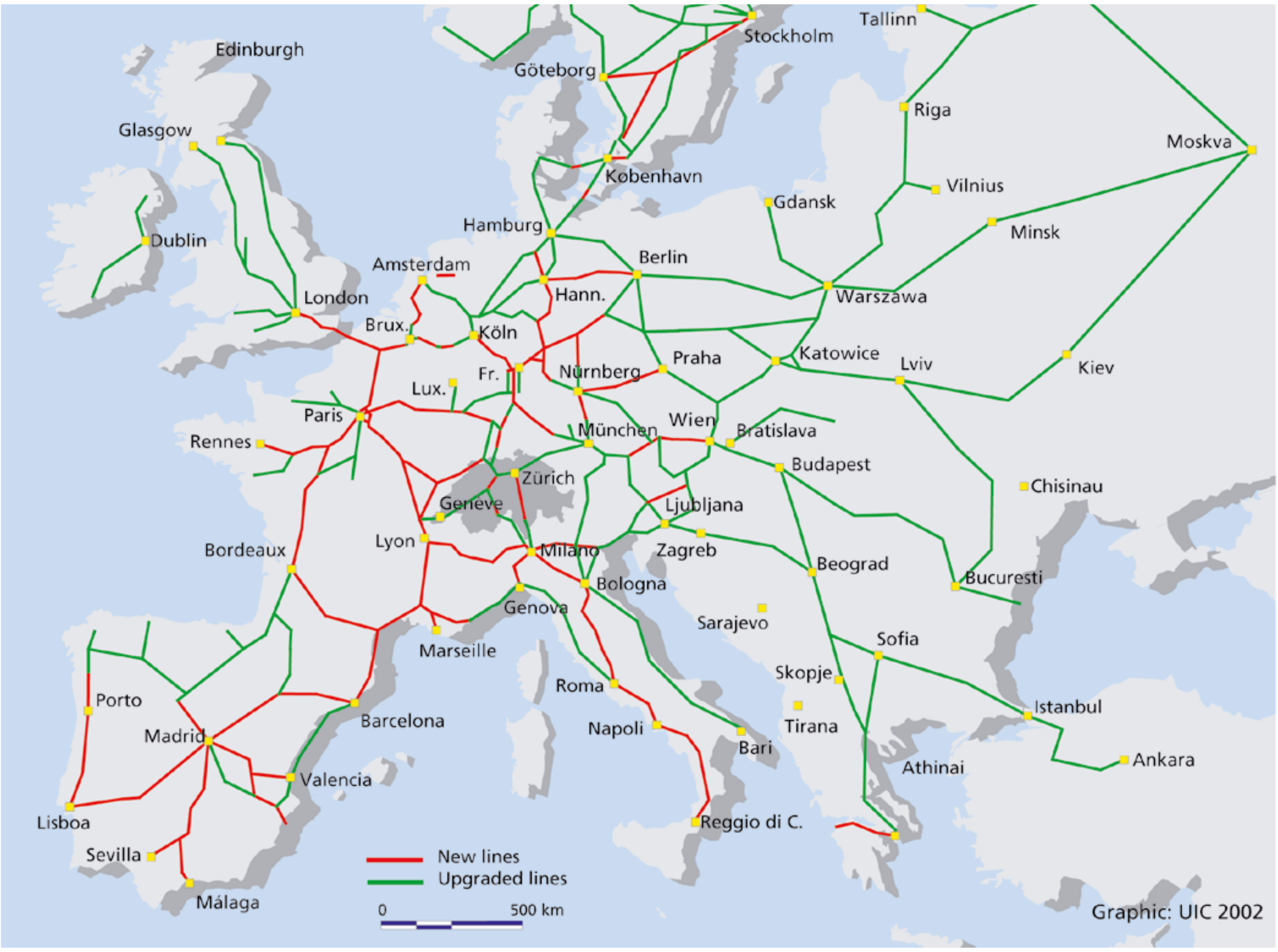
The New Gotthard Rail Link

AlpTransit Gotthard is creating a flat rail link for future travel through the Alps. At the heart of the new trans-alpine rail route is the world's longest tunnel – the 57 km Gotthard Base Tunnel. This pioneering achievement of the 21st century will bring major improvements to travel and transportation systems in the heart of Europe.

