehicle inspection is the imagery cannot be easily examined in real time. Interpretation has to wait until the data is retrieved at the end of the inspection run.

Tethered systems, conversely, are better at interrupting planned inspections to investigate unexpected anomalies, able to deviate from plans and zoom into an area of interest before proceeding. They can carry out additional spot dives.

Most underwater systems use video. High definition (HD) and ultra-high definition (UHD) systems are readily available on the market. Pipeline-tracking software can automatically guide the vehicle to ensure that the downward pointing camera is always focussed at the target.

In order for continuous video to work, the image needs to be sufficiently illuminated. If the intensity is not strong enough, the video imagery becomes less effective.

Just over 10 years ago, Cathx Ocean entered the subsea inspection market. Along its journey, the company has developed a number of innovative tools designed for operations on autonomous vehicles.

“Capturing a moving image at anything over 0.5 kt can often introduce motion blur into the video footage,” said Frank Lennon, Product Manager at Cathx Ocean.

These speed limitations can mean extended vessel deployment– it is not uncommon for a standard video survey to take over a month to complete at a substantial cost.

“Looking to improve efficiency, we decided to approach the problem from an alternative direction based on stills cameras being able to produce higher definition images than video cameras.

“The Cathx Ocean Imaging System captures images at a frame rate of three images a second as the vehicle traverses over the pipeline.

"The actual frame rate is decided pre-mission to ensure 50%–70% overlap. This is important when the images are used with photogrammetry and mosaic software tools that rely on feature-matching from one image to the next.

"The level of detail captured in an image from a Cathx imaging system is ideal for machine vision algorithms.”

This approach affords a significant advantage.

Autonomous vehicles have a finite energy payload. Once the cells are exhausted, the vehicle needs to return to a base for recharging. An important property for equipment used on vehicles, therefore, is low power consumption. Unfortunately, this is largely incompatible with the need to continually shine high-intensity lights downwards, possibly for many hours, to illuminate the inspection target.

A key difference between stills and moving imagery is that videos are illuminated by constant light while photos use a high-intensity flash. A considerably lower electric charge is trickle-fed into the capacitor banks and discharged on demand to create the rapid light.

“We use a strobe lighting system called the Pulsar I, which provides a large increase in the lumen output in comparison to standard ROV lighting,” said Lennon. “It is characterised by far shorter light pulses but with higher power intensity to ensure the field of view is always fully saturated with light.

3D IMAGING

In recent years, laser imaging has emerged as a very useful tool for subsea inspection.

Transmitting a laser line towards the target forms a three dimensional point cloud which can be fed into graphics software to produce an imaging model that can be viewed in three dimensions.

“Sending out laser beams into an area bleached with light is not always successful because of the lack of contrast available," said Lennon.

"Conversely, emitting a light pulse into the blackness of the sea makes any target and reflection stand out. All the actions are synchronised by the camera’s processing and operating system

“We have enjoyed significant success in the oil and gas industry when surveying pipelines. Trunk lines that are hundreds of kilometres long, need to be surveyed every year or so. This used to take survey companies 30 to 40 days and now we can do it in under ten.

“We use Cathx's SOLID post processing system to optimise image collection, using functions such as flat field correction, orthorectification, optical distortion correction and sharpening."

This high-definition low power technology has made this the imaging system of choice on Autonomous Vehicles like Kongsberg’s HUGIN, Teledyne Gavia’s SeaRaptor and International Submarine Engineering’s (ISE) Explorer vehicles.

This allows the Cathx camera to operate at low exposure thus reducing motion blur and this in turn means the vehicles can travel faster and cover more distance.”

The camera that Cathx Ocean has developed is no ordinary device but a smart system which controls all the peripheral Cathx equipment, while also incorporating information from other sensors on the vehicle such as a depth sensor.

This means that the operator always knows the camera position relative to the seabed, a property useful ensuring that the images are always in focus and that sufficient light is distributed to the target.

During a typical camera survey, the light is turned on to capture the image. The darkness between the strobe pulses, however, gives the imaging system another significant advantage – it allows 3-D laser data to be captured.

The simultaneous capture of two datasets would not be possible during traditional video surveys

“Mechanically, it would be quite possible to capture more, but recording too much data can take up space.

"We normally capture in 4K UHD mode but this can be drop down to conventional HD mode if data storage space becomes an issue" concluded Lennon.

3D COLOUR POINT CLOUD

With the unique data collection process employed by Cathx Ocean another data deliverable available to clients is 3D colour point cloud.

Colour laser point cloud is the result of taking the original 3D laser data and combining it with the 2D images of the same scene. The image pixels that have known corresponding 3D points into world space are positioned into a point cloud.

This dataset provides all the visual benefits with a photogrammetry model but can be processed in a fraction of the time.

Additionally, it is highly accurate as it uses laser data to build the model and as it does not have to rely on feature matching and image blending to create the finished model which can affect the accuracy.

3D Point cloud

STEREOPHOTOGRAMMETRY

COMBINING COMMERCIAL APPLICATION WITH ACADEMIC RIGOUR

Martin Sayer, Managing Director, Tritonia Scientific Limited

Stereophotogrammetry, sometimes referred to as Structure from Motion (SfM), is a computer-based technique that can generate highly complex three-dimensional point-cloud models using image-based material obtained relatively simply and quickly. It is a rapidly evolving tool that is highly adaptable and can be based on most videographic or photographic data where there is significant and relatively consistent overlap between frames or images.

A broadscale reconstruction of Helensburgh pier, combined from aerial and sub-tidal surveys, made to map the underwater structure of the pier and the areas of damages caused by collisions and fire.

SfM software identifies thousands of discrete points within an image. The three-dimensional movement of the points in relation to each other is tracked between successive images with the two assumptions that the camera is moving and that the structure is static. As the points become located within an xyz framework, three-dimensional structure is generated, firstly as a point-cloud, secondly as a mesh where the points become joined, and then as a textured mesh where fragments of the images are attached back onto the mesh to complete the models.

