Acoustic Technology in Historic Wreck Recovery

Remaining parts of the famous 16th century ship the Mary Rose have been recovered in Portsmouth Harbour entrance using standard offshore equipment. The use of acoustic navigation enabled both divers and ROV to work with more efficiency, precision and more conveniently.

One of the more memorable broadcasts seen on British television in 1982 showed the lifting of the wreck of the Mary Rose, sunk outside Portsmouth Harbour in 1545. Although regularly monitored, the wreck site has remained largely untouched since then. In December 2002 the UK Ministry of Defence approached the Mary Rose Trust and relevant heritage agencies to inform them of its plans to regenerate parts of Portsmouth Harbour to enable the base porting of two new aircraft carriers in 2012. These will require a wider and deeper approach channel to the harbour, the preferred route for which clips the zone containing the remaining wreckage of the historic Mary Rose. In a joint venture between the Mary Rose Trust and the MoD, a programme of work for 2003 was subsequently agreed.

Background
The Mary Rose was one of the first ships built during the early years of the reign of King Henry VIII. She served as flagship during Henryâ€™s First French campaign and was sunk in 1545 whilst attempting to defend Portsmouth from an invading French fleet.
The Mary Rose is today a symbol of Portsmouth and Henry VIIIâ€™s Navy, due largely to the high-profile excavation that took place between 1979 and 1982. This culminated in the raising of a substantial portion of the hull. What is not as widely known is that the bow area was not fully excavated and parts of the collapsed forecastle may still lie buried on the seabed.
The schedule of works for 2003 included the recovery of hard-ware remaining from the 1979-1982 excavation, along with any recent modern surface debris. This was partly to clear the site of modern â€˜clutterâ€™ in preparation for a complete hydrographic survey of the harbour entrance in September 2003. The programme also included the excavation and lifting of objects or caches of objects previously left buried on the site as experiments of â€˜preservation in-situâ€™.
The third task was the excavation of as much as possible from the two spoil heaps which flank either side of the hole left by the recovered hull. These were formed during the original excavation by the removal of hull sediments through unfiltered airlifts on opposing tidal runs. A tracked Remotely Operated Vehicle carrying an airlift suction head was used to recover all sediments to the surface for screening. This was the first use of remote excavation on an historic wreck site in the UK and the availability of precision subsea positioning was a key element in the decision to trial this technique.

New Techniques
For the first time, The Mary Rose Trust has been using a Fusion Long BaseLine acoustic positioning system loaned to them by Sonardyne International to provide high accuracy positioning for the 40m dive support vessel Terschelling, a team of divers and an ROV (Figure 1). The use of such equipment represents a very different approach compared with methods routinely used by archaeologists during the original excavation. Then, the 40 by 20m site was completely covered by a rigid grid of coloured plastic pipe. The divers used tape-measures to fix the position of objects in relation to primary control points on the structure of the Mary Rose. With up to twelve divers in the water together, strong currents and occasional complete lack of visibility, the difficulties can be imagined.

Fusion LBL
The Long BaseLine (LBL) or 'range-range' acoustic navigation technique is widely used in the offshore construction survey industry as it offers the highest levels of subsea positioning accuracy, independent of water depth. By using a network of transponders deployed at known locations on the seabed a user may quickly and accurately position any structures or mobile targets equipped with an acoustic beacon.
Despite very shallow water and small work area, standard offshore equipment was used on this project, with the transponders and transceivers operating in the Extra High Frequency (EHF) band (50Ã105kHz). Four Sonardyne Compatt transponders were installed into rigid frames to prevent movement and deployed on the seabed around the wreck site. One transponder was fitted with a high-accuracy DigiQuartz depth sensor to monitor the 4m tidal range. It was also fitted with a salinity sensor to calculate the speed of sound in water (Figure 2).
Acoustic positioning and control tasks were undertaken using Pharos - the Sonardyne navigation software application. Pharos optimises Sonardyne acoustic systems, allowing complex subsea positioning tasks to be carried out quickly and easily.

System Calibration
Before work began with the system, a â€˜top-downâ€™ and â€˜baselineâ€™ calibration was conducted to determine the positions of the transponders in real-world coordinates. Acoustic range measurements were made from a transceiver on Terschelling to all four transponders as the vessel sailed once around the array.
The transponders were then commanded in turn to measure the acoustic range from themselves to the other three transponders in the array and to telemeter the values back to the Fusion computer. Once all the range measurements had been collected, these were used to compute absolute positions for the transponders.

