

Moving London safely forward

by Natalie Binder

Paddington Station – famous worldwide not only for its creator Isambard Kingdom Brunel but also for a small marmalade loving bear. An average of 26,500 passengers travel from Paddington station every day. Despite its Victorian elegance and regality, plans were developed to build a brand new underground station directly beneath the historic landmark. This infrastructure project has been undertaken by Crossrail and forms part of Europe’s largest construction project. The new station will be known as the Crossrail Paddington Station.

Since July 2011, plans have been developed by Crossrail to complete a new underground network for London. In August 2011, working as a joint venture on behalf of Crossrail Limited, Costain Skanska was awarded Crossrail contract 405 to complete the complex £14.8bn rail project. This project is creating

a major new railway line, stretching 118 kilometres (approx. 73 miles) from Reading and Heathrow to the west of London, to Abbey Wood in the east. It will also pass directly underneath central London. The new network will now connect seven brand new main-line underground stations, all of which are important interchanges between existing Network Rail services and the London Underground. One of these new stations is the Crossrail Paddington Station.

Meticulous planning to monitor structures above and below

Working directly under the very heart of London has many challenges. The city is home to over eight million people and its underground handles a billion journey’s per year. The new Crossrail station at Paddington is surrounded not only by modern buildings but by historic ones as well. It is also located in the densely built-up zone of central London with its maze of pipes, cables and sewers, making it an extremely complicated construction project. Since London is



■ Up to 49 Leica TM30 total stations were used to monitor building movement in the surrounding Paddington Station.

considered a global city, it had to work without disruption, even for a project of this magnitude. Therefore, the Crossrail station is being built as a four-storey top down construction, with two-way live traffic above ground as excavation carries on below.

With all this digging, loosened dirt in central London could settle unevenly and potentially cause structures to tilt or severe cracking could develop. Constant monitoring of buildings in this area was vital to avoid possible damage and this is how Leica Geosystems products and solutions play an important role in securing the success of this new railway line by monitoring structures and the degree of earth settlement.

Robotic total stations observing Paddington 24/7

Costain-Skanska decided to implement real-time monitoring solutions by using 52 Leica TM30's, especially for monitoring designed total stations, and over

1,800 monitoring prisms of all types in and around the Paddington area. The equipment was attached to various key positions on the outside of buildings. Highly accurate 3D data is collected from the total stations that measure key reference points of the various prisms placed strategically throughout the area's buildings. These measurements, roughly 8,500 points a day, are made in daily cycles. At the recent phase of the project which was called "the bulk dig", the data capture for the majority of the area's total stations takes place at six hour intervals each day, after which the data is sent to be processed with Leica GeoMoS, which sends the results to the web portal before they are distributed to the construction team. The use of Leica Geosystems monitoring sensors, software and communications is vital to the Crossrail project, as these accurate measurements provide information on any variations in structures caused by earth movement and minimise risks, not only to the buildings themselves, but also to public safety.



Automated data processing in near real-time

Such projects require constant observation, repetitively measuring the same routes and reference points several times daily throughout the entire project's life span. By using robotic total stations such activities can be done automatically and data is directly transferred for processing using Leica GeoMoS, GeoMos Adjust and GeoOffice software.