The advantages coming from underwater SfM modelling are many, one is the reduction in survey time because of a decreased need to undertake measurements *in situ*. By transferring any quantitative assessment from the underwater structures to a computer model, accuracy is improved and can be checked easily through replicated measurements.

The models also provide a permanent record of the targets permitting comparisons to be made over time. Although surveys that are purpose-designed produce better results, some models can be generated from 'video of opportunity' where the primary purpose of the survey was unrelated to SfM. In some instances, models can still be produced from videos taken many years ago and support a 'Back to the Future' approach to some forms of monitoring.

A 3D model of coral coverage on an oil platform leg at 40+ metres depth in the Gulf of Thailand. The model was generated from ROV video of opportunity.

Tritonia Scientific, a company based near Oban on the west coast of Scotland, owns and manages a unit that specialises in underwater stereophotogrammetry. It started using SfM in 2013 to support a range of underwater academic projects while operating as the Natural Environment Research Council's National Facility for Scientific Diving.

A diver setting up a temporary quadrat with scaling bars prior to collecting the photographs required to generate a 10 x 10 m 3D model of impacted coral in the Indian Ocean.

The initial challenge was to take SfM software, that had been developed for terrestrial applications, and make it work for imagery obtained underwater. There were numerous commercial and open-source SfM software packages available and they varied in aspects of user-control, the numbers of images that could be modelled, the outputs available and time taken to process the models.

In addition to choosing the most optimum software there was also a requirement to invest significantly in advanced computer capability.

Dr Andrew Mogg is employed as a full-time photogrammetry postdoctoral researcher at Tritonia and has seen the technique evolve markedly over the last few years.

"Initially the accuracy and precision of the underwater models was very dependent on the type and quality of the image data.

More recently, the software has evolved to become more adaptable and, if the initial survey material has proper scaling and orientation information, we are satisfied with the quality of the models being delivered."

Tritonia Scientific has applied SfM modelling in support of a range of academic research projects. It is a technique that is widely employed in coral reef research and Tritonia has used it as a way of more accurately assessing the levels of carbonate production of reefs, in studies of reef complexity, combining it with fluorescence photography to estimate the settlement of juvenile corals, and as a method to base assessments of the efficacy of small-scale marine protected areas. In temperate waters stereophotogrammetry has been used to quantify the rugosity and percentage coverage of mussel beds, and to determine and identify the optimum habitat types for endangered shark nursery sites.

The company has even used overlapping scanning electron micrographs to estimate the surface area of microplastic fibres that had been ingested by deep-ocean animals.

"The variety and flexibility of how the technique can be applied has few limits" says Andrew. "There are, however, always choices to be made based on the size and complexity of the target to be modelled, the methods to be used to capture the imagery, the desired resolution of the outputs, and the eventual file sizes of the finished models.
The range in size of the models we have produced is significant. We have delivered broad-scale models using aerial drone footage from 5 x 5 km surveys of glaciers in the Arctic, down to some at the micron level for subjects photographed using microscopy.

When diving, the size of model can be influenced by dive times and water visibility, but optimally configured camera and lighting equipment, combined with the ability to join multiple sub-models together seamlessly, can produce detailed models under challenging conditions. In the final result, the water 'disappears' to reveal structures that could never normally be seen in their entirety."

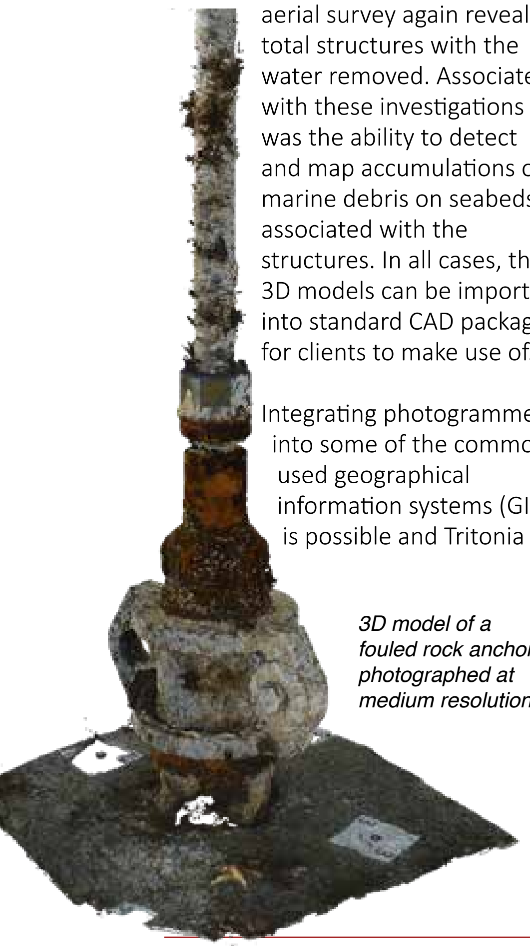
In 2018, the unit became privatised as Tritonia Scientific Limited and the team expanded to undertake projects with more commercial focus while retaining an academically based approach. Initial work included using modelling to quantify the types and volumes of biofouling on oil and gas platforms designated for decommissioning in tropical regions such as Thailand and Angola.

The growth of soft and hard coral on marine structures can be substantial in warm waters and add significantly to the weight of jackets intended for removal. Once the models are created, it is a relatively straightforward operation to ‘remove’ the jacket structure digitally and reveal the total volumes attributable to biofouling.

Tritonia has also used stereophotogrammetry to complement diving-based principal inspections of shallow inshore submerged structures such as piers, harbours, slipways and breakwaters. The objectives varied but the new SfM techniques supported identifying and quantifying physical defects and damage while, at the same time providing an overall view of the subtidal structures. Combining underwater models based on imagery obtained at high water with ones generated using low-water drone-based aerial survey again revealed total structures with the water removed. Associated with these investigations was the ability to detect and map accumulations of marine debris on seabeds associated with the structures. In all cases, the 3D models can be imported into standard CAD packages for clients to make use of.

