FUTURE CIRCULAR COLLIDER

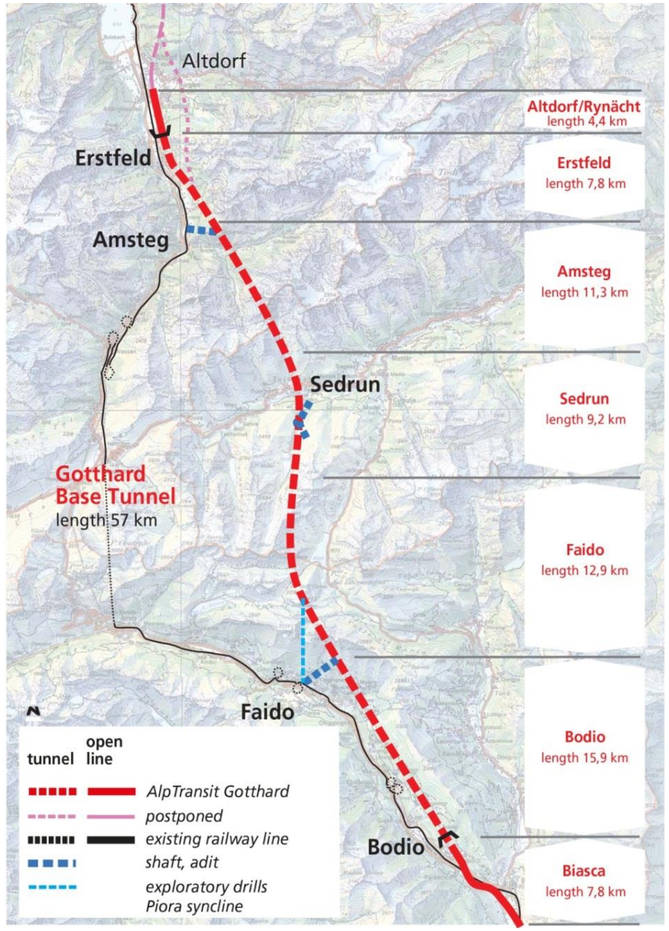
FUTURE CIRCULAR COLLIDER

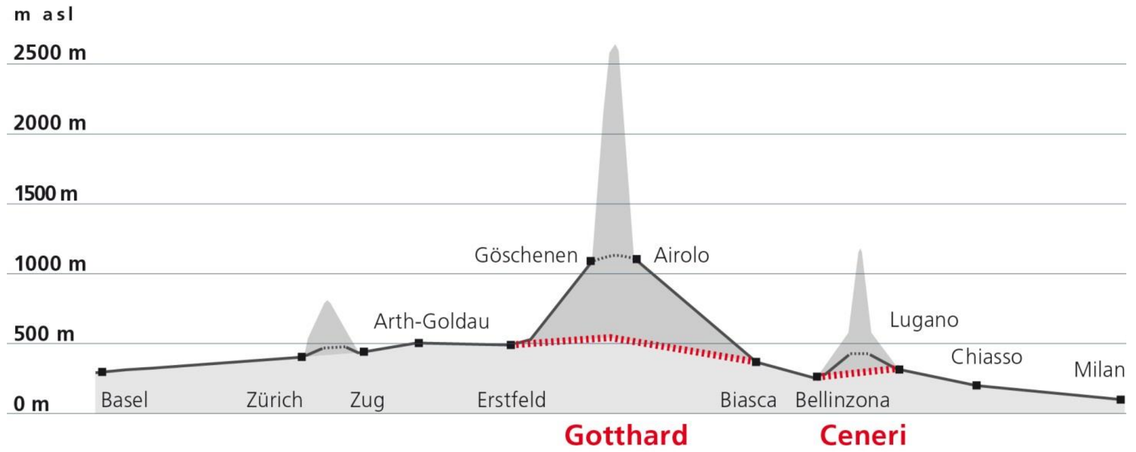
SURVEYING OF THE FCC EXPERIENCES FROM THE GOTTHARD BASE TUNNEL PROJECT

Adrian Ryf
Member of the FCC Geodesy Advisory Board
Former head of geomatics at AlpTransit Gotthard Ltd

