

CUSTOMER Align JV

PROJECT

Documentation and as-builts for HS2's Chiltern Tunnel

SOLUTION

Trimble SX12 Scanning Total Station and Trimble Business Center office software

Streamlining Success

How the Trimble SX12 Scanning Total Station saved vital time on HS2's Chiltern Tunnel whilst providing the highly detailed documentation and as-builts that contributed to the tunnel's successful delivery by Align JV.



Celebrating the Chiltern Tunnel Breakthrough

In July 2017, Align JV was awarded the Central 1 (C1) package of the UK High Speed 2 line (HS2) phase one. C1 consists of 21.6km of high-speed rail infrastructure and includes a 16.04km twin-bored tunnel. The Chiltern Tunnel, which passes beneath an Area of Outstanding Natural Beauty (AONB), is the longest on the HS2 route and was created using two identical TBMs named Florence and Cecilia launched in the summer of 2021, with 'Florence' breaking through at the North Portal in February 2024 and 'Cecilia' in March 2024.

The C1 package includes the 16km Chiltern Tunnel and the 3.4km Colne Valley Viaduct which are two of the most technically challenging elements on HS2 Phase One, making it ideally suited to the specialist tunnelling and viaduct construction expertise included in the Align JV, a partnership of three international construction companies: Bouygues Travaux Publics, Sir Robert McAlpine and VolkerFitzpatrick.

Technical Challenges

The Chiltern Tunnel, the longest rail tunnel in the UK, was designed to be constructed using two Tunnel Boring Machines (TBMs) operating continuously without intermediate breakthroughs. This made the project particularly complex, especially for the survey team responsible for guiding the machines and maintaining the precise tolerances required to meet the design specifications for the high-speed railway.

Responsible for determining the best methods for the highly technical requirements of the



underground surveys and for coordinating the joint venture (JV) team and ensuring they are all fully trained is Align Tunnel Survey Manager, Dimitris Dimitriou.

The specification for Dimitris's team included all the survey work centred around establishing the open-ended control, the constant checking of the misalignment of the TBMs and the creation of as-builts at each of stage of each construction element. These as-builts also included the precast concrete ring sections and in-situ cast concrete for the creation of the base for the track.

Time pressures

A number of challenges dictated how the team could work most effectively. Not only did the survey work have to adhere to extremely strict principles including a requirement to document every structure "This is the first project I've worked on using KOREC and Trimble and it's been very positive."

Dimitris Dimitriou, Align JV



Aerial shot of the south portal site in spring 2021



TBC view of the tunnel scans with SX12 resections using existing tunnel control highlighted

with an as-built point cloud, but the window in which scans capturing the whole round profile could be undertaken was very tight. All scanning had to be completed after the TBMs had passed but before the invert concrete was in place. To further complicate things on an already extremely busy site with a lot of traffic and machinery, thirty-eight cross passage tunnels connecting the two main ones were also being constructed creating a massive operation requiring many different specialist skills and different workflows.

Dimitris emphasises that establishing surveying control was one of the most challenging tasks compounded by the pressure to capture all data in a dynamic environment where everyone was focused on maximising efficiency.

Following consultation with KOREC, a number of Trimble instruments were purchased for the project including a Trimble SX12 Scanning Total Station. The Trimble SX12 Robotic Total Station functionality achieves 1" angular accuracy which combines with a very precise long-range scanner that produces exceptionally clean point clouds. This combination would provide Dimitris with the high-quality scan data he needed along with the means to establish control far more efficiently than if the team were to use a separate scanner and total station. Dimitris explains:

"Unlike a regular day on site, tunnelling and working with TBMs is a high intensity environment. If you lose one hour, you lose a lot, if you gain one hour, you gain a lot. We are always chasing a massive machine and being chased ourselves, so the pressure is on to have no downtime. Extensive planning was therefore imperative, and that included a very careful appraisal of our workflows and survey equipment.

The SX12 is a perfect fit for the tunnelling environment."

Delivering quality data in a tough environment

The Trimble SX12 delivered in a number of key areas:

• Dimitris estimates that on the days that they were scanning, the SX12's functionality as a hybrid scanner/



With the SX12, we got all our data sets without delays and the quality was excellent which meant no need for rework.