Integrating photogrammetry into some of the commonly used geographical information systems (GIS) is possible and Tritonia has invested recently in new compact through-water GPS equipment that supports accurate georeferencing of the models.

insert (below left) showing close up detail



3D model of a fouled rock anchor photographed at medium resolution

Even though SfM produces high quality and highly accurate models, their sizes will often be limited by operational constraints and while their use may have to be contained to targets of interest, it remains important to ensure that their location and orientation are consistent. Kathryn Dawson, a postgraduate research assistant who works at Tritonia, and is responsible for assimilating SfM into GIS applications, explains:

“Underwater surveying is a perfect scenario for using SfM. In addition to the 3D models, the technology can also create orthomosaics. These correct for the perspective of the camera and the different distances that each point is from the camera, and are powerful mapping tools in instances where seabeds are not flat.

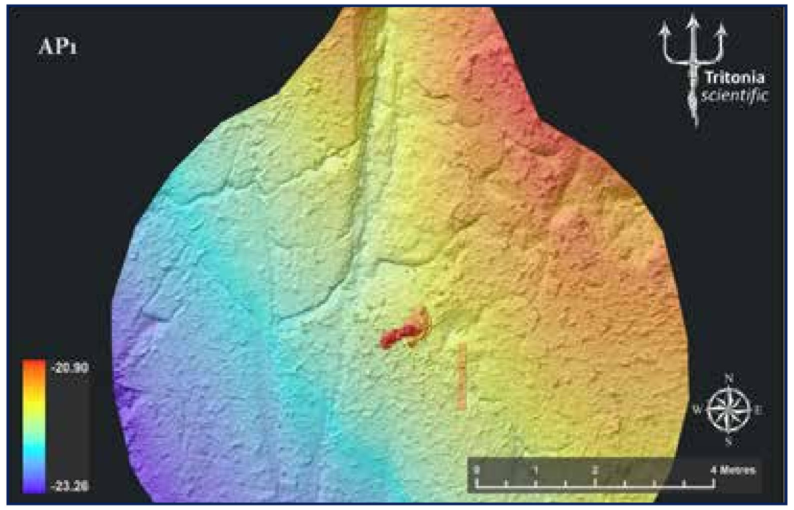
If accurate depth and levelling controls are included in the raw image data, then additional depth contouring can be added to the orthomosaics to generate digital elevation models. The GPS locator modules we are now using are so small, that they can simply be attached to the cameras to provide accurate locational data required for GIS integration.”

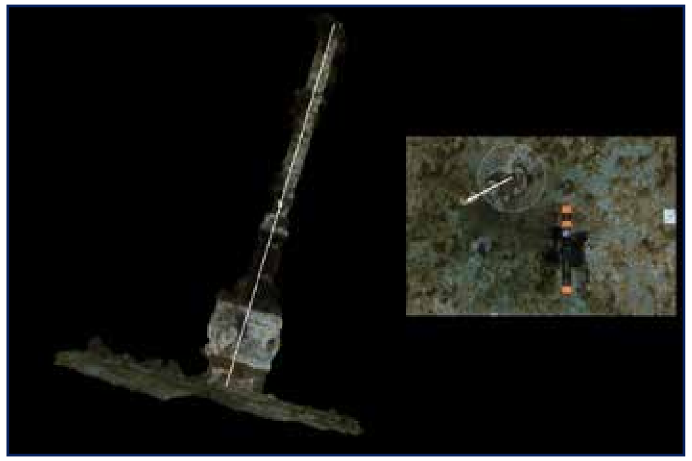
Combining georeferenced orthomosaics and digital elevation models with detailed 3D modelling is used by Tritonia when undertaking habitat mapping for environmental assessment. It has been particularly useful when conducting monitoring programmes for the aquaculture industry, when producing accurate habitat information for regulators and for surveying marine protected areas.

Tritonia has successfully employed remotely operated and autonomous underwater vehicles (ROVs and AUVs) for extending the areas that can be covered using SfM techniques for these broader-scale surveys.

The most recent application for this technology has been through a research partnership between Tritonia and Sustainable Marine Energy Limited. As part of their integrated tidal energy systems, Sustainable Marine Energy provide innovative anchoring and mooring systems that are used both for marine renewable energy projects and in aquaculture.

An example of a medium-scale digital elevation model of a rock anchor site





An example of the type of information that can be measured from a model. In this case the metrics taken were that the anchor was projecting 136cm from the seabed, at an inclination of 16° from the vertical and 249° from North

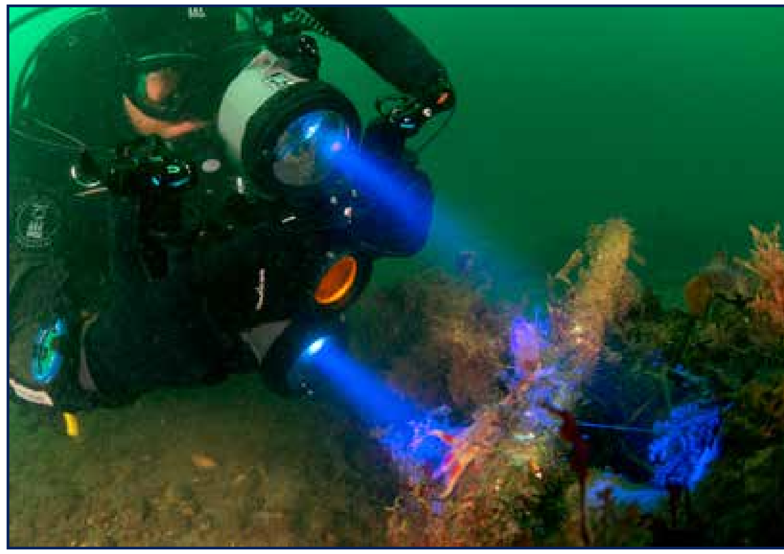
The two companies have been working together to evaluate stereophotogrammetry combined with orthomosaic-based mapping as methods for measuring and monitoring the condition of the direct embedment anchors. High-resolution 3D-models combined with point-cloud comparison methods can quickly and accurately quantify areas of deterioration or erosion in the anchors, in addition to measuring the exact depth of penetration. Level-controlled and digital elevation models have determined the direction and extent of the angle of the anchor’s penetration, and georeferenced orthomosaics were used to provide feedback on the anchor positioning.

