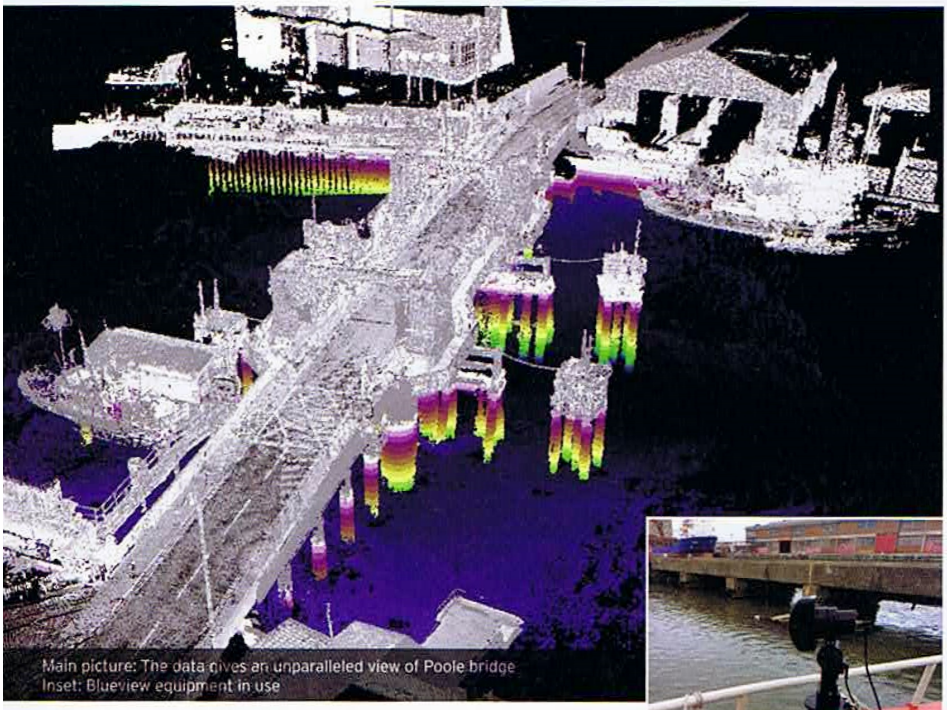

Main picture: The data gives an unparalleled view of Poole bridge
Inset: Blueview equipment in use

POWERFUL COMBINATION

Above and below-water surveys of an existing bridge have been combined to create a very detailed model for use in planning repairs

Until recently the underwater inspection of bridges and structures has been conducted solely through diver survey. In many cases this remains fit for purpose; however for complex cases, where there is a need for greater resolution, detail and accuracy, specialist Landscope has developed a 3D multibeam sonar-based modelling service. This removes the need for personnel to enter the water and delivers a level of detail from which bridge inspectors and even divers can benefit. The system employs the Teledyne Blueview BV5000, a 3D scanning sonar system that works in a similar way to a standard multi-beam echo-sounder; rather being deployed in a dynamic mode, it is mounted on a tripod and lowered to the bed of the river. From this position it completes up to four 360° scans to acquire a three-dimensional point cloud of the surrounding underwater environment. Multiple scans can be registered together to build up a picture over a larger area.

Landscope recently used the system to survey a lifting bridge in Poole, in the south west of England, following some diver intervention and maintenance works. The firm was approached by Poole Borough Council to provide an underwater survey of the bridge, which spans some 90m across the entrance to Poole Harbour. Given the potential risks due to the tidal flow, there was an obvious safety concern in enlisting divers to undertake further underwater works. Additionally, there was some uncertainty as to what standard previous surveys and sub-contracted works had been completed.

The Blueview scanner offered greater accuracy and superior resolution, allowing engineers to gain a clear understanding of the underwater environment and to acquire all the necessary metrics to provide data for any future maintenance or refurbishment projects.

However, Poole Borough Council was not interested in simply obtaining underwater data. Based on the capability of the Blueview system and the laser scanning expertise of Landscope, the survey was specified to develop a single, high-resolution, 3D model of the entire structure both above and below water. Essentially the lidar (laser scan) and sonar point clouds were to be co-registered and 'stitched' together.

Furthermore, by acquiring the laser scan point cloud data at low tide and the 3D sonar data at high tide, there is a significant vertical overlap between the two data sets, which not only provides verification through redundancy but also strengthens the 3D geometry between the underwater and above-water elements. Top of the list of the critical success factors for surveyors, when designing such a scheme, is the establishment of a robust survey control network. In this case survey control had to encompass carriageway level, soffit level, the inter-tidal zone and even the channel bed. Following this, laser scanning was carried out using both a Trimble TX8 and a Faro Focus 3D system, ensuring the acquisition of adequate data within a restricted operating time window.

With the laser scanning complete, survey focus shifted to the wet part. Tasked with acquiring as much information as possible from immediately beneath the bridge, 14 separate scan locations were selected to capture the data. Important considerations included ensuring there was adequate coverage without endangering boat or crew and ensuring adequate provision of underwater control – ie reference objects – to allow for the co-registration of sonar scans.

The team also had to consider how they could capture as much data as possible at high tide to maximise overlap with the laser scanner datasets. From an operational point of view, they had to plan how they would manage the system in strong tidal flow - ie how they would stabilise the tripod - and they also had to give consideration to the best way of managing data acquisition without affecting either bridge operations or marine traffic.

The laser scan data processing was completed first as this provides a reference framework for the sonar data. Post-processing the Blueview data is more complex as essentially each scan has seven degrees of freedom (X,Y,Z,rX,rY,rZ and scale), all of which need to be resolved during the registration process once the data has been cleaned of turbidity noise. This can be time-consuming and the quality of field survey control network design is a key factor in determining the time required to converge on solution. There were the inevitable small gaps in the data caused by the shadows of underwater obstructions, debris, moored vessels and the bridge structure itself. Given the model resolution required, the team revisited the bridge to augment the model with further Blueview scans.

With the additional scans added to the model, the complete dataset provided an unprecedented view of the bridge. The level of detail, resolution and completeness of the point cloud model was extraordinary. Individual items of debris could be identified, exposed cable crossings could be examined and remedial works planned, the erosion of dolphin pile bases could be measured, scour features could be understood and so on.

The point cloud model had been collected to a high degree of resolution and it was essential that all stakeholders could view it at the highest possible level of detail. The final challenge was to make it possible for the council staff to exploit this functionality. Landscope considered a number of point cloud viewers and concluded that Autodesk Recap would be the most appropriate in this instance as it allows for visualisation, annotation and measurement of the point cloud in a relatively straightforward user interface. The completed homogenous model of laser and sonar point cloud data provided an unparalleled view of the bridge for all parties ■