The high-speed link with Europe

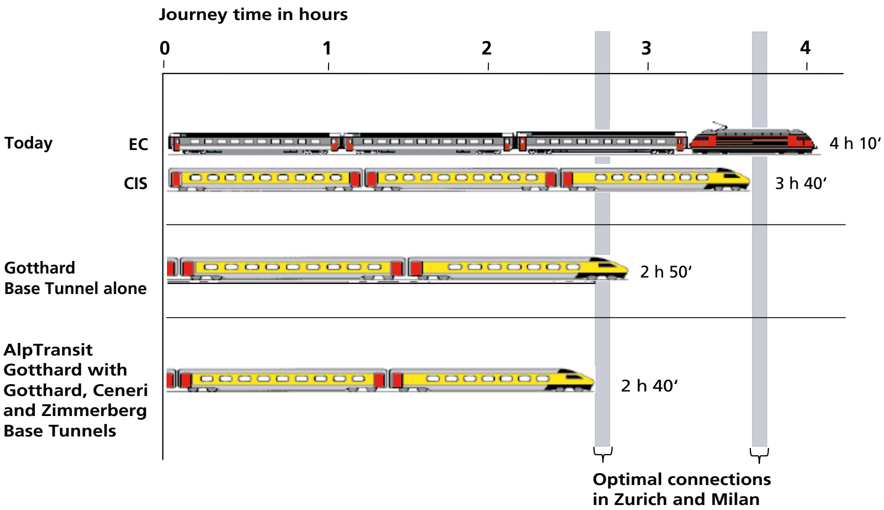
By constructing the New Rail Link through the Alps (NRLA), Switzerland is integrating itself into the growing European high-speed network. The future rail link will bring the economic centres on both sides of the Alps closer together – the flat link under the Gotthard opens up new prospects for rail traffic through the Alps.



The European high-speed rail network in 2020

In the last 20 years a pan-European network of high-speed railways has come into existence and is steadily growing further. Depending on how projects develop, there may be up to 20,000 km of high-speed lines in Europe by 2020. With such a well-developed railway system, passenger travel by train becomes an attractive alternative to the car. If the train journey time between two cities can be reduced to under four hours, the railway also offers serious competition to flying.

The high-speed systems in Europe are being expanded further, and coordination between them is being improved. The goal is for signalling systems and train control systems to be standardised across national boundaries. The resulting interoperability is a key factor for efficient operation.



Journey times for passenger trains between Zurich and Milan at different project stages

The new lines in Switzerland are also designed for inter-operability. The New Rail Link through the Alps (NRLA) will make high-speed travel in Switzerland a reality: the AlpTransit trains of the future will travel at 200 to 250 km/h. In addition, the new Gotthard route is the most impressive Alpine crossing ever made: at 57 km the Gotthard Base Tunnel will be the longest railway tunnel in the world.