Tritonia Scientific is basing its use of stereophotogrammtetry on proprietary ‘black box’ software and, in order to be certain of the accuracy and precision of its models, undertakes a range of testing and evaluation based on the transfer characteristics of the inputs and outputs.

There are some very basic limitations to the methodology caused by the movement of non-static animals and plants that are attached to or associated with the structures. These can ‘confuse’ the software but, in general, if the movement is relatively large and doesn’t obscure the basic imagery, then most moving objects will vanish from the resultant models.

However, where covering organisms, such as seaweeds, exist then they may have to be removed first, particularly if they obscure areas of specific interest. Some moveable structures such as mooring chains and swivels can be modelled if they are relatively static in mid-water or through the use of multi-camera systems to capture imagery from many directions simultaneously.

When the models are being used for measurement, then dependable accuracy will only be possible where the raw image data can be related to in-situ scaling and orientation controls. For depth elevation modelling, frequent independent recordings of depth are required, and Tritonia is involved in a project to deliver methods for estimating depth accurately based on continuous pressure measurements corrected in real-time for conductivity variations.



Evaluating the additional benefits of combining stereophoto-grammetry with fluorescence photography.

3D RENDERING

SAVANTE CONDUCTS PHOTOREALISTIC IMAGING

Over the past decade, advances in underwater imaging has meant that it is possible to make 3D renders of structures at very high definition and speeds. Existing heritage video footage taken by companies can also be converted to 3-D.

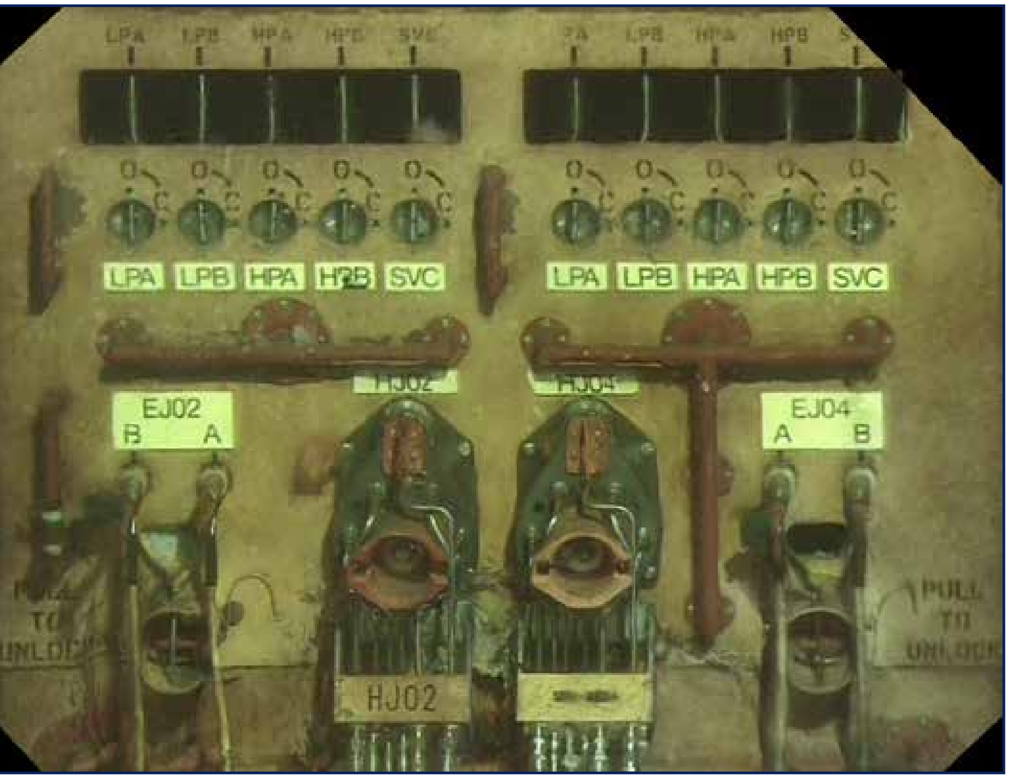
One such exponent of this technology, Savante, has not only worked up its own camera designs, but is also offering new and cost effective ways of deploying them.

“This year has seen a combined collapse of the oil price and the ravages of COVID” said Grant Thomson, principal at Savante."There has been a huge rationalisation in the market but an uptake in the demand for globally delivered imaging services."

In the past year, Savante has invested a lot of money in new technologies, to increase processing speed. Projects that once took days can now be delivered in 20 to 30 mins.

“Our biggest market is carrying out inspection by making photorealistic high-resolution digital 3-D models of objects," said Thomson. "We originally offered services under a framework agreement but more recently, we have concentrated on bespoke projects.

“We used to install tools on third-party ROVs but projects were sometimes delayed due to waiting on the vehicle. We have now purchased our own mini-ROV which is small enough to fit into a helicopter.



3D rendered model of UTA and SDU

"This was bought off-the-shelf but now the only original parts are the flotation framework and thrusters. The latest iteration has eight lateral thrusters."

PHOTOGRAMMETRY

“We have made considerable improvements in our subsea photogrammetry technology" said Thomson.

"Photogrammetry involves capturing images and feeding them into an engine to create a 3-D CAD model.
There are two basic types

MONOCULAR

This is based on a single camera system.

