Delivering the Three Rs of Monitoring

A massive infrastructure project uses geospatial technologies to streamline essential construction processes

It's been a long time coming. First envisioned shortly after World War II, Crossrail is a 118-km long (73-mi) railway serving the greater London area. Under construction since 2009, the £15-billion ($24-billion) project will provide passenger transportation for commuters and suburban residents and include direct passenger connections to Britain's Network Rail.

The new line includes 42 km (26 mi) of new tunnels beneath central London. A critical part of constructing the tunnels is understanding how the work affects existing rail lines near the sites. Using blended geospatial technologies, a Crossrail construction contractor created a monitoring solution to provide timely, accurate information for project stakeholders.

Protecting the Rails

The contractor, Morgan Sindall plc, was awarded a roughly £100-million ($160-million) contract to link new Crossrail tunnels to the Network Rail infrastructure in the London Borough of Newham. The work includes construction of a tunnel portal and a new elevated Docklands Light Railway (DLR) station.

The contract required Morgan Sindall to provide 24-hour monitoring to measure the impact of its cut-and-cover tunnel construction along an 860 m (2,800 ft) stretch of Network Rail and DLR track. The monitoring was needed to reliably detect movement and enable project teams to avoid the possibility of compromising passenger safety or project schedules.

Morgan Sindall assigned Chief Land Surveyor Nick Giles to handle surveying and monitoring on the project. The requirements for the monitoring system were clear: It needed to be robust, reliable and repeatable to provide total confidence for those depending on it. Working with Monitoring Surveyor Pawel Owsianka, Giles developed a unique two-pronged approach to provide the required confidence. An optical system using total stations and monitoring software would monitor horizontal displacement. Simultaneously, several hundred wireless tilt meters attached directly to the track would monitor cant and twist. The two systems could provide constant checks for each other while reducing the number of trackside optical instruments.

To provide optical monitoring, Giles selected 10 Trimble S8 total stations equipped with Trimble VISION™ technology. The instruments were installed at regular intervals along Network Rail and DLR tracks and controlled by Trimble 4D Control™ software (T4D) running on a central server. The team attached small prism targets directly to the tracks at 3-m (10-ft) intervals. Each total station had line-of-sight to up to 60 of the rail-mounted prisms.

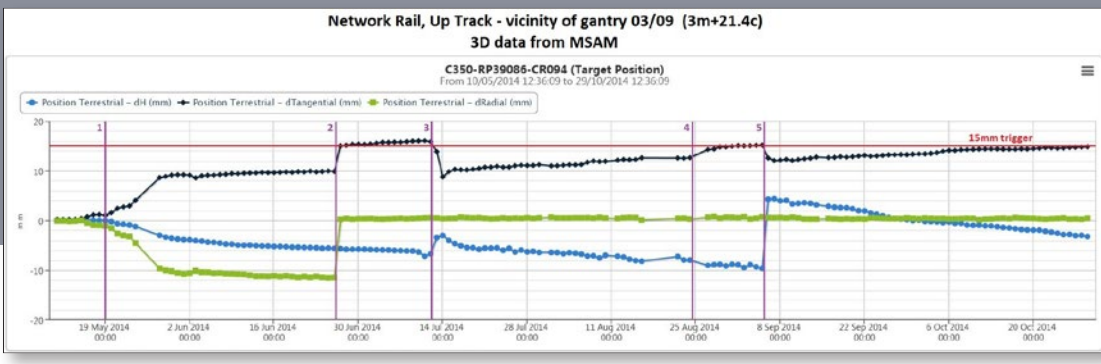
Providing Flexibility and Consistency

The core of the monitoring system was in the T4D software, which the team used to create customized operation and analyses, including remotely managing the 10 total stations, all measurement cycles and communications.

The system provided 24-hour coverage using a pre-programmed hourly cycle. Each instrument's cycle began with readings to fixed reference targets before measuring to the prisms attached to the rails. The T4D software

Left to right, Chris Hind, DLR; Pawel Owsianka, Morgan Sindall; Nick Giles, Morgan Sindall and Darius Rindeika, DLR, collaborated on the monitoring efforts.

One of more than 600 prisms attached to the track. The Trimble software combined optical measurements with data from tilt sensors.



Measurement data for a single prism reveals changes in three dimensions. Each prism was measured on an hourly cycle.

collected and recorded the data in an SQL database. From there, technicians could extract data to create maps, charts and graphs needed for meetings and client reports.

As part of creating the customized system, Giles defined alerts that would be issued when the software detected changes or motions that exceeded specific levels. The alerts, sent by email or text messaging, enabled rapid reaction to changes in the field. The team created customized alarm triggers to provide information including tolerances for displacement, with pre-programmed alert levels at 8 mm, 15 mm and 20 mm (0.3, 0.6, 0.8 in). Other sets of alarms monitored instrument maintenance and detected damage to an instrument or prism or if the line-of-sight to a prism became obstructed.

By using the T4D filtering to manage who received the alarms, Owsianka established a new level of security. If an alarm were triggered, an email alert was sent to three selected members of the Morgan Sindall monitoring team. One of the members could then immediately log onto the system—even from home—and analyze the data to decide if action and further alerts were necessary. Typically, an initial alarm was triggered if measurements revealed prism movement of 8 mm. The data was compared to the tilt sensor system and the prism was then "watched" over the next three monitoring cycles to detect any changes.

Giles described an example of the system's performance. An alarm triggered at 8 mm, alerting the three members of the Morgan Sindall team. They monitored the affected prism through subsequent cycles and no further movement was detected over the next three months. Network Rail was advised of the 8-mm alarm from the outset, but because no action was necessary, Morgan Sindall's filtering process prevented distraction to other parties. Later, when a second alarm was triggered at 15 mm, the monitoring team immediately alerted Network Rail and stakeholders with full confidence that the alarm was genuine. The track was realigned in less than 12 hours.

Producing Information from Data

Morgan Sindall produced a daily monitoring report detailing any recorded movement (including a graph if an alarm had been triggered) as well as reports for weekly Review Panel meetings. Additionally, all the data was uploaded in Crossrail's preferred format to the underground construction information management system (UCIMS). The customized reports enabled Morgan Sindall to quickly observe and analyze trends and present their findings in formats preferred by project stakeholders.

Giles is happy with the system performance. "Managing the monitoring in-house has brought us innumerable benefits—including satisfied clients and stakeholders," he said. "Should significant movement in the track occur, there is no ambiguity and trains can be stopped immediately." Morgan Sindall has delivered on the requirements for a robust, reliable and repeatable system.

Read feature in Rail Engineer UK's February issue: www.railengineer.uk