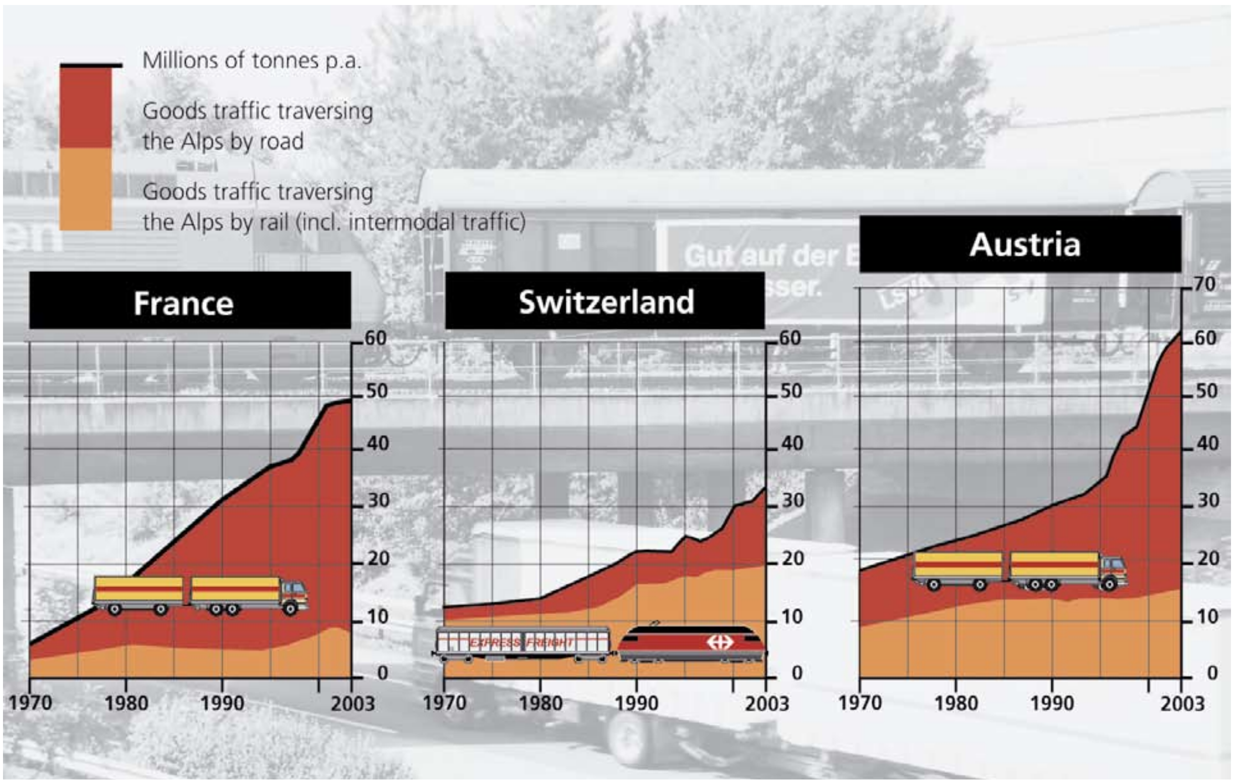
A new era in transalpine transportation

More and more people and goods cross the Alps. Switzerland wants as much as possible of this growing volume of traffic to travel by rail. Construction of the NRLA sets a milestone in Swiss transport policy and lays the foundation for environmentally compatible management of mobility.

Transalpine freight traffic by road and rail has increased continuously in the EU and Switzerland. International trade is growing faster than domestic trade. Demand for freight transportation to and from Italy will continue to rise steeply.

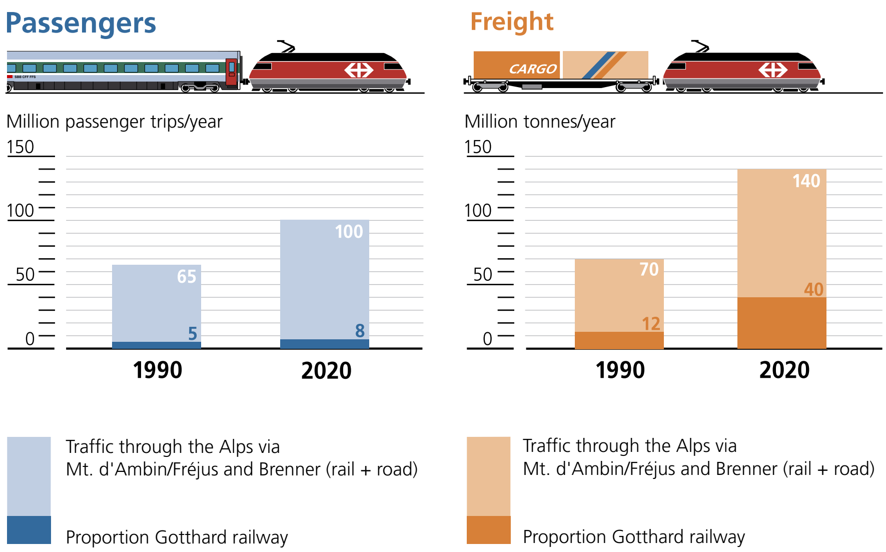
European freight traffic across the Alps today mainly burdens the roads. Transalpine road traffic doubles every eight years whereas rail traffic remains constant. Raising the weight limit from 28 to 40 tonnes has resulted in fewer trucks bypassing Switzerland via Austria and France. Transit traffic will continue to increase. Freight traffic in the entire Alpine region will grow by as much as 75% by 2010 according to a study by the EU Commission.

If this trend continues it will endanger the quality of the environment for ourselves as well as future generations. Earlier than other nations, Switzerland has therefore incorporated into its constitution a traffic policy aimed at making mobility as environmentally compatible as possible. However, such traffic volumes are more than the 130-years-old Gotthard route can accommodate. Only by upgrading its railway infrastructure can Switzerland meet the rising demand for freight transportation and the increasing needs of customers. Thanks to the two NRLA routes through the Gotthard and Lötschberg, annual freight transportation capacity will be more than doubled from 20 million tonnes now to around 50 million tonnes. That is sufficient to cope with the forecast increase. Higher capacity and quality bring major benefits for customers.



Modernising the railway infrastructure

Transferring traffic from road to rail is a step towards Switzerland's goal of sustainable, environmentally compatible transportation. To achieve this goal, enormous investments in public transport infrastructure are needed.



Forecast growth in transalpine traffic from 1991 to 2020

Switzerland's existing railway network is being expanded and modernised with four key objectives: making Switzerland more attractive to business; improving environmental compatibility; ensuring that public transport can be financed; and embedding the Swiss transportation infrastructure in the European network.

Four projects will achieve these objectives: AlpTransit, Rail 2000, integrating Switzerland into the European high-speed network, and noise reduction on existing lines and rolling stock. The demand for freight traffic will be met mainly by expanding the north-south axis to make it more attractive in the domestic market, as well as to provide more efficient connections between economically strategic areas of Switzerland, Italy and Germany.