> Dimitris Dimitriou, Tunnel Survey Manager, Align JV

"Unlike a regular day on site, tunnelling and working with TBMs is a high intensity environment....If you lose one hour, you lose a lot, if you gain one hour, you gain a lot.

The SX12's hybrid functionality enables us to save around 90 minutes on the days that we scan"

Dimitris Dimitriou, Align JV

robotic total station meant that they saved at least 90 minutes. With just a conventional scanner and total station, the team would have to use a total station to tie the scan target to the existing network and then come back with a scanner meaning two different pieces of equipment and double the site time. With the SX12, existing prisms can be used, you don't need to create a new system to register your point cloud.

• With the tunnels being constructed with no intermediate breakthroughs, the team would be traversing down an open-ended tunnel with no fix. They were therefore always aware that once the TBMs have broken out at the surface, the raw data would be reprocessed with the new control network that would be established on completion. The ability to use the SX12's hybrid functionality means that the scan is related to control. If the control is changed, there is no requirement to rescan – the scans are automatically aligned to any adjusted control in Trimble Business Center office software (TBC) for a true as-built. Therefore, the SX12 does not have to rely on Cloud to Cloud or complex point cloud adjustments. This significantly cuts down on office time – a new control file can be simply dragged and dropped.



Tunnel view prior to the invert concrete being poured. Survey control brackets are visible on the left/right of the tunnel

• In the tunnels, the Align team used the SX12 to complete scans from one set up, 20m in each direction, with at least 10m overlapping with the next set up. Dimitris reports that even using the SX12 on medium density rather than the highest density, they were able to achieve more than sufficiently dense point clouds in less than 12 minutes, all with just a minimal amount of additional work because the existing control could be used with no extra scan targets or office processing required.

• Additionally, the ability to use the Trimble Access field software to set a maximum distance range on the SX12 greatly cut the amount of office time to clean the data, especially useful on a linear site such as this one with so much noise.

• The SX12 workflow, because you can use it as a total station, means that you can set the instrument up by resection, or over a known point, ensuring that when you bring the data into TBC, all scans will be at the correct position and correct orientation in global coordinates.

Easy, detailed reporting in Trimble Business Centre

Trimble Business Center software enables surveyors to transform field data, from a range of sensors, into high-quality client deliverables. For the Align team, the software's reporting functionality was key in providing the highly specific, customised reports cited by the client. Once formatted, the reports required just the addition of names and dates before submission.

"The formatted reporting in TBC creates the detail that this demanding spec requires – I've never seen anything else that can do it as quickly as TBC."

Dimitris Dimitriou, Align JV



Cutterhead breakthrough measured against design: -0.024 m horizontal offset +0.007 m vertical offset



HS2 Chiltern tunnel TBM Cecilia Breakthrough

For Dimitris, the breakthrough of the first tunnel, well within the design tolerance, was a particularly proud moment which he credits to the talents of the Align survey team who were able to respond to the challenges presented to them:

"We were given a challenge, but it was feasible, and we were able to deliver within the very strict parameters that we were set. Our ability to do this has made the life of other teams working on the project far easier. The breakthrough is a date to remember, a lovely finish for the team's journey over the three years.

"This is the first project I've worked on using KOREC and Trimble and it's been very positive. The SX12 has been well used and we've never had anything but the most minor of issues with it. It's a solid solution that needs to be appreciated. Undoubtedly the standout benefit is the very detailed point clouds we were able to achieve in a very short time, with the minimum amount of additional work because we could use the existing control. We got all our data sets without delays and the quality was excellent which meant no need for rework. However, we're always looking to improve and the fact that this job has been successfully completed is a good message for future projects."

HS2's Chiltern Tunnel - the facts and the figures:

- 16.04 km twin-bore tunnels through the Chiltern Hills
- 2 TBMs, Florence and Cecilia, built to handle chalk with flint bands
- 170m long and 2,200t each
- Excavation diameter 10.26m
- Concrete segments 2x 0.4m
- 7 segments per ring 112,300 segments in total
- 3 million m3 excavated material produced 24/7 and processed through the slurry treatment plant at the South Portal
- 5 ventilation and access shafts

CONTACT US

Please do get in touch for further information on any of the products or services mentioned in this case study, a demonstration, support or just a chat about your requirements.

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