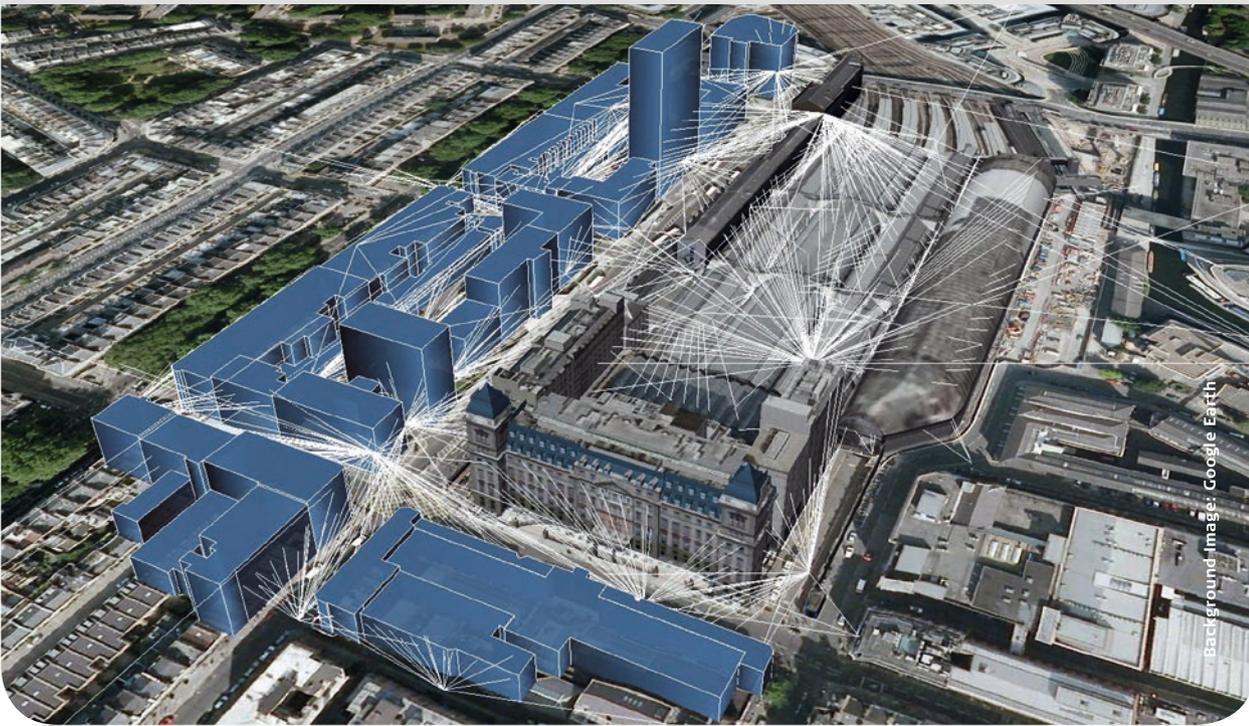
Three interlinked servers are used to run the Leica Geosystems software programs at the Crossrail construction site. The software is used to detect and analyse ground movement and the deformation of buildings above and below the site, and also helps to speed up and simplify the processing of real-time data collected by the total stations by up to 90%, allowing data to be available from field to issue quickly. This software solution for the new Crossrail Station is entirely from Leica Geosystems, and is the largest of its kind existing anywhere in the world. Engineering Survey Manager for Constrain-Skanska Joint Venture, Steve Thurgood, reports "The software systems have to be very prescriptive and procedural to control the quality and repeatability of the project, yet also allow for dynamic change in the environment and construction phase

changes. Our operation runs non-stop, we manage the software system to minimise and repair any faults that might occur. Both software systems log a phenomenal amount of data which correlates with an astonishing degree of accuracy and precision."

The Leica GeoMoS software solution is a fully automated system for data generation. It offers automated processing and evaluation using statistical analysis, comparing new data to the original base model by using easy to understand graphs. The software also continuously updates deformation analysis and network adjustment with vast volumes of real-time data received by the 44 to 49* total stations, resulting in highly accurate data delivered fast.

When the data is processed, it is additionally optimised by network adjustment software for co-ordinated geometry, topography and accuracy. Should any of the data not be within a $\pm 10\text{mm}$ sphere of the previously collected data (generally not older than approx. six hours), it is considered incorrect. The engineering surveyors overseeing the operation evaluate and compare the data with deviations to the predefined data parameters and quickly decide if measures need to be taken.





■ A depiction of the vast monitoring network covered by the total stations surrounding Paddington Station area.

The co-ordination of displaying the processed data with on-site construction teams helps considerably to complete technical work without disruptions. GeoMoS increases not only productivity uptime by displaying real-time data but also simplifies workflows by constantly validating data before issuing it to the teams.

Dedicated teams and reliable equipment

Dedicated round-the-clock operation and maintenance teams actively maintain the entire Crossrail project's Leica GeoMoS software solution and also clean and maintain the 42 to 49 total stations and over 1,800 prisms. The total stations take six people to run plus an additional part time support staff of five persons in the field. All involved total stations are serviced and maintained at Leica Geosystems Service Centre in Milton Keynes.

"Crossrail's motto is 'Moving London Forward'. Within our engineering surveying team who run the precise levelling scheme and the largest Leica Geosystems homogeneously adjusted total station scheme in the world, we adopted a complementary motto due to the success we've had to 'Moving surveying for monitoring forward'. None of the above however would be possible without the continued support of Leica Geosystems and its supply chain partners", concludes Steve Thurgood, Engineering Survey Manager for Constain-Skanska Joint Venture. ■

About the author:

Natalie Binder is Marketing and Communications Manager at Leica Geosystems Ltd. based in Milton Keynes, UK. natalie.binder@leica-geosystems.com

*Figure variation due to working environment changes.

Maximising space while preserving history

Built in 1854, Paddington Station is a fine example of an English Heritage grade 1 listed building and is site to the world's first underground railway, opened in 1863. The new Paddington Station will maximise space while preserving its historic features. The underground consists of a station box that is 28 m

deep, 265m long and 26m wide (approx. 91 ft deep, 869 ft long and 85 ft wide). Constain-Skanska JV was awarded £14.8 billion (24 billion Dollars, 18,5 billion Euro) to complete this complex rail project and they choose to use Leica Geosystems products for this extremely meticulous project.