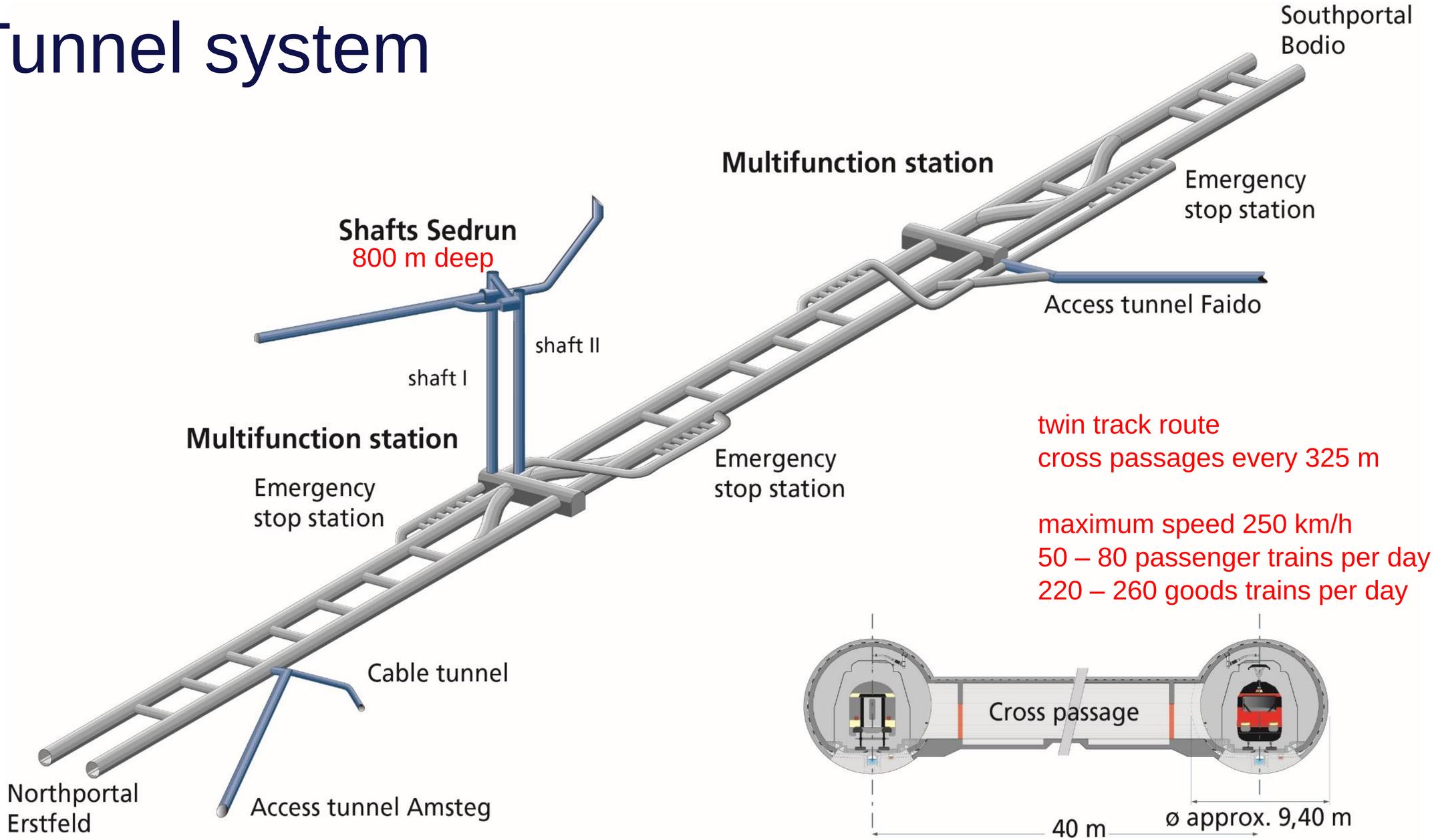
Gotthard Base Tunnel

Part of the Rail Freight Corridor Rotterdam – Genoa, length 57 km, flat railway route through the Alps, opened in 2016





