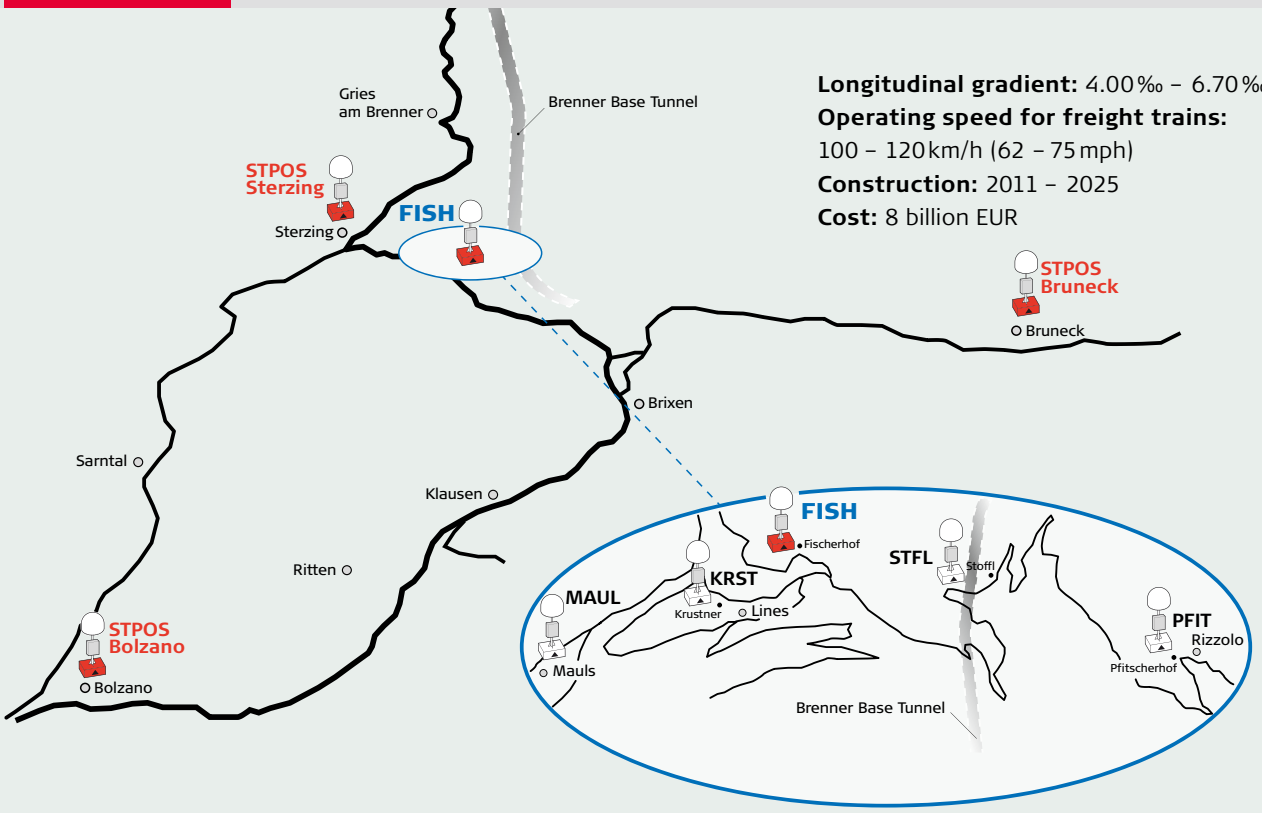
GNSS Monitoring for Safety on the Brenner

by Agnes Zeiner

When it is complete in thirteen years the 55 km (34 mi) Brenner Base Tunnel will be only 2 km (1.2 mi) shorter than the Gotthard Base Tunnel, which celebrated its breakthrough almost two years ago. Leica Geosystems instruments ensured the centimeter accuracy of the Gotthard miners' work and the engineers in charge at the Brenner Base Tunnel have also opted to use Leica Geosystems instruments and equipment for a wide range of tasks, among them the monitoring of a geologically unstable zone on the South Tyrol side of the Brenner Pass. Consulting engineers Trigonos and the European public limited company BBT SE (Brenner Base Tunnel Societas Europaea) are responsible for developing and executing the monitoring work, based on a sophisticated multi-stage continuous (GNSS) monitoring network.