Passenger traffic today stays mainly within Switzerland, or travels between Switzerland and Italy, rather than crossing the country from border to border. However, implementation of a pan-European high-speed railway network is proceeding rapidly, business is becoming increasingly international, and cross-border mobility is growing in significance. Against this backdrop, integration into the European high-speed railway network is vitally important for Switzerland.

Freight traffic will enter a new era when high-performance freight trains travel at speeds of up to 160 km/h. Thanks to these high speeds, freight trains will not have to stop so often, or so long, to let passenger trains overtake.

Thanks to AlpTransit the north-south rail link will become an ultramodern, highly efficient traffic carrier offering increased transportation capacities and shorter journey times. In addition, it will guarantee sustainable, environmentally friendly management of mobility for the ever increasing volumes of traffic.

Financing the modernisation

Modernisation of the railways is part of an integral financing plan approved by Swiss voters in 1998.

The Swiss electorate accepted the proposal for financing construction of the public transport infrastructure (Finöv) on November 29, 1998. This provides the means for comprehensive modernisation and expansion of the railway infrastructure. In addition to the NRLA and Rail 2000, connections from east and west Switzerland to the European high-speed network, as well as noise reduction measures along the railway lines, will be implemented.

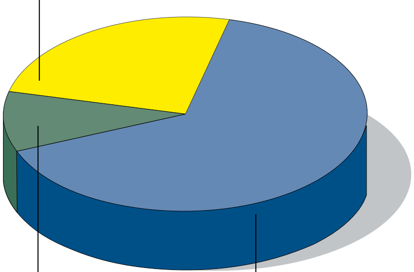
Financing is through a special fund fed by a tax on oil products, a heavy-vehicle tax, and one-tenth of one percent value added tax (VAT).

Approximately CHF 30 billion are being invested over a period of 20 years in the modernisation package, of which about half is for the New Rail Link through the Alps (NRLA). Construction of the Gotthard Base Tunnel, for example, will cost about CHF 7 billion and construction of the Ceneri Base Tunnel more than CHF 2 billion.

The two base routes are being constructed in phases. On the new Gotthard route, construction of the Gotthard Base Tunnel has started. Construction of the base tunnels under the Ceneri and the Zimmerberg will follow somewhat later.

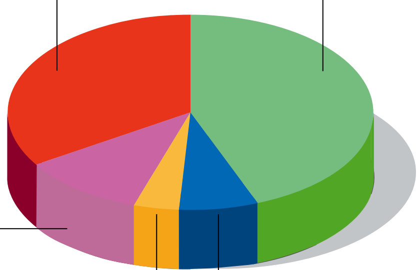
Origin of revenues

Total approx. CHF 30 billion



Use of the financial resources

Total approx. CHF 30 billion



Faster trains, better connections, quicker journeys

Future rail services will be improved not only by the superior railway network but also through new rolling stock. The main passenger axis will be between the centres of Zurich and Milan.

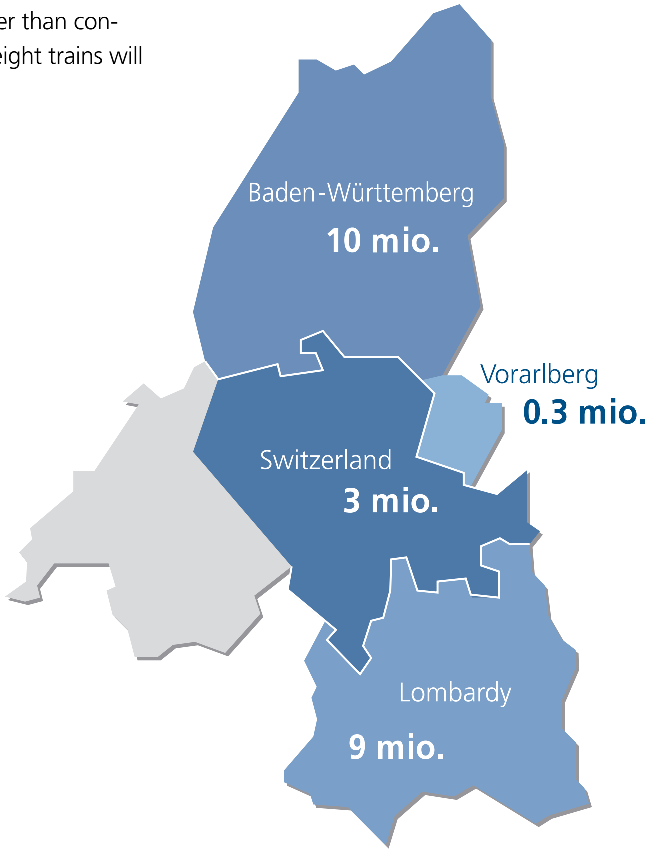
The new Gotthard railway, along with improvements made within Rail 2000, and thanks to new rolling stock, will bring much shorter journey times. The 3 hours and 40 minutes needed now to travel from Zurich to Milan through the Gotthard on the Cisalpino tilting train will be cut to 2 hours and 40 minutes. Further reductions are entirely conceivable. Rail travel is then a genuine alternative to road and air. The shorter travel times will benefit approximately 20 million people living in the immediate catchment area of the new line through the Gotthard.