Tunnel system



twin track route
cross passages every 325 m

maximum speed 250 km/h
50 – 80 passenger trains per day
220 – 260 goods trains per day

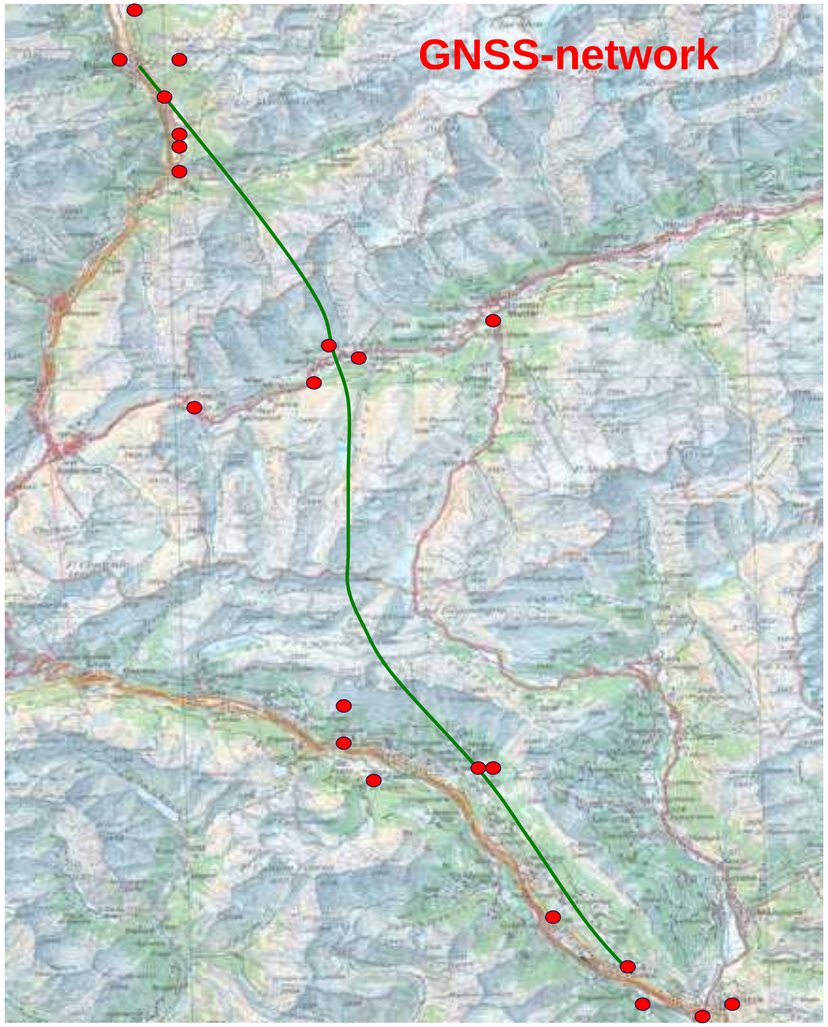
Accuracy requirements for the shell construction

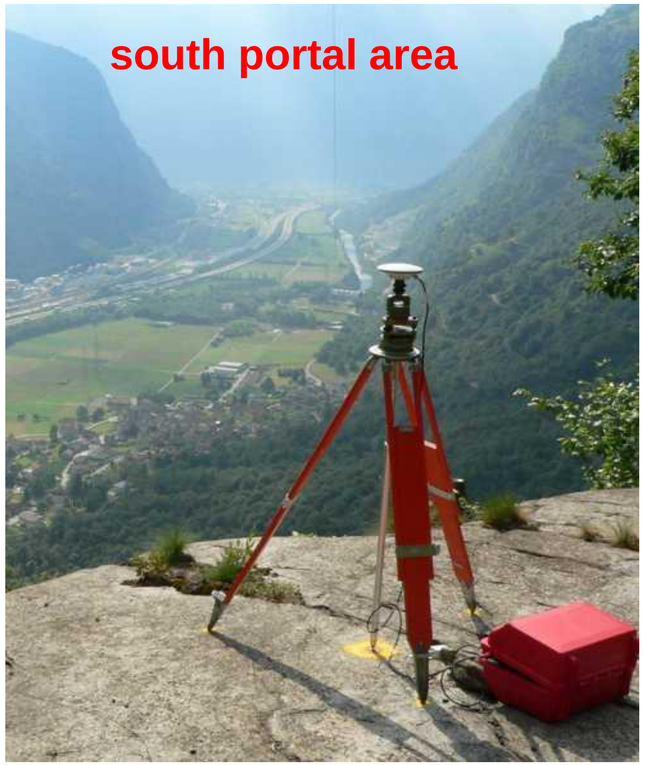
	standard deviation	tolerance (reliability)	realized in the main breakthrough
position (direction)	10 cm	25 cm	8 cm
height	5 cm	12.5 cm	1 cm