ROV Positioning
The Swan 2002 ROV, known as Monica, was custom-built by Nigel Boston, the owner of the Terschelling, specifically for excavation, burial

and trenching work. Fitted with colour cameras and scanning sonar, its principal job was to excavate trenches in spoil heaps arising from the 1979-1982 excavation. It was therefore of utmost importance that the exact position of the vehicle was known, that the depth below seabed level of the suction head was monitored and that the excavation could be â€˜drivenâ€™ by the Fusion system, generating the â€˜site planâ€™ as it progressed.
Monica was fitted with a Sonardyne RovNav 5 transceiver connected by an umbilical to the navigation computer onboard the vessel. The ROV operator and archaeologists could thus precisely monitor the progress of the excavation. Two remote acoustic transducers were mounted at each end of the ROVâ€™s suction tool boom and connected to the transceiver by cables. By measuring acoustic ranges to these transducers it was possible to obtain very accurate position fixes for the ROV in three dimensions: X, Y and Z.

Diver Monitoring
The relocation of previously buried remains required diver search and survey, so it was necessary to be able to accurately position points on the seabed nominated by divers for further excavation. Diver positioning was also required for ground-truthing of magnetometer anomalies identified during the pre-site survey donated by Andrews Survey and Sea Boston. It was also required for the divers once they had found items and, more importantly, for guiding them onto the anomalies.
To achieve this a 2.5m long survey staff carried by the divers was equipped with a lightweight Mini RovNav transceiver, a 100m-rated depth sensor and with an acoustic transducer fitted to the top. Acoustic range measurements made by the transducer to each Compatt were sent via a dedicated umbilical cable to the navigation computer so that the position of the diver could be calculated (Figure 3).
The speed and simplicity with which the staff could be used made â€˜Mr. Stickyâ€™, as it became nicknamed, an invaluable member of the team. It was used for position-fixing artefacts and structure, outlining the boundaries of trenches and the hull depression and, most importantly, positioning the major find of the season - a portion of the stem of the Mary Rose (Figure 4).

Recovering Artefacts
Excavation of the spoil mounds by Monica resulted in all mud, silt and any artefacts in it being lifted aboard Terschelling and washed over sieves for separation. This highly productive method enabled â€˜finds supervisorsâ€™ Martin Read and Leslie McKewan to recover over 380 objects in just three weeks. These included a huge range of items used by 16th century mariners such as arrows, coins, dagger handles and even a mini sundial that had once served the same purpose as a wristwatch (Figure 5).
Objects and artefacts located but not recovered were plotted on a live site-plan generated by a Geographic Information System. Position and fix data logged by the Fusion system was archived and used as part of the primary archive for the project.

Efficient Diving
An important requirement was to be able to position Terschelling as close as possible to the work areas to minimise umbilical runs. â€œWe were able to manoeuvre the vessel and position the bell exactly where
we wanted itâ€, said Peter Magowan, one of the three Irish divers in the team. He said that the ability to reduce the amount of walking on the seabed was an important benefit provided by the acoustic positioning and pointed out that time saved in getting to the work location has practical benefits in such poor visibility. â€œOften it can take twenty minutes of a dive to even find the job,â€ he said, â€œand thatâ€™s nearly a third of your dive time wasted.â€
Compared with the methods traditionally used to investigate a site and record the location of artefacts, Peter Magowan felt that using acoustics was an outright winner. â€œItâ€™s a lot quicker than tapes and top wires,â€ he said, and he felt that it could prove to be a useful tool in many other areas of his work (Figure 6).
With the 2003 season ended, the Mary Rose Trust has the benefit of four more years before dredging begins.

User-friendliness
The 30mm position accuracy achieved on this project is believed to be the highest achievable by any commercial off-the-shelf acoustic positioning system and more consistently accurate than divers working with tape-measures in strong currents and very poor visibility. The project also demonstrated the user-friendliness of the Fusion LBL system. Once an experienced operator had set up the system it was run for the remainder of the project by a marine archaeologist and an ROV pilot with only a few hours training.

Conclusion
When funding or other factors impose time limitations on marine archaeological projects, the work of the Mary Rose Trust has clearly demonstrated the practical benefits available from the use of modern commercial acoustic positioning systems. Greater speed, accuracy and convenience can make a significant contribution to their work. It also enabled the precise placing of both ROV and divers on predetermined targets. This was fundamental in recovering previously buried items and locating targets identified by other means.