“Our Vector cameras are used for a wide range of applications from fish imaging to high-speed pipeline survey,” said Thomson. "The cameras are capable of 400 frames/second without image blur.

Conversely it is possible to run the cameras at lower speeds of maybe 5 to 10 frames/second and produce 85 – 120 megapixel images. Today, many subsea vehicles such as ROVs, towfish or drop frames, have at least one camera that we can exploit.”

Importantly, over the past 30 years or so, a tremendous amount of video data already has been accumulated by offshore operators. This was based on SVHS formats with a resolution of 320 by 240 pixels, but even these can be used in some cases.

Applications include the measurement of geometry changes, possibly identify movement and generally indicate potential future problems.

“The 3-D model produced from a single video camera can not be really considered a digital twin as the user still needs ***a priori*** knowledge about the object. The technique can determine shape from the image, but not scale," said Thomson.

"It may be possible, however, to calculate this. If the user, for example, knows the pipeline's actual diameter or radius of curvature, it is possible to calculate the scale on the image. With that knowledge, it can be used to measure other parameters such as wall thickness loss or impact dents.

Nevertheless, monocular photogrammetry can be used for a large number of applications such as identifying the presence explosive ordnance for the military or recognising anchor strikes on pipelines. It is possible to strip back coatings on pipes, look at concrete wall loss or image offshore boulders on the seabed.

It can also be coupled with acoustic technology to show such events as marine growth on the concrete mattress or image seabed scour.

Monocular requires a high quality strobe. Instead of incorporating off-the-shelf strobes with a refresh rate of every 4.5 seconds, Savante’s house-designed strobe can achieve rates of nearer 80 per second, nearer 360 times faster than the original technology.

STEREO VISION

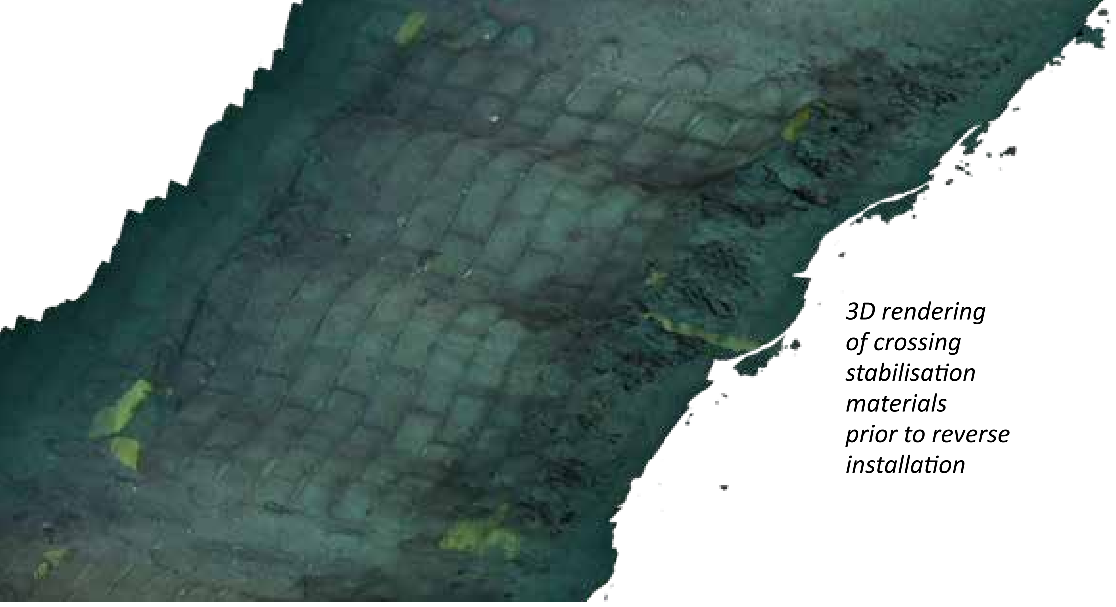
Binocular vision has been an extraordinarily successful evolutionary strategy throughout the animal kingdom. From a pair of images, it is possible for the brain to calculate relative depth. This is also true of stereo photogrammetry.

“The key advantage of this is that the 3D data from a stereo imaging system is already calibrated and as such does not require a scale bar," said Thomson. “We combine our cameras with a very fast processor which can marry the two images up. By correlating thousands of points, it is possible to create a 3-D model.

Stereo systems have a 20% enhancement when compared with

3D rendered model of Conductor and Guide Clamp: General Overview

3D model of Conductor and Guide Clamp: Close-up showing guide profile



3D rendering of crossing stabilisation materials prior to reverse installation

3D rendering of platform members and conductors

monocular photogrammetry systems video technology."

Savante has named its stereo camera 'Vergence'. It incorporates a pair of 20Mp cameras in a 133 mm diameter housing. This design affords an immediate advantage in that the optics and electronics can be kept at the same temperature and pressure. The video camera can capture images at 30 frames per second with the data being fed into a 60 TB onboard storage module. The camera pair is supported by a 1 microsec, 120k Lumen strobe and a 3D laser profiler.

Instead of using a single Vergence camera, it is instead possible to combine a pair of monocular Vector cameras for the same effect.

LASER SCANNING

While Subsea photogrammetry is flexible and versatile, subsea laser scanning provides an alternative, higher performance technology. It provides repeatable, high precision measurements to even develop a photorealistic digital twin.

"We developed our own high definition video camera, the equivalent of what is often referred to as fast digital imaging," said Thomson. "We also optimised all the lenses that goes in front of it.

"This can be used to scan images at around 60 times a second to produce highly accurate images in only seconds. It can generate a 3D walk-though with the image able to be rotated in the CAD model to allow the user a view of points of interest."

