Anett Dude of Severn Partnership considers how Network Rail benefited from the latest 3D kinematic laser scanning data capture.

Last October, engineering consultants Parsons Brinckerhoff commissioned Severn Partnership to survey clearances on 205 structures on the Great Western Main Line - later extended by a further 70 - all to be completed before Christmas 2009. Once the project management teams from both companies had met to consider the safest and most efficient work flows and the proposed survey methodology, the multi-disciplinary design team at Parsons Brinckerhoff’s Birmingham office agreed that Severn Partnership’s approach would enable them to meet the tight survey deadlines necessary to secure the required timetable for design schedules. The structures survey list for the project read like a submission for a ‘best of British’ railway engineering competition - starting with Twyford Station, the GWR’s first western terminus, through Swindon, site of Brunel’s great railway works, passing through Box Tunnel, the longest railway tunnel in the world when it opened and then the Severn Tunnel under Europe’s largest estuary, before finally terminating at Swansea Station.

The project’s full to-do list also included more than 250 miles of unspoilt countryside, a number of busy city centres and yet more dark tunnels, presenting the Severn Partnership team with a complex and diverse range of surveying challenges. By employing the latest high-accuracy, reflector-less robotic total stations, the survey teams were able to ensure comprehensive data capture for many structures such as overbridges, underbridges, stations and signal gantries, without having to physically access the track from a separated green zone. Track access and possessions were though required for the larger structures - including seven tunnels - and were rapidly arranged through the well defined lines of communication, reporting and planning processes Severn Partnership, Parsons Brinckerhoff and Network Rail already had in place.

As Network Rail was insisting that the survey be completed within 16 weeks, a bi-weekly reporting process was established between all contractors to ensure that progress on site could be closely monitored by both Parsons Brinckerhoff and Network Rail.

Beneath the Severn

At 7km in length, the Severn Tunnel was the largest structure to be surveyed and exemplified the challenge facing the survey teams, especially as Parsons Brinckerhoff required all work to be safely completed in green zones.

As Severn Partnership had previous experience of surveying the Severn Tunnel, it was acutely aware of the value of precious possessions and understood that every minute would have to count if deadlines were to be met. The 3D data capture on this and many other elements of the project would therefore have to be more efficient than ever before.

This could not however be allowed to compromise the accuracy of key deliverables. Network Rail was demanding highly accurate information on existing track alignment linked to an Engineering Grid, Scale Factor 1 as well as clearance profiles in ClearRoute™ format for the tunnels and a full 3D laser-scanned point cloud on the site grid.

To meet these exacting requirements, it was decided to employ track-mounted kinematic laser scanning using the FX System, with the GRP5000 supplied through SCCS, the UK distributor for Amberg. While Severn Partnership has five years experience of kinematic rail surveying, achieving the production rates and accuracy levels in the time available would demand the very latest in scanning technology combined with good survey methodology.

The Leica 6100 laser scanner provided by SCCS was therefore modified to operate at 50Hz, providing double the density of scan data previously attainable through normal kinematic scanning. This enabled the scanner to be pushed through the Severn Tunnel in just four hours whilst maintaining the resolution necessary for ClearRoute™ sections to be taken accurately at any point through the tunnel.
In order to further enhance the performance of the FX System, Severn Partnership bought the very latest Amberg Rail 3D software, which has the unique ability to generate ClearRoute™ sections automatically, using the high-accuracy cant measurements and gauge results to combine data sources into 3D point cloud data.

The resulting outputs were the largest ever produced by Severn Partnership. On its own, the Severn Tunnel point cloud consisted of two billion points with 700 ClearRoute™ profiles outputted and could generate even more profiles should these be required at a later date.

**The big push**

Propelling the scanner on the track-mounted FX system was an even bigger push than the lucky surveyor allocated to the task realised, starting at 11.7m below sea level on the English side of the Bristol Channel before descending to 44m below sea level and then climbing into Wales, arriving still 4.7m below sea level.

The use of the FX GRP5000 allowed for the allocation of other surveyors for survey control works such as levelling and GPS observation adjacent to each of the tunnel portals. So intensive was the project schedule that there were always surveyors at multiple sites simultaneously.

Severn Partnership’s ability to provide the latest in kinematic scanning allowed this extra resource to be made available. Spigots or TMGs - track machine guidance points - were also installed on structures to maintain longevity of survey control through all phases of construction, through to as-built survey and long into the future.

This working methodology, having proved so successful on the Severn Tunnel, was then applied on a further six tunnels - Box, Sodbury, Newport, Alderton and the twin bore Patchway tunnels. Surveying tunnels in this way proved advantageous in that the work was not hampered by heavy snowfalls - that is, until the surveyors had to leave site!

**It’s all about 3D specs**

The point cloud of the Severn Tunnel has allowed the design engineers at Parsons Brinckerhoff to extract ClearRoute™ profiles from wherever they chose, to rail industry standard SCO format for clearance gauging. The value-added benefits that can be generated from the point cloud include 3D DX® wireframe models, elevations of the tunnel portals, details of all railway furniture and a complete 3D dataset that can be interrogated to provide unforeseen information requirements at a later date, long after the surveyors have gone!

Severn Partnership has recently added Leica’s latest C10 laser scanner to its instrument fleet, increasing capacity to capture 3D data and thus expanding the company’s 3D modelling capability. The next development from point cloud visualisation is to offer clients complete, fully-rendered 3D models to support their activities during later phases of projects. For example, 3D models could play an important part in signal sighting projects.

**Working in harmony**

The Amberg software used on this project provides high confidence levels in data output as a result of its design concept which incorporates an integrated quality system based on calculations employing two separate methodologies. The odometry of the GRP5000 is scaled against the high accuracy survey control points, providing a direct check on the integrity of the final scan cloud.

This approach dovetails well with Severn Partnership’s quality assurance system which incorporates a complete set of procedures for both site and office work, aligned to the company’s Chartered RICS and CICES and ISO9001:2008 accreditations. Applied by a highly trained workforce of surveyors, these resulted in the achievement of Network Rail accuracies for clearance surveys to 5mm and better, also ensuring that the very intensive survey schedule was completed on time and within budget for the client.

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