Several sections of the exploratory tunnel for the Brenner Base Tunnel (BBT) are currently under construction. The six-meter in diameter exploratory tunnel will be centered directly below the two single-track main tunnel tubes and will serve as an escape and service tunnel after the BBT is open. The 1.5 km (0.9 mi) "Periadriatic Seam" section of the tunnel, running under the village of Mauls (Community of Freienfeld) in South Tyrol, is particularly precarious. Here the tunnel passes through the Periadriatic Seam – a geologic fault separating the Southern Limestone Alps from the Austrian Central Eastern Alps. The main fault zone is estimated to be about 200 m (656 ft) wide, with adjacent overstressed rock stretching for a kilometer.

The challenge posed by the Periadriatic Seam is well known to the project company – the European public limited company BBT SE, a cooperative venture between Austria and Italy. This section of the works was therefore undertaken with greatest caution. It is being carried out as a separate contract and the underground measurements required during tunnel driving are particularly complex. In addition, the Schwaz-based Tyrolean firm of consulting engineers



Longitudinal gradient: 4.00‰ – 6.70‰
Operating speed for freight trains:
100 – 120 km/h (62 – 75 mph)
Construction: 2011 – 2025
Cost: 8 billion EUR

Products used

Sensors:
- L1 – Leica GMX901 monitoring receiver
- L1/L2 – Leica GMX902 GG monitoring receiver and AX1202 GG antenna
- Leica Viva TS15 imaging total station

Software:
- Leica GNSS Spider, Leica SpiderQC, Leica GeoMoS

Services:
- Leica CrossCheck

Trigonos was commissioned to develop an above-ground monitoring concept: "In close cooperation with surveying engineers of BBT SE, we designed a GNSS monitoring concept and proved its suitability in practice during the baseline measurement and the initial follow-up survey," explains Lienhart Troyer, Managing Director of Trigonos, who is also involved in several other projects for the Brenner Base Tunnel.

Multistage Monitoring Network with 5 + 3 Stations

The above-ground survey has one primary question to answer: is surface settlement occuring during tunneling? The system must run fully automatically, and – should tolerances be exceeded – send text and e-mail notifications to the client and the site supervisory staff.

"We decided to set up a local GNSS network consisting of five points near the village of Mauls, which was then embedded in a higher-order network," explains Lienhart Troyer. The monitored zone covers an area of about two square kilometers, so only a GNSS solution would be able to achieve the required accuracy. The centrally positioned station in Fischerhof (FISH) is used as a reference station for the calculation of the baselines to the other stations in Mauls (MAUL), Krustner (KRST), Stoffl (STFL), and Pfitscherhof (PFIT).

"We wanted to keep the baselines as short as possible to maintain the highest possible accuracy. However, this also means the reference station itself is positioned in a potential deformation zone. Any settlement or movement of the reference station would influence the results of the other four stations. This

BBT SE

Headquarters:
Bolzano, Italy and Innsbruck, Austria
Employees: > 90
Established:
2004 as a European public limited company
Executive Board:
Raffaele Zurlo, Konrad Bergmeister
Responsibles Surveying:
Pierluigi Sibilla, Claudio Floretta, Gregor Windischer