3D Rendering of FPSO Mooring Cheekplate

LEAK DETECTION

OceanTools' new DyeTector technology is based on the principle that if light of a certain wavelength is directed onto a specific dye, it causes that to dye fluoresce and emit light at a different wavelength. When introducing this dye into a material such as hydraulic fluid in a subsea control system, therefore, it is possible for the DyeTector to immediately recognise any leakage.

The DyeTector product range includes the D7 ROV-mounted single-dye detector, the D9 diver-held detector and the D10 ROV-mounted dual-dye detector. The output is fed into surface software (or into the display built into the diver-held unit) to warn of the presence of dye, clearly and unambiguously, even sounding an audio alarm if a threshold is reached.

"One traditional problem of trying to detect a leak, is the presence of strong ambient illumination. This is because the reflected light emitted by the dye can be at a very low intensity, it is often easily washed out by the ROV's far more powerful lighting," said Kevin Parker, Managing Director of OceanTools.

"The DyeTector, however, incorporates very innovative processing techniques to avoid this problem. This means the ROV's lights can be left on while the DyeTector is in use."

CEMENT

As well as detecting leaks from subsea infrastructure, dyes may added to the cement used in casing cementing operations when drilling. When the cement returns to the surface, the DyeTector can notify the cementing company and allow them to cease pumping cement. "This could mean very significant cost savings as, typically, operators need to pump 200-300% of the calculated cement to take account of losses into cracks and fissures," said Parker.

The DyeTector

The DyeTectors are produced in Aberdeen with the titanium housings being machined in OceanTools' in-house CNC machine shop. The units are offered with a 6000m depth rating as standard with shallower 1000m units being offered as an option.

There are three main dye types in use for subsea leak detection. These are rhodamine, fluorescein and ultraviolet. Fluorescein is progressively being phased out due to it's environmentally unfriendliness. OceanTools DyeTectors are able to detect all three dyes.

OIL DETECTION IN WATER

For many years, Long Wave InfraRed (LWIR) cameras have been established a useful tool for the detection of oil spills, however, they do have specific shortcomings.

This prompted, Polaris Sensor Technologies to develop Pyxis, a novel camera system able to generate more reliable imagery. It has proven itself to be a vital tool for oil spill detection.

Pyxis is mall enough (3.5in x 2in x 2i) and light enough (less than 0.5lb) to be mounted on an unmanned vehicle yet robust enough to withstand constant salt spray on an open water oil rig.

The Pyxis camera works by capturing both LWIR data and polarization data, superimposing them into a single image, thus providing the best possible detection capability regardless of which method is providing a stronger signal.

“Sometimes, LWIR radiation provides a stronger signal than polarization when detecting an oil spill," said Pyxis sales manager John Rauseo, "while at other times such as in the hours of darkness, when the oil has reached thermal equilibrium with the water, when waves confuse the scene, or when oil becomes emulsified, then polarization gives a stronger signal.

Pyxis camera

The camera was the subject of testing at the Ohmsett National Oil Spill Response and Renewable Energy Test Facility located in Leonardo, New Jersey, USA.

NIGHT-TIME TESTING

Floating "boxes" (4 walls with no bottom) were placed in a pool. Oil was deposited in them. Their function was simply to help prevent the oil from leaking out into the surrounding pool water.

The visible camera immediately showed good contrast between the oil (black) and the clear water during the hours of daylight. At sundown, the entire image was black,

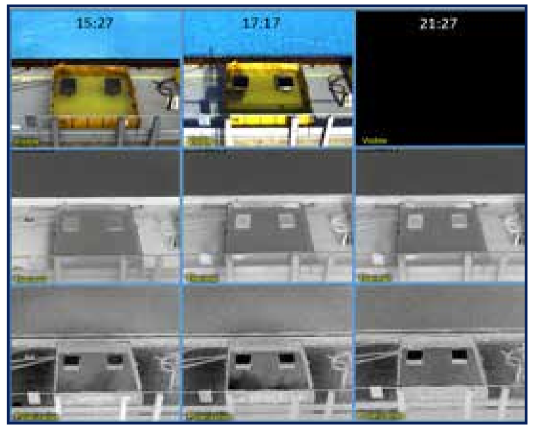
The thermal imagery also shows relatively weak contrast in all three pictures between the grey water and the lighter grey oil, although at least there was a recognisable image at nighttime, as opposed to the visible camera.

Polarization, however, gives a consistently strong contrast of black oil on grey water at all times of day.

VISIBLE THERMAL POLARIZATION

The laboratory conducted a continuous test to show nighttime performance between thermal imagery and polarization imagery

Polarization provided far better contrast over thermal IR imagery at almost all times although there was a small time window when the rising sun heated the oil faster than the water. This resulted in the thermal imagery having a stronger contrast but within an hour, the polarization imagery once again showed a stronger signal than the LWIR data.



Images at different times of day

WAVE ACTION

“In the presence of waves, if you didn't know to look for oil, then you wouldn't know that a contaminant was in the water in either the visible or the thermal imagery," said Rauso. "Only the polarization image provided a strong enough contrast to make it obvious that some kind of contamination exists.

Shortly after the wave pool was turned on, the oil quickly migrated out of the containment boxes and spread over a much larger surface area, with Polarization able to best show the spread.

EMULSIFIED OIL DETECTION TESTING

It is often relatively easy to detect solid oil slicks on the water surface, but it becomes more difficult if the oil becomes emulsified.

In an actual oil spill, floating oil ages and changes properties significantly due the action of UV radiation and the waves. As the oil emulsifies, the detection capability of various techniques can be severely degraded.

In particular, detection methods based solely on LWIR can suffer dramatically.

"Polarization detection also yields significant benefits under these conditions," said Rauso. " One of the tests conducted during the Ohmsett research involved trying to create emulsified oil."

