

Beside the savings in labour there are major potential savings in overall project costs using a system such as TMS Solution from Amberg Technologies. Another area of application was at the portal sections of the soft ground sections. Here a pipe umbrella had to be created to enable the full span of the crown section to be excavated. A key component of this technique is to drill the pipes in a very precise fan shaped pattern from regular points on the arch.

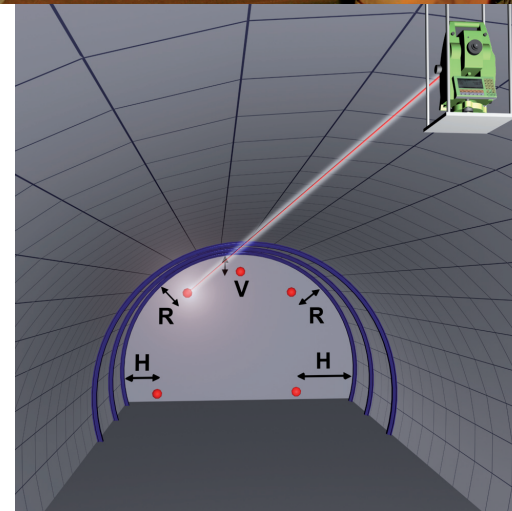
The setting out for this operation was also achieved using TMS Solution which calculated the point on the face and identified it with the red laser so that it could be marked with paint. Then, once the face was marked up and the drilling machine had located the drill bit on the point, by calculating the offset in three dimensions the operator was able to identify the exact position of the back of the drill carriage, in turn controlling the direction of the drill or tube being placed in the ground. Prior to the TMS „jetting“ task being used the total marking up operation was taking as long as 10 hours. After starting with TMS Setout the whole cycle took only 3 hours. More significantly the location of the drill carriage previously required the presence of the surveyor and would take at least 30 minutes for each hole whereas afterwards the foreman was able to achieve the same accuracy and reliability in only 10 minutes.

TMS Solution can find applications in almost every activity required for conventional tunnel construction and many in the works carried out behind the TBMs for the finished tunnel. All the applications in TMS Solution are defined through TMS Office and set up by the surveyor but operated on a repetitive basis by the tunnelling crew. To maintain some regulation over the activities if the crew in doing their own setting out each foreman has a password controlled user name and it is possible for the surveyor to check all the actions carried out on the total stations.

**Complete drill setout within short time.**



Steel arch positioning by tunnel crew - easy, fast and precise. Visual control with help of red laser and target plate.



Finally combined with the identification of what tasks have been carried out is the reporting functions available in TMS Office to provide the project management team with the facts and figures needed from cost management through to quality assurance.

Amberg Technologies AG  
Trockenloostrasse 21  
CH-8105 Regensdorf  
Switzerland

Phone +41 44 870 92 22  
Fax +41 44 870 06 18  
info@amberg.ch  
www.amberg.ch



Project report TMS Solution

## Accepting the challenges in tunneling - TMS Solution at its best

Uetliberg Zürich, Switzerland



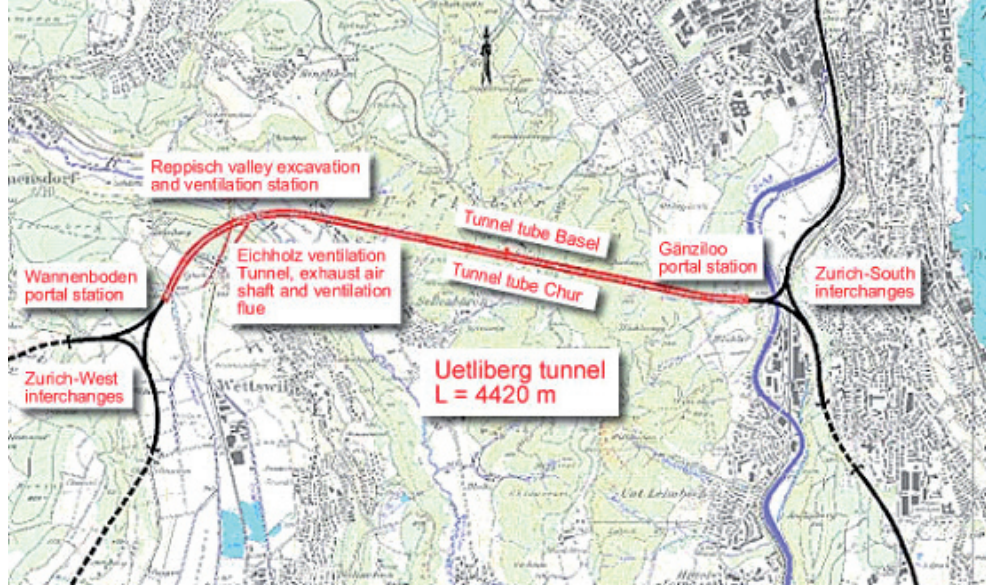
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The Uetliberg tunnel is the major part the Zurich Western Bypass, a project to reduce congestion of through traffic from Germany through Switzerland to Italy. The Uetliberg project consists of two parallel tubes 4420m long containing 2 lanes and a hard shoulder; the overall project cost is 1.1 billion Swiss francs or 770 million Euros