For the FCC, the definitive accuracy requirements have yet to be defined with the civil engineers.

The tolerances might be smaller!

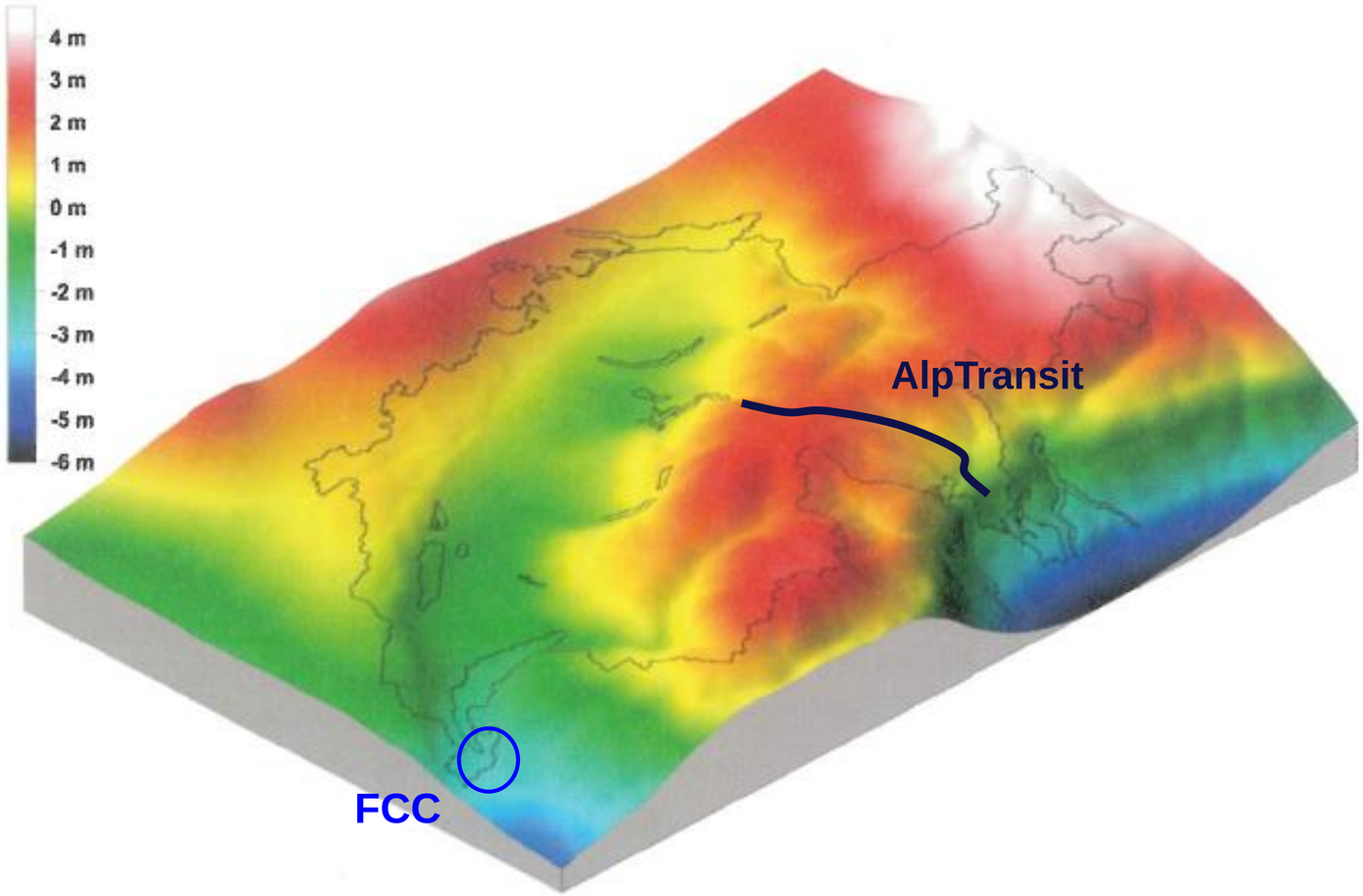
Surface geodetic reference network





For the FCC a similar GNSS-network has to be established before the construction works start.

Geoid in the Swiss Alps



Differences of the geoid heights: several meters

Deviations of the verticals: several mgon

The plumb lines are curved

In the FCC area the differences are smaller, but the accuracy requirements are higher!

Geodetic tasks in the Sedrun shafts (800 m)

Transfer of 3D-coordinates (north, east, height): plumbing and vertical distance measurements → accuracy: 5 mm

Optical plumbing

top of the shaft

Nadir plumb instrument

bottom of the shaft

Mechanical plumbing

determination of the wires
(Ø 2mm) at the top of the shaft

weight: 375 kg

determination of the wires
at the bottom of the shaft

Geodetic tasks in the Sedrun shafts