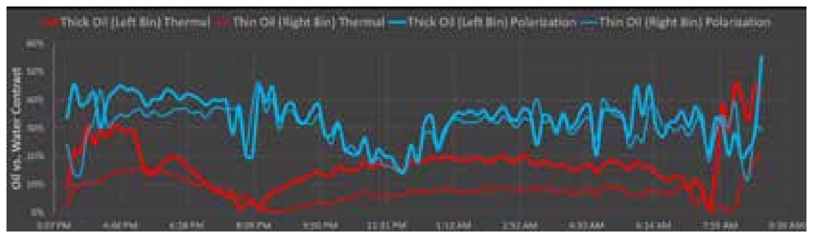
Oil was left on the surface of a calm pool and exposed to the sunlight for several days so any chemical changes caused by UV radiation had sufficient time to take effect. One hour before the test was conducted, the wave generator was engaged.

Despite the mixing and emulsifying that occurred from the wave action, the researchers obtained a strong signal in the visible waveband and in polarization. It was not possible, however, to clearly identify the oil in the water in the thermal imagery.

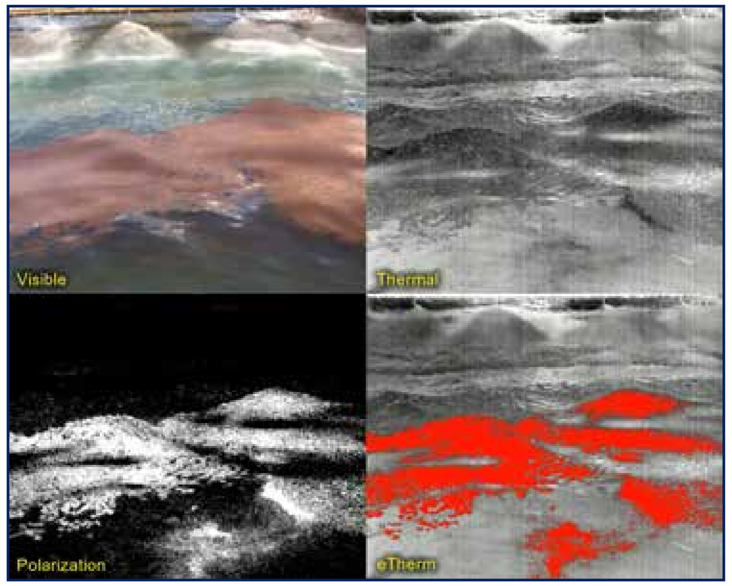
These tests and others performed by Polaris have shown that, in most situations, polarization imagery gives a much stronger signal when trying to detect oil on water than does thermal IR imagery alone.

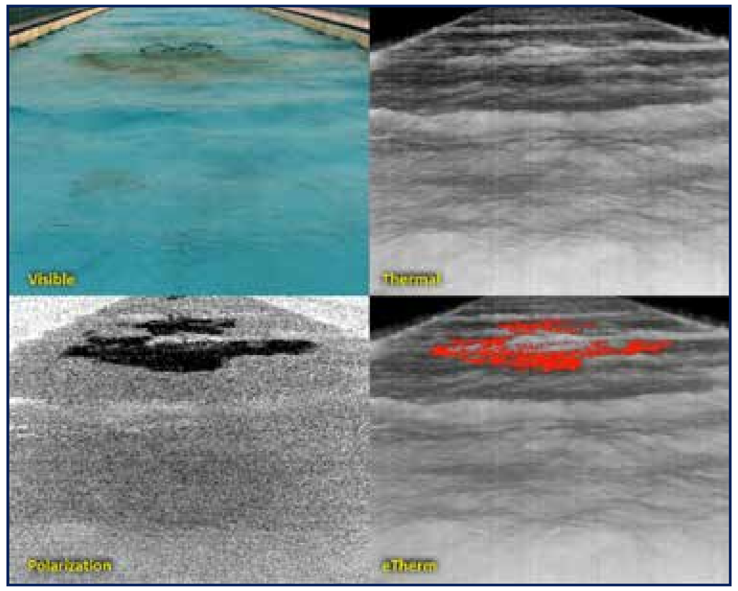
However, Polaris Sensor Technologies' Pyxis camera does not force the user to choose between polarization and thermal imagery – it provides both.

"The Pyxis thermal/polarization hybrid camera captures the LWIR data and the polarization data in each frame, thus allowing the user to view only the thermal imagery, only the polarization imagery, or both in a fused image called eTherm," said Rauso.



Imaging contrast performance: Thermal IR imagery vs. Polarization Imagery





Oil deposits viewed using different techniques

ADDITIONAL TESTING

"Other less rigorous tests not conducted at Ohmsett imply that vegetation and water fowl that have oil on them can also be identified by Pyxis, however, it is difficult to ethically perform this testing on a large scale," said Rauso.

"Additionally, due to the nature of polarization, the minimum detectable thickness of oil with the polarization signature is approximately 50 microns but depends on ocean and weather conditions.

"This amount is very close to the minimum thickness typically considered to be worthy of recovery, so the physics of polarization itself helps prevent false positive detections

ACOUSTIC IMAGING

MINSAS INCOPRORATED IN GAVIA AUVS

Teledyne Gavia, manufacturer of Gavia, SeaRaptor and Osprey AUVs, has integrated the Kraken Robotics MINSAS Interferometric Synthetic Aperture Sonar (SAS) into its vehcles.

The MINSAS is an off the shelf configurable Interferometric Synthetic Aperture Sonar (SAS) which replaces high end sidescan systems at an affordable price, while delivering significantly higher resolution, range, and area coverage rates (ACR).

The increased range and resolution and associated higher ACR of SAS over traditional systems can significantly expand the capabilities of Teledyne Gavia AUV systems for a variety of tasks for naval, scientific and commercial applications
During the initial integration of the Kraken MINSAS at Teledyne Gavia facilities in Kopavogur Iceland a Gavia class vehicle was utilized.

Due to the modular design of the Gavia AUV it was possible to use a Kraken MINSAS demonstration payload that was designed for a third party AUV along with a Gavia module adaptor to conduct sea trials.

