

# BUILDING UNDER PARIS

AUTOMATED SURVEYING TECHNOLOGY IS BEING USED TO MONITOR THE HEALTH OF ONE OF THE LARGEST INFRASTRUCTURE PROJECTS IN EUROPE. **CHRIS EMERY** EXPLAINS HOW ROBOTIC TOTAL STATIONS ARE BEING USED TO SPEED UP WORK, KEEP DOWN COSTS AND PREVENT ACCIDENTS

The €22bn Grand Paris project is one of the biggest and most exciting infrastructure projects in Europe at the moment, and is one of the many projects across the continent to facilitate increasingly urbanised populations. With growing pressure on the industry to adopt automated technology to deliver such vital projects efficiently and safely, leading infrastructure monitoring contractor Cementys is working with Topcon Positioning Group to bring smart monitoring and added security to Grand Paris Express.

Part of the Grand Paris project announced in 2007, Grand Paris Express will see the construction of four new automatic metro lines and the expansion of two existing lines of Paris Metro by 2030. Led by Société du Grand Paris (SGP), the 205km network will provide direct links between Paris' suburbs – removing the need to go through the city centre. It will also remove approximately 150,000 cars from the city's roads, bringing daily congestion down.



More than 100  
Topcon MS Series  
robotic total stations  
are being used on  
Line 15 to provide  
monitoring data in 3D



### The need for structural monitoring

With 85 per cent of the Grand Paris Express network underground, monitoring structural movement across the vast network is essential to avoid potential risk to surrounding structures and the Parisian population.

Grand Paris will see 68 new stations added in total, which typically involves excavating the sites then building the stations within these 'boxes'. Tunnel boring machines then travel from station box to station box, creating the tunnels that build up the Metro system. To minimise disruption, surface construction is kept to a minimum and involves engineering work only at station sites and shaft ventilation locations.

Naturally, the enormous amount of material being excavated from the surface down, together with the tunnelling taking place underneath, can cause ground and structure stability issues. Surrounding buildings, roads and bridges can all be affected, but perhaps the most hazardous issue is the existing light rail and Metro infrastructure; it's essential that trains can pass freely and safely on the existing network while work takes place. If running rails move differently from each other, this can

cause unusual movement in the carriage if it's moving at speed, which can lead to derailments. Structural monitoring across the entire network is therefore vital.

### Top technology for Line 15

Cementys is one of the specialist monitoring service providers awarded contracts on the first stage of the enormous infrastructure project, Line 15. Creating a ring around Paris, Line 15 will connect suburban towns including La Défense, Saint-Denis, Rosny-sous-Bois, Champigny-sur-Marne, Villejuif, Issy-les-Moulineaux and Nanterre.

### STRUCTURAL MONITORING ACROSS THE ENTIRE NETWORK IS VITAL

The leading contractor needed a reliable, accurate and high-performance monitoring system in place that could deliver the data required on such a large scale. Topcon's MS Series robotic total stations were specified for the project chiefly because they provide data in 3D, whereas other structural sensors usually only work in 2D or have to combine

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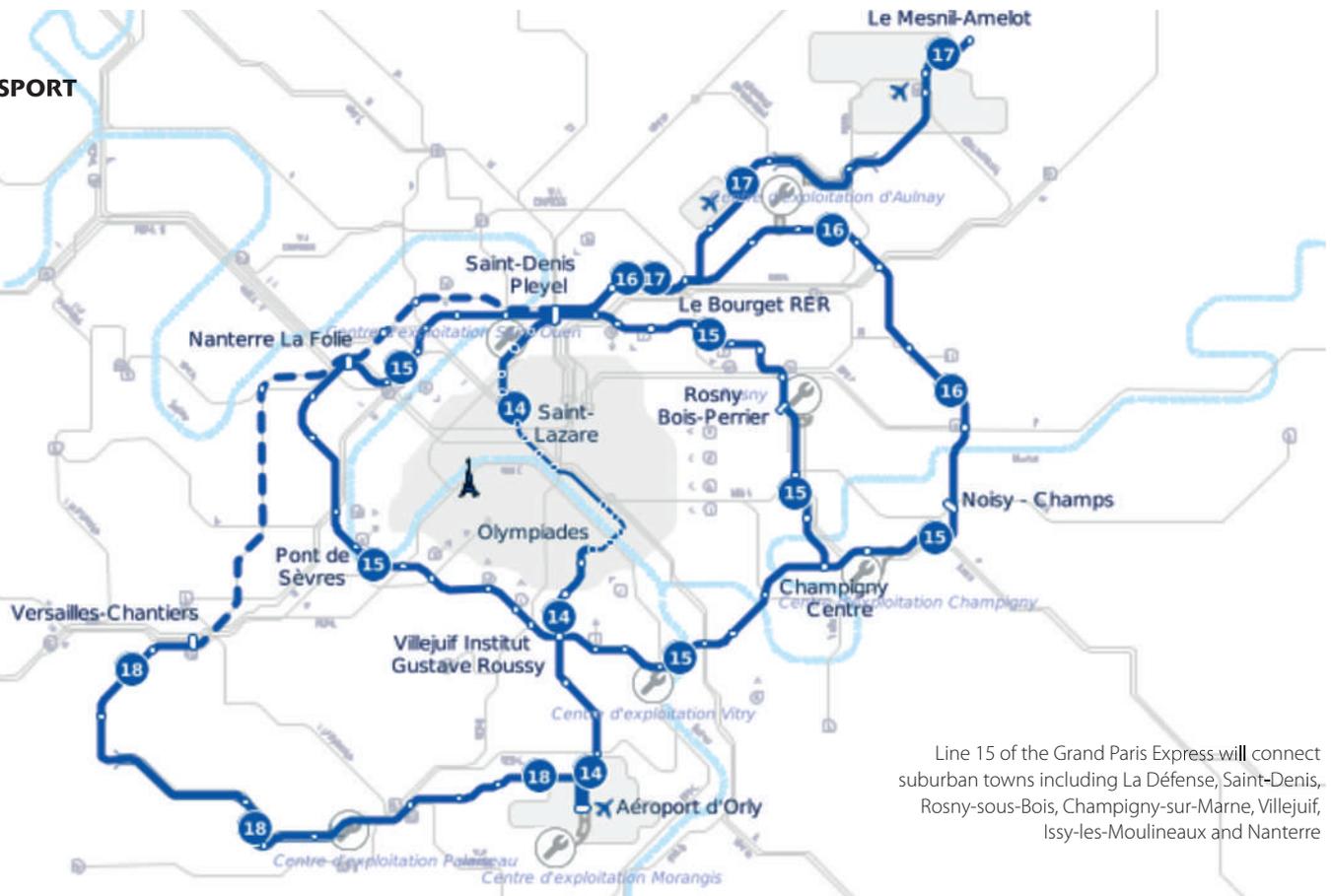


