An sonar has been developed that can provide near-video quality images in areas with minimal visibility

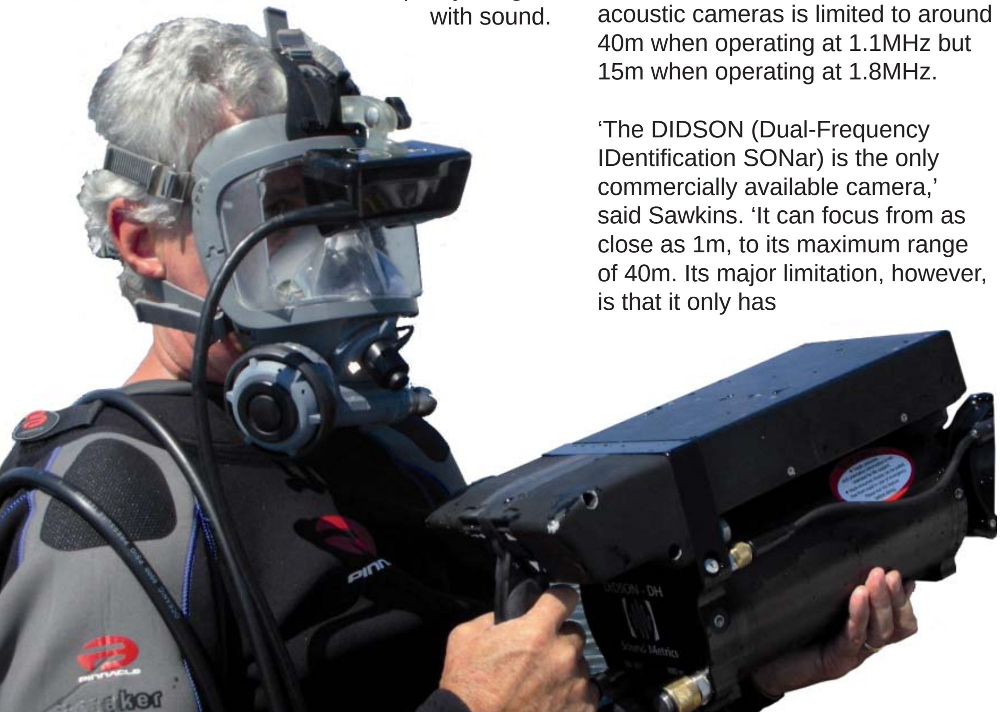
SONAR IMAGING

Acoustic Cameras

When working underwater, it is invaluable to get some form of visual feedback through cameras, for both navigation and basic inspection operations. However, in many seas, rivers and coastal areas, where a significant amount of ROV work is conducted, waters are often turbid and characterised by minimal visibility. As conventional optical systems generate blank screens in such conditions, the industry has had to resort to alternative methods of imaging. One solution is by using sonar.

While conventional sonars may provide rudimentary imaging in these conditions, the detail is often inadequate for identification, inspection and object manipulation purposes. Consequently, divers may be required to descend to work on or view structures or objects in such murky conditions but would have to use their hands to identify the objects by tactile examination.

The demand for better imaging in turbid waters has fuelled the development of a new breed of sonars which are able to provide near-video-quality images with sound.



'In the same way that light waves can refract, sound waves have the same property. They can therefore be focused with an acoustic lens system in the same way that light is focused with optical lenses, principally by moving one of the lens elements,' said Mike Sawkins, product manager at MacArtney. 'The result is an acoustic image with significant detail.

'In many ways, the acoustic camera bridges the gap between conventional sonars that can image a shipwreck at 300m and medical ultrasound which can image inside the womb at a range of 10cms.'

Acoustic cameras operate using a combination of high frequencies, acoustic lenses and very narrow beams to increase the detail in images. The operating frequencies range up to 3MHz with the high-frequency sound being more quickly absorbed in the water than low-frequency sound. As a consequence, the range of these high-frequency acoustic cameras is limited to around 40m when operating at 1.1MHz but 15m when operating at 1.8MHz.

'The DIDSON (Dual-Frequency IDentification SONar) is the only commercially available camera,' said Sawkins. 'It can focus from as close as 1m, to its maximum range of 40m. Its major limitation, however, is that it only has

a 29 deg field of view, leading some users to call it an acoustic flashlight. It therefore requires a mount that pans or alternatively requires the operator to pan by turning the ROV to cover a larger field of view.'