The Gotthard: the fastest Alpine crossing

International passenger connections between the hubs of Zurich and Milan will be much faster through the Gotthard Base Tunnel. They will bring the centres of southern Germany and the industrial cities of northern Italy – especially its metropolis Milan – much closer together.

Trains on the new route through the Gotthard will travel according to the basic-interval timetable of Rail 2000 north of the Alps. The basic-interval systems of Rail 2000 and Italian National Railways (Trenitalia) can be integrated. There will be hourly connections from eastern Switzerland to Arth-Goldau. Milan will become the southern hub of the Rail 2000 system. Hourly connections between Zurich/Basel and Milan will form the basic interval. Zurich and Bellinzona will be within commuting distance.

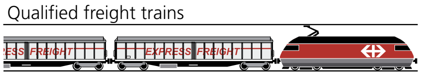
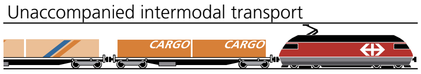
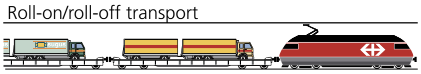
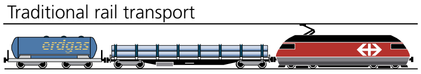
Rolling stock will match the new infrastructure. international passenger trains will be more comfortable, faster and quieter. Modern tilting trains, as well as the familiar TGV and ICE high-speed trains, can travel at more than 200 km/h on the new lines, and on existing tracks are up to about 30% faster than conventional trains. Transit freight trains will also be faster and quieter.



More than 20 million people live in the Gotthard catchment area

Freight travels best by rail

European demand for freight traffic will continue to grow. The biggest market opportunities for railway freight traffic will be in unaccompanied intermodal transport and high-performance freight trains.

Future freight trains	Maximum speed (km/h)	Maximum load hauled (t)	Maximum length, incl. locomotive (m)
Qualified freight trains 	≤160	1200	450
Unaccompanied intermodal transport 	120	2000–4000	750–1500
Roll-on/roll-off transport 	120	2000–4000	750–1500
Traditional rail transport 	100–120	2000–3200	750

Freight transportation will be more efficient

Demand for freight traffic in Switzerland will increase by up to 78% by 2030 according to studies conducted by the Swiss Federal Office for Spatial Development. Transit traffic will grow faster than this. The proportion of freight traffic which travels by rail will increase in response to the Swiss traffic policy. Customers will also demand improvements in operations and administration. The future quality of the timetable for freight traffic must be improved, and coordinated with the timetable for passenger trains.

150 freight trains per day cross the Gotthard today. Construction of the AlpTransit Gotthard will increase this capacity to more than 200 trains per day and also allow longer trains. Compared with the present, this will just about double the amount of freight which can be transported to around 40 million tonnes per year.