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## TRANSPORT



Line 15 of the Grand Paris Express will connect suburban towns including La Défense, Saint-Denis, Rosny-sous-Bois, Champigny-sur-Marne, Villejuif, Issy-les-Moulineaux and Nanterre

multiple datasets to get a full 3D profile. They also offer the highest precision angular and distance measurements available on the market, and there are currently over 100 of these instruments being used on Line 15.

Vincent Lamour, Cementys CEO, says: "We selected Topcon Total Stations for this project as not only are they highly robust and can withstand harsh construction environments, but they also offer long-term reliability."

### How total stations work

A total station is an ultra-high-precision surveying device that continuously measures the angles and distances of targets, or prisms, that have been fixed to a structure. Such structures include buildings, bridges, electrical or energy substations and existing rail infrastructure. Each instrument typically monitors around 75-100 different prisms, but they do have the capacity to monitor many more, with one total station on Grand Paris connected to 400 prisms in total.

The total stations are piloted by software that's installed locally to the instrument – usually within a metre or so. The software instructs the total station to turn, target a prism and take an observation. This is repeated three times an hour for each prism, with any change in the measurements being immediately communicated to site engineers as it indicates structural movement. For example, on existing railways, by putting prisms in pairs every two or three metres along the same track, you can compare the two datasets and understand how the rails are running relevant to each other, and to surrounding rails, to ensure the track is still safe to use.

Topcon's technology also includes unique Matrix Detection software that automatically locates all prisms within a specified area – ensuring quick, reliable data – while reducing the amount of installation time required, helping to minimise costs.

### Processing the data

Once the data is captured, it is transferred to the server – in this case via cellular modem – which processes it using computation and processing software.

The software takes the raw angles and distance data and processes it into coordinates and engineering units, giving the difference in movement in millimetres from the previous dataset.

Data is then presented via a web-based visualisation platform, which acts as a single portal where all the different data – including information from Topcon's total stations, as well as from Cementys' geotechnical sensors, strain gauges and tilt metres – can be compared and analysed.

Drawing on our experience from similar infrastructure projects, we worked with Cementys to provide a system of monitoring technology that could integrate into its own software systems, giving the team the 3D data it requires, but with extremely simple installation and monitoring frequencies that could be changed remotely.

Vincent comments: "We have been able to integrate this open technology perfectly into our global data management system, which also includes optical fibre sensors, vibrating wire sensors, and others. Furthermore, we received efficient technical service support during this integration

phase. Topcon engineers helped us to quickly select a fit-to-purpose solution."

### Added security

One of the major issues of concern for contractors working on the Grand Paris project is that of equipment safety. A project of this size requires thousands of pieces of high-value hardware installed all over the city and surrounding areas.

Construction equipment theft is a significant problem across the world, and something that has a genuine, tangible impact on contractors – from loss of profit to loss of time. On a project such as Grand Paris Express, this is obviously amplified, so Cementys needed added support in the form of security and anti-theft measures.

Topcon's integrated security software, TS shield, comes as standard with all its total stations, offering remote locking and location positioning data to within 100m anywhere on the planet depending on GPS/cellular coverage.

With urbanisation continuing at a rapid pace and the world population growing exponentially, the number of tunnelling and infrastructure projects around the world is only set to increase – and they're getting larger and more complex, as evidenced by Grand Paris. The use of automation and monitoring workflows will therefore be critical to ensure the safe and cost-effective delivery of subterranean projects.

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