Transmission of direction with gyroscope and inertial measurement unit (IMU) as an independent control

Gyromat 2000

IMU platform in the shaft hoisting system

IMU with 3 acceleration sensors and 3 laser gyros

connection with the tunnel network with autocollimation

velocity of hoisting system: 16 m/s

Accuracy oft the direction transfer: 1.3 mgon (gyroscope), 1.5 mgon (IMU)

The FCC is built almost entirely over shafts several 100 m deep.
One of the biggest challenges for the surveyors is the highly accurate and reliable transmission of direction in the shafts.

Slab track

In order to minimize maintenance, a slab track (ballastless track) was installed in the Gotthard Base Tunnel

The high precision stakeout (0.1 mm) was done with a motorized track measurement system:

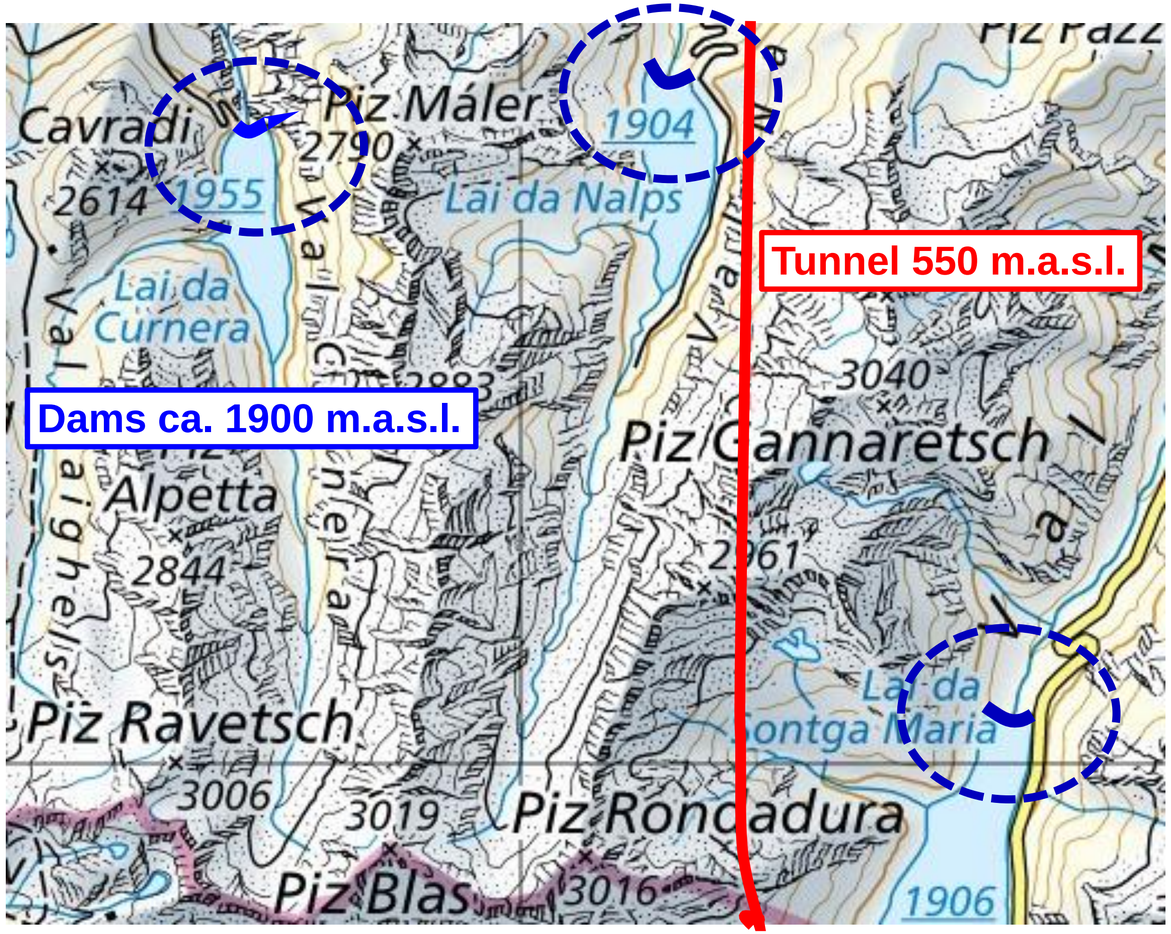
- Reference points every 50 m at the tunnel walls
- Tacheometer to fix the absolute position
- 4 laser scanners to fix the relative position of the two rails