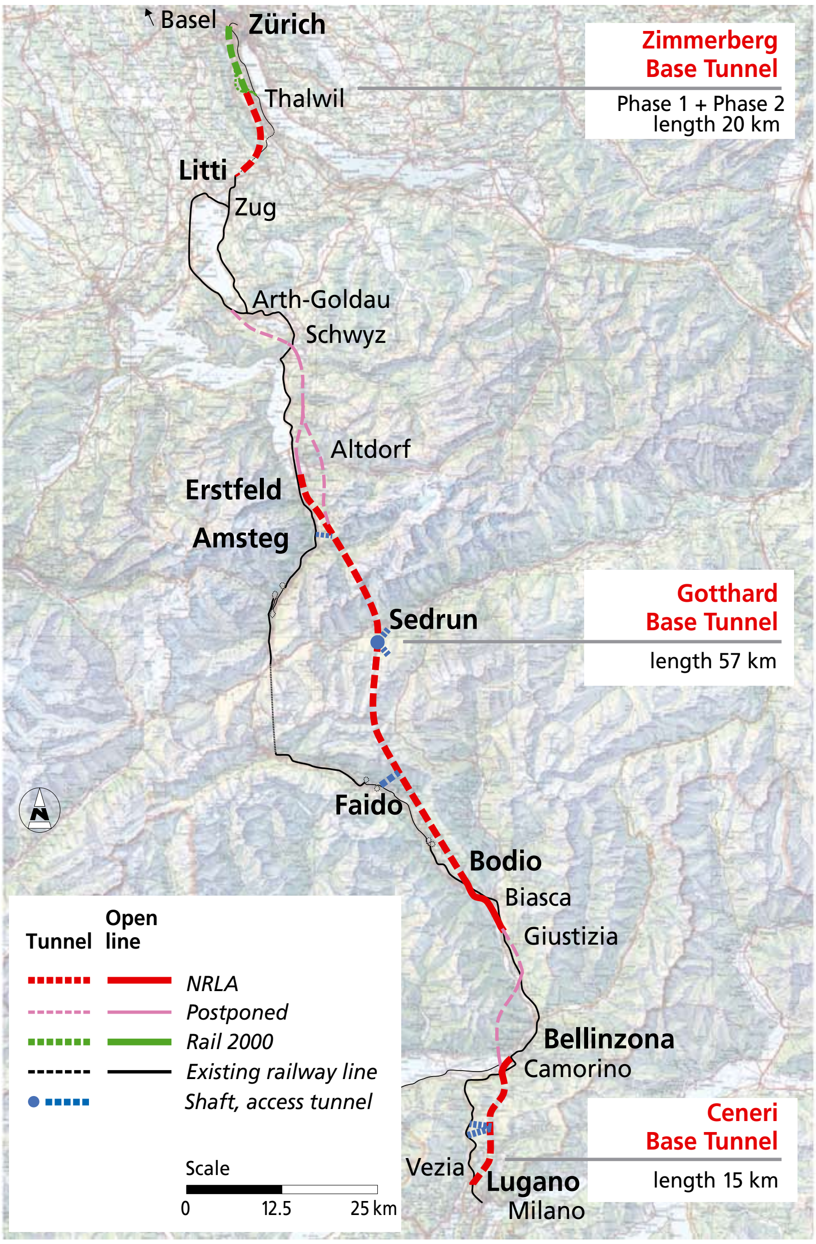
To reach Italy it is planned that a good third of the freight trains through the Gotthard Base Tunnel will continue via Luino to the loading and unloading terminals for unaccompanied intermodal traffic in northern Italy. Slightly under two thirds of the freight trains will enter Italy via Chiasso.

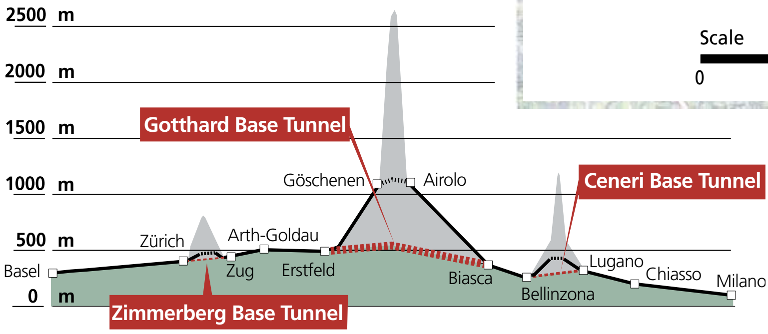
Flat all the way – and faster, too

Creation of a flat rail link on the Gotthard route makes freight transportation more productive, while passenger traffic benefits from massively shorter journey times.

Construction of base tunnels under the Gotthard and Ceneri creates an ultramodern flat rail link whose highest point at 550 metres above sea level is no higher than the city of Berne. This is much lower than the highest point of the existing route through the mountains at 1150 metres. Gradients will be no steeper than where the railway crosses the Jura mountains through the Hauenstein tunnel (Basel – Olten) or the Bözberg tunnel (Basel – Brugg). The route through Switzerland becomes flatter and 40 km shorter. Italy and Germany come much closer together.

Freight trains travelling on the flat route can be longer and pull up to twice today's weight – 4000 tonnes instead of 2000 tonnes. They will be up to twice as fast, too: the fastest freight trains will have a top speed of 160 km/h. Trains like this cannot be used on existing Alpine routes because of the steep gradients and tight curves. When the flat route is complete, it will be possible to transport an equal volume of freight with fewer locomotives and personnel, and less energy.