The ability of Gavia AUVs to carry payloads from other commercially available AUV systems further highlights the benefits of a truly plug and play modular system for unmatched versatility.

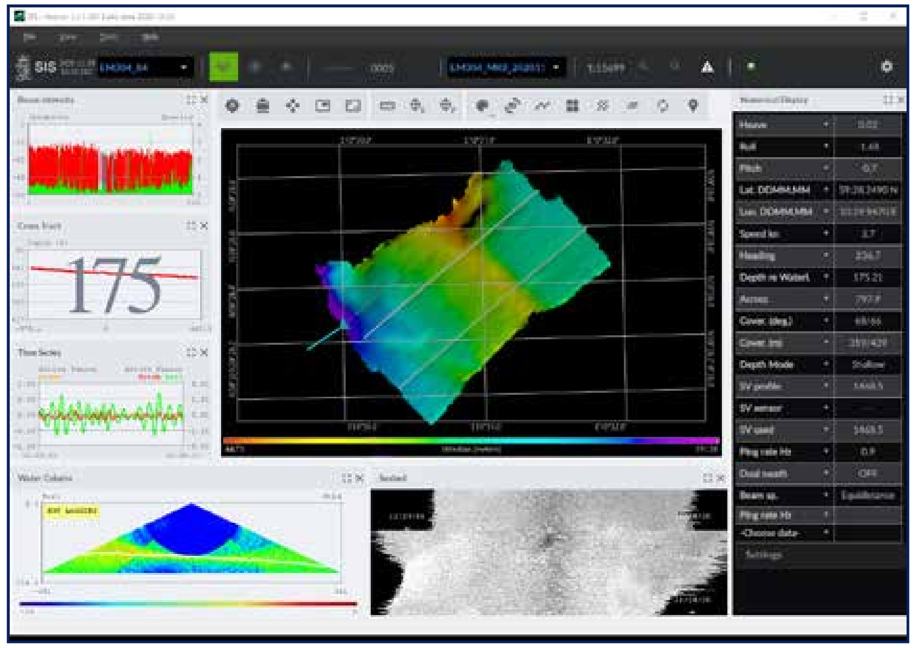
The Integration and testing of the MINSAS culminated in operations with the Icelandic Coast Guard to examine targets of interest including what is believed to be the remnant of a B-24 bomber operated by the RAF for ASW patrols during WW2 and shipwrecks from the same period found in Icelandic waters.

Equipping the Gavia AUV with Synthetic Aperture Sonar enables the Gavia AUV to provide both bathymetry and high resolution / high area coverage sonar coverage which is ideally suited for a variety of applications including mine countermeasures, SAR and other operations where speed of response and actionable data are paramount.

The low logistics Gavia class vehicles will utilize the MINSAS 60 system while the larger Osprey and SeaRaptor AUVs are capable of carrying the larger MINSAS 120 configuration.

EM 304 MKII

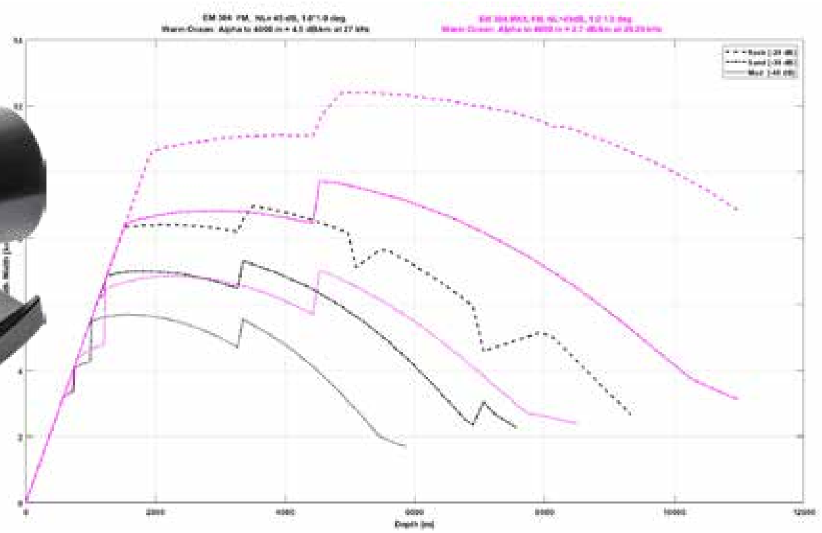
Kongsberg Maritime has launched its EM 304 MKII to its portfolio of deep-water multibeam echo sounders. Underpinned by a brand new KONGSBERG-designed wideband transmitter working in the 20-32kHz band with a nominal frequency of 26kHz, the new mapping system significantly improves upon the performance of the MKI model, boosting range from a previous maximum of 8,000m to full ocean depth, and increasing swath performance by up to 75%.



In addition, the EM 304 MKII delivers an unprecedented 0.3° x 0.5° resolution – the highest achieved by a deep-water multibeam echo sounder – yielding optimal performance and precision. Meanwhile, the system's modular construction and flexible transducer design make installation easy and enable it to be adapted to fit almost any size of vessel.

As part of a new EM technology platform designed to anticipate and address future challenges, the EM 304 MKII is compatible with a novel KONGSBERG-developed datagram format.

This supports several innovative features such as extended backscatter calibration, and more features are already in development. The new format is supported by Kognifai, KONGSBERG's open digital ecosystem, which provides operators with the potential to transform their survey operations via digitalisation.



IWBMS

NORBIT Subsea has supplied a iWBMS (Integrated Wideband Multibeam System) to PD Ports.

With a fully integrated and tightly coupled multibeam survey system, the NORBIT iWBMS provides high data quality and ease of use for PD Ports who operates in challenging environmental conditions.

Benefiting from high resolution and wide coverage, the NORBIT system will be used for hydrographic, engineering and dredging surveys.

NORBIT iWBMS