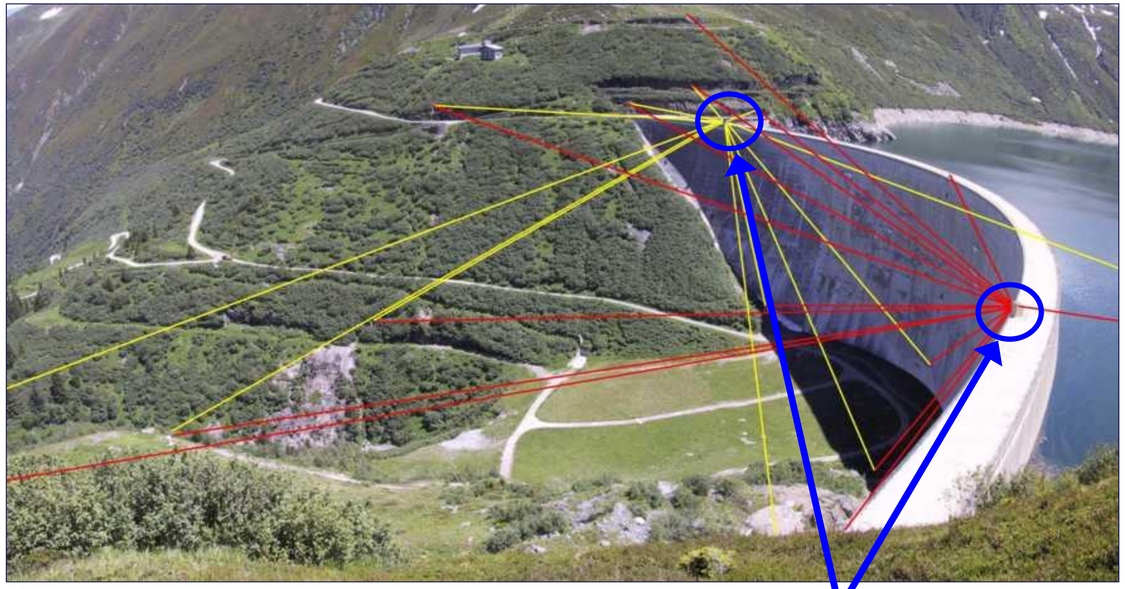
The installations in the FCC will require an even higher accuracy and therefore even more sophisticated instruments.

