THE CHALLENGES OF A MISSION (IM)POSSIBLE

Surveying the River Dee

In April 2004 an unusual vessel, the Afon Dyfwydwy made its first transit down the River Dee carrying the wings for the new Airbus A380. This was the culmination of many years of work for a number of companies, including Pelorus Surveys, and a proud moment for all involved.

The Airbus factory at Broughton produces the wings for the Airbus range of aircraft and, to date, these have all been transported to the assembly facility in Toulouse, France using a modified Airbus flying from Broughton. However, each of the wings for the A380 is 48 metres long, 14 metres wide and weighs 25 tonnes. For transportation these have to be placed in a jig that itself weighs 100 tonnes, making transport by air impossible. With the Broughton factories located adjacent to the River Dee and a deep-water port available some 25 kilometres away at Mostyn, the only likely method of transportation seemed to be to use the river.

Complicated River Dee

The River Dee rises in the Welsh hills and flows past Chester before entering a canalised section that continues past the Broughton factory. This section is tidal and is characterised by strong currents, including a bore that can rise in excess of 0.5 metres on large spring tides. The canalised section enters the Dee Estuary at Flint, some 12 kilometres downstream of the Brought-on facility. The transit of the Dee estuary from Flint to Mostyn is approximately 13 kilometres, as the seagull flies. The estuary has numerous shallows and is characterised by areas of shifting sands, the navigable channel sometimes moving 20 to 30 metres between tides. The sands in the canalised section are rapidly put into suspension with entry of the tide. This makes the placing of seabed instruments particularly hazardous, as sand can rapidly bury anything placed on the bed. To further complicate the movement of goods down the river, there are three road crossings and a rail crossing to contend with. Two of the roads and the railway-bridge provide little clearance at high water.

Checking Feasibility

Thus the initial feasibility survey was of crucial importance, but had to be conducted to strict budget requirements and within a short period of time. A series of single-beam bathymetric profiles of the river were collected whilst simultaneously carrying out clearance surveys of bridge decks and piers using traditional land-survey techniques. Given the nature of the tidal regime in the area, a number of temporary gauges were deployed in the canalised section, along with some current meters to obtain data on the expected current velocity.
This survey was completed, processed and presented. It highlighted a number of characteristics of the river, the first being that it was feasible to move a barge downstream but the vessel would have to be specially constructed to be shallow-drafted, powerful and with low clearance, so as to be able to get under the bridges. The tidal regime in the river was odd, showing an asymmetric distribution, with flood coming very quickly and ebb taking longer than expected. This meant that strict vessel-movement planning would have to be employed to ensure the vessel would have sufficient water to move against the tidal stream and clear the bridges. Moreover, the movement of sediment during the tide was not the only hazard to seabed-mounted instrumentation. The normal debris found in rivers, such as trees etc., could also cause problems, as we found out one day when a tree trunk managed to move one of the current metres a kilometre downstream! However, to turn plan into reality more data would be needed to provide background information for the Environmental Impact Assessment as part of the planning application. The River Dee is a SSSI (Site of Special Scientific Interest), a RAMSAR site (the Convention on Wetlands, signed in Ramsar, Iran, in 1971: an intergovernmental treaty providing the framework for national action and international co-operation for the conservation and wise use of wetlands and their resources. Throughout the world there are presently 146 Contracting Parties to the Convention, with 1,459 wetland sites, totalling 125.4 million hectares designated for inclusion in the Ramsar List of Wetlands of International Importance) and a Special Protection Site. Data was also required to allow accurate tidal prediction for the River.

Tidal Prediction

So Aanderaa tidal monitoring systems were placed at strategic points along the river, sensors incorporated into the units including pressure, temperature, turbidity and current-speed and direction. There are now six units in place, each recording at one-minute intervals. These are downloaded weekly using a GSM phone line, and the data collated and provided monthly to the client in graphical and digital form. A strict programme of maintenance and visits to the gauges is in place so that any drift from observed tides can be noted and corrected, and sediment build-up, maintenance or vandalism can be dealt with quickly. Archived data for more than four years is available from some of the gauges. The gauges are also used in real time by the barge during transiting, so that real-time tidal data is available at critical points on the journey, particularly about the bridges and at the mouth of the river.

Multi-beam Survey

From inception to date a number of hydrographic surveys of the whole of the river and estuary sections have been completed, latterly using both Reson and GeoAcoustics Multi-beam Echo Sounder (MBES) systems. A shallow-drafted MCA Cat II survey vessel, Seacat, has been used, as well as RTK GPS, with corrections being obtained via a dedicated GSM connection. A permanent RTK reference station has been established at the Deeside offices of Pelorus surveys for use both during surveys and barge movement. This has allowed rapid processing and charting of data and provides further checks on the accuracy of the tide gauges.

The bed material in the river and estuary consists of fine to medium-grained sand. When the tide comes in, particularly on spring tides when the bore occurs, this is rapidly put into suspension, survey becomes impossible and the effect causes bed-forms to rapidly move, meaning channels can shift many metres within a single tide. Mean bed levels in the canalised section of the site also appear to vary depending upon the time of year. This is considered to be an effect of varying river flow in relation to tidal flow, which remains relatively static. The results of the most important multi-beam surveys conducted several years apart were compared, providing an insight into the long-term dynamics of the river and estuary system sediment-transportation regime.

The Last Leg

For the six months prior to the first vessel movement, dual-frequency, single-beam surveys were conducted on a regular basis using a heave-compensated Knudsen 320M dual-frequency echo sounder with hull-mounted transducers from the Seacat. These surveys not only provided information on the position of channels allowing navigation up and down-river, but also comparison charts which provided information on short-term sediment transportation regimes. The volume of change could be calculated from these, allowing future survey campaigns to be planned prior to each transport of a wing down the river. The charts themselves had to be constructed in a specific way to allow rapid identification of shoaling and passage areas, so that the barge-master could plan his routes. This was simply achieved using a consistent colour scheme, as the dimensions of the Afon Dyfydwy were known at this time.

Survey Overview

Both in-situ and dynamic current measurements have been conducted along the river and estuary to obtain data on how the current may affect barge movement and allow this to be integrated into the vessel-movement programme. Detailed surveys of the bathymetry and currents in Mostyn Dock have been undertaken for input into a simulator programme. This allows movements for entry into the dock to be practised for both barge and the larger vessel used to transport the wings from Mostyn to Toulouse. Extremely detailed surveys of the bridge structures have been completed, in addition to surveys of any structures in the river exposed only at low water, such as the remains of old piers and dolphins.

A ground investigation was also completed in the SSSI in which the Load Out Facility (LOF) at Broughton was constructed along with a detailed topographic survey of the approaches from the factory to the LOF, involving negotiation of a road and rail crossing.

Final Remarks

Now that the wings are being moved on a regular basis, the vast majority of Pelorus Surveys work is completed. However, regular monitoring, along with data handling and processing from the gauges, is undertaken under our ISO9001 accreditation, in addition to maintenance of the RTK base station. Personnel are on 24-hour call-out rota for any problems that may arise during barge movement, and a rolling 12-year contract for this is in place.