'This relatively narrow beam means that while the DIDSON is a good identification tool, it is not such a good search tool. Therefore, side scan sonars etc are conventionally be employed to locate the targets of interest. This leaves the acoustic camera to follow up and make the positive identification.

Over 150 acoustic cameras have been placed in the field since 2001 in applications ranging from 3000 meters to shallow rivers. The versatile systems have been mounted on fixed bottom mounts, AUVs, ROVs and even held by divers. Because of its unprecedented vision in turbid waters, it has seen a wide variety of applications.

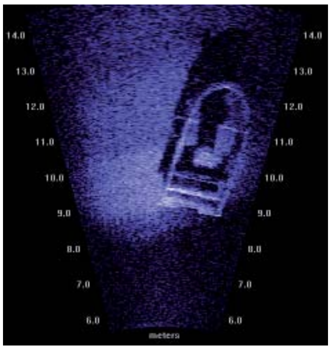
Above: The DIDSON sonar. Left: A diver with mask-mounted display and diver-held model DIDSON DH, (Courtesy of Dave Elliott).

Applications

Of particular importance in the current political climate, is homeland security, and the protection of economic targets like ports and oil terminals. A Maritime Safety and Security Team (MSST) at the Port of New Orleans, currently uses acoustic cameras as part of a waterborne antiterrorism force protection initiative for strategic shipping, high interest vessels and critical infrastructure.

The tools involve a swimmer detection sonar (Kongsberg SM2000) to look at various movements and a WQX-2 ACAP processor to rank the targets in importance. If a potential alarm is triggered, an acoustic camera is then lowered into the water from a quickly mobilised boat to verify that the number of divers and suspect packages, the image from the acoustic camera then determines their actions.

Diver-held acoustic cameras are also available for security and general underwater civil engineering applications. One such system has been purchased by the Galveston Police Department as part of their declaration of stepping up security around the port.



DIDSON systems can also be used to detect the presence of mines on hulls. This was the subject of a meeting in 2006 when the Hull Unmanned Underwater Vehicle Localization System demonstration in San Diego attracted 26 ROV and AUV manufacturers to look at providing a suitable platform to image such targets using acoustic cameras and other sensors.

The use of acoustic camera systems on remote vehicles is not limited to such short range applications. Longer range versions can detect objects up to 80m away and would be therefore suitable for use as a forward looking sensor system for obstacle avoidance and navigation functions while also filling in the information gaps between sonars mounted on the side of the AUV.

While security provides a useful application of acoustic cameras, they are similarly useful in a wide range of other uses. One such is in aquaculture, where they can be employed for both behavioural studies of fish and to determining fish numbers, particularly in shallow waters. According to the Alaska Department of Fish and Game, 22 acoustic cameras have been installed in remote locations over recent years to count fish in turbid rivers that in which the glacial silt load renders optical systems ineffective. These cameras can also be used to detect predators of protected species or monitor the position of marine life to ensure they are out of the way of water intakes such as those in water processing systems.

Their primary use however, is probably for inspection purposes. Salvage work is a typical application, particularly following the Rita and Katrina hurricanes in the Gulf of Mexico which scattered pipes and other structures across the seabed. In the turbid water, acoustic cameras have been used as the basis of seabed surveys to look at part-buried pipes and establish the optimum locations to locate cutting and lifting equipment for the removal of trees, etc.

In pipelaying operations, it is generally the practice to monitor the 'touchdown point, where the pipe comes to rest on the seabed. This is done to ensure that there are no abnormalities such as damage to the concrete coating or buckling of the field joint. This is conventionally monitored using an ROV trailing some distance behind the stinger of the pipelay system. In practice, the touchdown is not a smooth process, with the pipe continually bouncing vertically, disturbing the sediment and reducing the optical visibility. The acoustic camera however is able to monitor the process and provide useful feedback to the laybarge.

Above: A US Coastguard boat with DIDSON (in circle) intercepts and verifies detected swimmer-intruders. (Courtesy of Space and Naval Warfare Systems Command. Left: A sunken boat seen with a DIDSON sonar. Below: A DIDSON image of a 36in pipe as it bounces at touchdown and stirs up sediment. (Courtesy of Oceaneering International Inc).