For more information, please visit: www.bbt-se.com

The Brenner Base Tunnel

The Brenner Base Tunnel is the key section of the 2,200 km (1,367 mi) long Berlin-Munich-Verona-Bologna-Palermo high-speed railway axis. This flat trajectory, rail-only tunnel with a length of 55 km (34 mi) will be primarily used for the transport of goods. It consists of two single-track main tubes with an exploratory tunnel running below them. The main tubes will be driven 70 m (230 ft) apart and linked every 333 m (1,092 ft) by connecting side tunnels. Including the existing 7.7 km (4.8 mi) underground freight train bypass around Innsbruck, the 62.7 km (39 mi) base tunnel will be the longest railway tunnel in the world. The tunnel is designed for a maximum speed of 250 km/h (155 mph). In addition to the Innsbruck freight bypass, the line will tie-in to the existing infrastructure of the Innsbruck and Fortezza train stations. Multi-function stations in the tunnel will be located at Innsbruck, St. Jodok, and Trens. *(Source: BBT SE)*

is why the reference station is additionally monitored using data from three stations forming part of the GPS reference service STPOS in the Bozen/South Tyrol province," explains Lienhart Troyer. The lengths of the baselines between the Fischerhof reference station and the three STPOS stations at Sterzing, Bozen, and Bruneck range from 10 km to more than 43 km (6 mi to more than 27 mi). "This hierarchical monitoring network can reliably detect movements of the Fischerhof station, while being able to provide precise local information about possible deformations in the area being monitored."

Installation and First Measurements

Trigonos' contract included implementation of their concept, including baseline measurement and the initial follow-up survey. After several visits with staff from BBT SE, the exact locations of the five stations were chosen. BBT SE conducted the negotiations with the landowners, followed by a construction company erecting the foundations and masts for the antenna communications equipment. Four stations have a 230 V power supply. The Stoffl station was powered by battery for the baseline measurement and initial follow-up survey but will subsequently be operating continuously with a photovoltaic supply of energy. Backup batteries with a capacity of 48 hours will ensure the stations' uninterrupted operation.

The necessary software was installed in the office and included Leica GNSS Spider to operate the network and the individual stations. "The baseline measurement took place in July over a period of 48 hours. We went through the entire GPS constellation several times," says Lienhart Troyer. A Leica GMX902 GG dual-frequency monitoring receiver was used at the reference station, and Leica GMX901 monitoring SmartAntennas were installed at the other four stations. Data transfer was wireless over GPRS/UMTS in real time, with Leica SpiderQC continuously checking data quality. A first follow-up survey, also lasting 48 hours, was performed in August to confirm the baseline measurement data.

Specialists from Leica Geosystems, Heerbrugg were involved with the data analysis, the results of which were incorporated into the BBT frame network. "Because of the length of the base lines and the high accuracy requirements, we relied on CrossCheck, the coordinate calculation service provided by Leica Geosystems, for the calculation of the higher-order network. This meant we avoided purchasing special software for this project and saved a great deal of additional training time. Our expectations of accuracy were completely fulfilled," says Lienhart Troyer, expressing Trigonos' satisfaction with the outcome.

A Leica Viva TS15 Total Station monitoring surface movements in Mauls.

Europe-wide Tender

In January 2012 Trigonos was awarded the Europe-wide tender for the continuous operation of the monitoring system issued by BBT SE. This phase of the project will start simultaneously with the tunnel driving in the area of the Periadriatic Seam in April 2012 and will be maintained for at least three years.

In addition to the GNSS monitoring, a terrestrial monitoring system, using a Leica Viva TS15 imaging total station and prisms, was installed in Mauls to obtain reliable and immediate information about ground surface movements, particularly in the densely built center of the 2000-strong community of Mauls. ■

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Trigonos ZT GmbH

Headquarters: Schwaz, Austria
Employees: 21
Established: 1975 as Vermessungsbüro Weiser, restructured in 2008
Managing Directors:
Lienhart Troyer, Christoph Kandler, Joachim Feldes

Projects on the Brenner Base Tunnel include:
Surveying framework contract for the Austrian sector, construction surveying on the Brenner North pilot tunnel, and geodetic level monitoring of the exploratory construction contracts

Leica Geosystems value-added reseller of geomonitoring products since 2009.