The tunnel is being constructed by a joint venture, ARGE Uetli, lead by Zschokke Locher, including the companies Murer AG, Prader AG, CSC Bauunternehmung AG, Wayss & Freytag GmbH, Alpine Mayreder Bau GmbH, ZüblinSchlittlerSpaltenstein Bau AG.

Because of the varied geology and the alignment required this project utilises many different types of tunnelling techniques. There are two different types of tunnel boring machine, sections of drill and blast and also various conventional soft ground techniques being applied. At the start of the project because of the demands of the overall schedule, tunnel development was being carried out on as many as 6 faces at one time. A project of this size and complexity would normally need perhaps 6-8 qualified surveyors and several assistants. However there are in fact only 2 surveyors on site for the contractor, even though the site is working 24 hours during the week. This is because the ARGE Uetli are using a system of Leica TPS1100 series total stations with TMS Setout (Plus) and TMS Profile (Plus) software packages to provide powerful flexible solutions for production efficiency. The concept



Overview Uetliberg tunnel project in Greater Zürich.

behind this software solution was to identify the production tasks required and automate them so that a non-expert surveyor such as the tunnel foreman could carry out the setting out. The key benefit of this approach is that there is no delay waiting for the surveyor and the work carried out by the excavation crew is much more accurate and productive. On this project there are as many as 8 TMS (Tunnel Measurement System) Solutions hardware and software systems from Amberg Technologies employed at any one time.

The most noticeable application of the TMS Solution was in the soft ground sections at the Gjuch, Juchegg and Diebis portals and soft ground geology. The cross section is excavated by two upper sidewall galleries, which are followed at a distance of 20 to 40m by the two lower sidewall

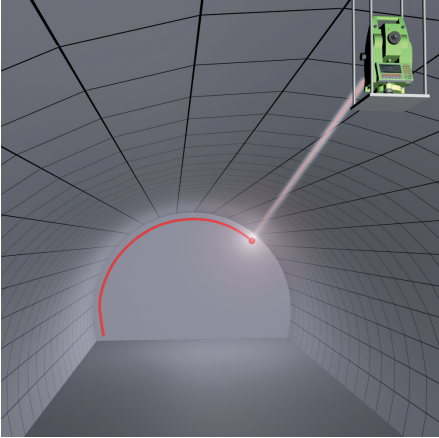
galleries. The crown and the core follow the sidewalls. The base ring is normally finished 40m behind the crown face. As soon as the crown is excavated to a depth of 12 meters, the work switches to the base excavation. Typical total overall advances are 1.3m per day.

This construction pattern is required to produce the finished tunnel profile as shown and also for the support of the soft ground. The surveying requirement for setting out these arches is vital because their position will dictate the final alignment, transverse slope and longitudinal slope. To position the arches accurately would normally be the job of a site surveyor who would be called into the site when the excavation crew had finished the excavation to the approximate profile required within which to fit the arches. However this causes serious delays due to having

all the design data, such as alignment, excavated profile, position of arches, thickness of shotcrete required and so forth. The project data is transferred from the PC to the total station via the PCMCIA card standard on Leica TPS.

For each excavation cycle the tunnel foreman first uses the task in TMS Setout (Plus) called "contour" to indicate precisely to the crew the correct excavated profile before erecting the steel arches. The steel arches can then be positioned in the face and adjusted to the exact position by lining up the visible red laser and a predefined offset using TMS Setout (Plus).

Once the arches are in place and fixed, shotcrete with steel fibres is used to complete the primary support. Once the shotcrete is applied it is again necessary to check the overall profile of the tunnel, this is performed using TMS Solution although this time with the TMS ProScan (plus) on-board software. The entire operation for the arches is carried out in approximately 15 minutes whereas previously it might sometimes take as much as several hours including down time waiting for the surveyor. The further into a tunnel and the more number and complex the excavations this becomes even more critical.