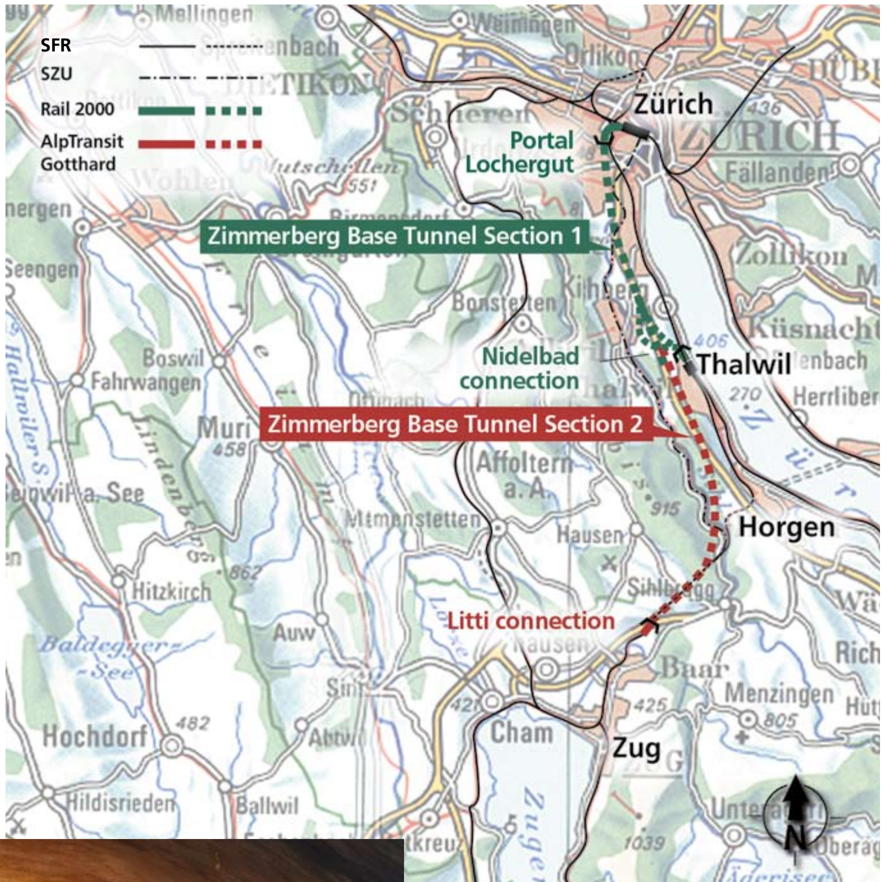




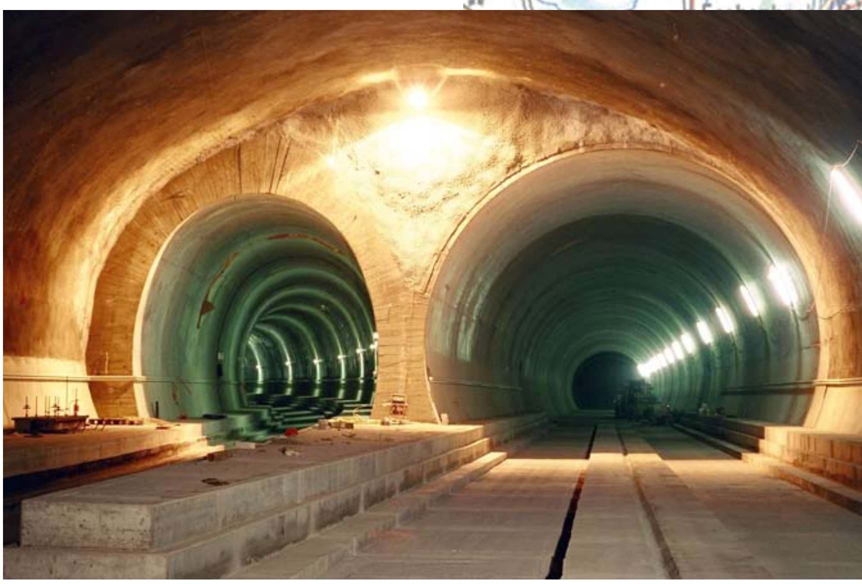
All good things come in threes

The base tunnel under the Zimmerberg complements the Gotthard and Ceneri base tunnels to the north. Together, the three tunnels create an ultramodern and efficient flat rail link through the entire Alpine region.

The Zimmerberg Base Tunnel complements the new Gotthard link to the north. The three base tunnels cut the journey time between Zurich and Milan to 2 hours and 40 minutes. This allows optimal connections between the Swiss and Italian timetable systems. Without the Zimmerberg Base Tunnel the journey time would be 2 hours and 50 minutes and the optimal connections would then not be possible.