Monitoring above the tunnel

Surrounding of three arch dams with tacheometer stations during almost 15 years

Three Arch dams above the Gotthard base tunnel





© swissphoto

Monitoring above the tunnel

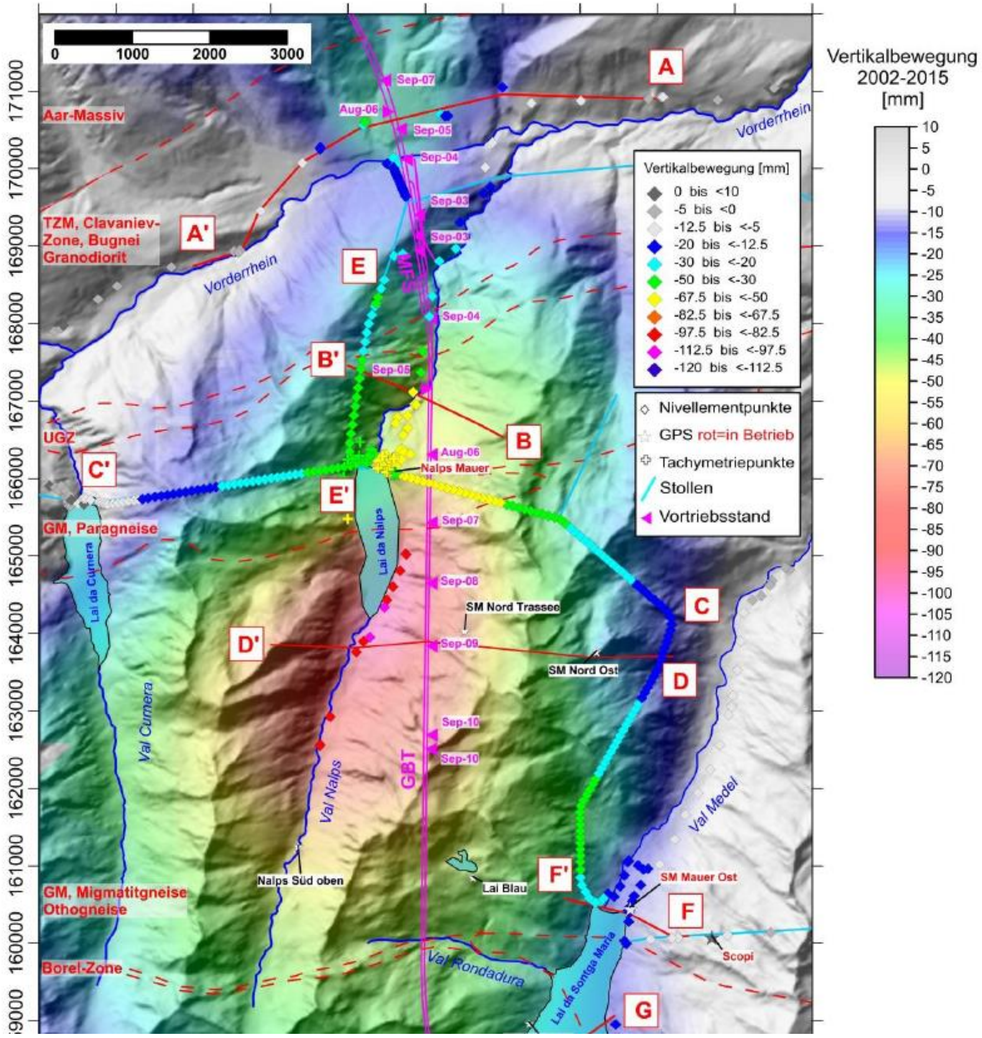
10 GNSS permanent stations during 13 years / precise levelling: 100 km every year

GNSS 2500 m.a.s.l.

Precise levelling

Monitoring above the tunnel

Syncline above the tunnel



Tunnel construction works had a drainage effect

Vertical movements of up to 12 cm in 13 years
in an area of 10 x 15 km

In the FCC area the vertical movements might be much smaller, but the FCC is much more sensitive than the Gotthard Base Tunnel.

→ The FCC area must be monitored.

→ The monitoring should start a few years before the construction works

Thank you for your interest and attention