Setout task „contour“ to demonstrate excavation profile.

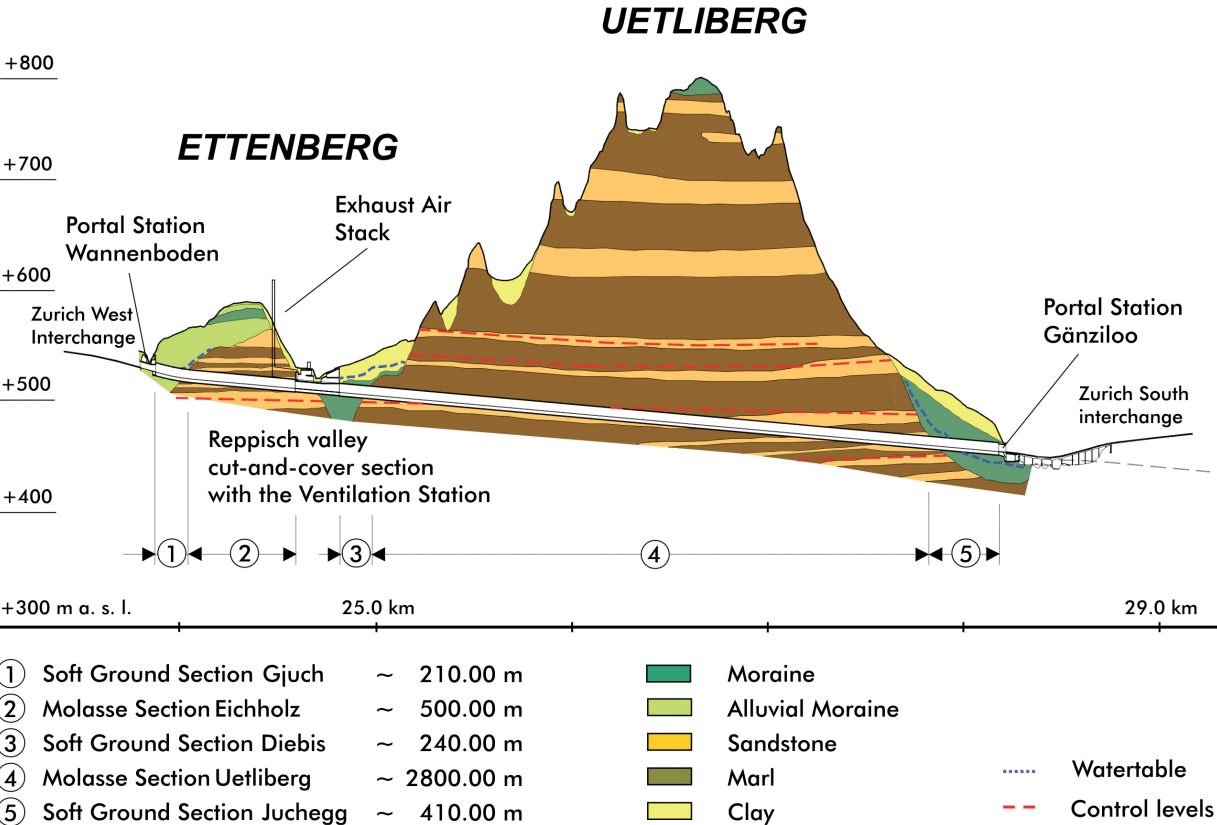


Perfect combination: The New Austrian Tunnelling Method (NATM) and TMS Solution from Amberg Technologies.

to wait for the surveyor and then once they have arrived in placing the arches in the face. If the face has not been excavated to a large enough profile then they will need to be removed and excavation continued. Alternatively if the profile is made too large the quantity of shotcrete required in between the arches is increased considerably. Both activities significantly increase the costs for the tunnel construction.

On the Uetliberg tunnel however this is not the case. On each side of the tunnel a Leica TCRA1105 is mounted on a permanent bracket out of the way of the construction equipment. Each of these instruments contains the powerful on-board TMS SetOut (plus) software with all project data prepared and loaded by TMS Office on an office based PC. TMS Office is the common platform for handling

The Amberg Technologies team (from left): Jürgen Jacob, Yves Tschudin, Jens Noack and Klaus Herbert



Longitudinal profile including geological profile of the Uetliberg tunnel.