The Zimmerberg Base Tunnel in the north

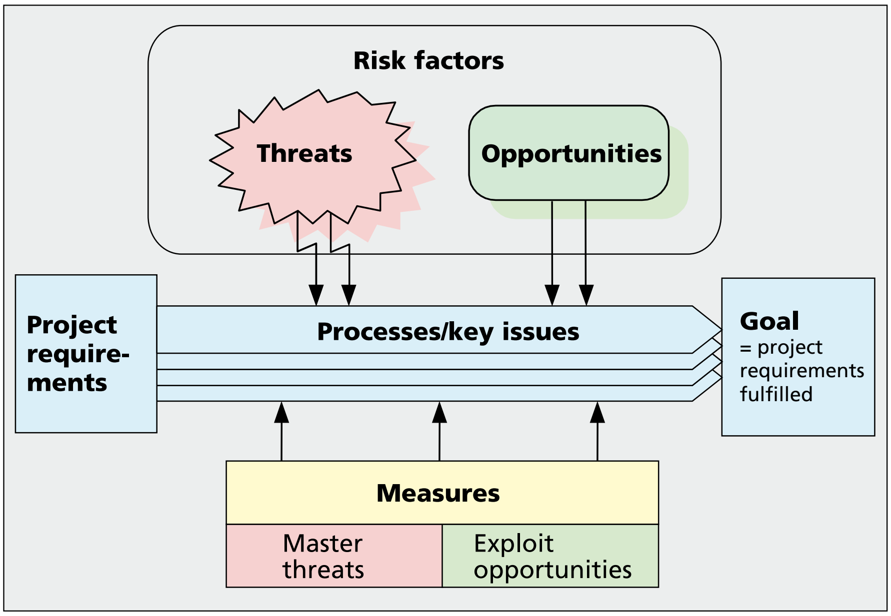


AlpTransit Gotthard connection at Nidelbad

The first section of the Zimmerberg Base Tunnel between Zurich and Thalwil was built as part of Rail 2000 and is already in operation. Close to Thalwil, at Nidelbad in the Canton of Zurich, the new line of the AlpTransit Gotthard branches off underground and continues towards Zug. This creates a tunnel with a total length of approximately 20 km. Construction was due to start in 2006 but has been postponed to a later date by the Swiss Federal Government as part of its cost-saving programme.

A tough challenge? Systematically mastered!

AlpTransit Gotthard Ltd. was established in May 1998 as a subsidiary of Swiss Federal Railways Ltd. As constructor, it is responsible for the overall task of building the Gotthard Base Link between Zurich and Lugano with the agreed quality, as rapidly as possible, and at minimum cost.



The AlpTransit Gotthard Ltd. risk management system

Mission of AlpTransit Gotthard Ltd.

- AlpTransit Gotthard Ltd. realizes under the Gotthard, the Ceneri and the Zimmerberg a continuous flat rail link which meets the requirements for an economically attractive and environmentally friendly traffic axis through the Alps. Connections shall be so planned that subsequent extension into a border-to-border high-speed rail network is possible.
- AlpTransit Gotthard Ltd. undertakes to the Swiss Confederation as client, as well as to Swiss Federal Railways Ltd., to adhere to the agreed standards, costs and deadlines. AlpTransit Gotthard Ltd. is characterised by professional project management and entrepreneurial thinking.
- AlpTransit Gotthard Ltd. continuously reviews and reports to the client on the prescribed standards and time schedules in order to identify potential savings on investments and future operating costs.
  It also strives to ensure that investments once made can be economically utilised as soon as possible.
- AlpTransit Gotthard Ltd. acts according to ethical principles.

The certified integral management system of AlpTransit Gotthard Ltd., which covers quality and environmental management as well as occupational safety and information security, provides the basis with which to accomplish the challenging project goals.

The project management interfaces are an important factor for the desired success of the overall project. Goals-oriented collaboration of the many project participants (Swiss Federal Government – constructor – planners – contractors – suppliers) is vital. Within the project-related quality management system (PQM), AlpTransit Gotthard Ltd. emphasises clear definition and management of the interfaces within the project organisation, i.e. where tasks, information and responsibilities change hands.

The risk management system addresses two key questions:

- Threats: What could hinder or prevent accomplishment of the goal?
- Opportunities: What could assist or enable accomplishment of the goal?

Concrete measures are taken to minimise threats and exploit opportunities. AlpTransit Gotthard Ltd., and all involved in the project, have a duty to periodically analyse the risks in their respective areas of responsibility and to plan and implement suitable measures.

The Gotthard Base Tunnel: 50 years of planning

The idea of building a Gotthard base tunnel is not new: a first idea was already put forward in 1947. Half a century after the first project of 1962, the world's longest railway tunnel will finally go into operation. Needless to say, those 50 years have left their mark on the project.

Acceptance in 1992 of the proposals for the New Rail Link through the Alps (NRLA) provided the basis for planning. Acceptance in 1998 of the Heavy Vehicle Tax (HVT), as well as the proposal for modernization of the railways, finally cleared the way for construction. In 2015, the world's longest railway tunnel will start to go into operation.

The first project for a base tunnel through the Gotthard was formulated by the Swiss Federal Department of Home Affairs in 1962. The plan envisaged a double-track tunnel running in a straight line from Amsteg to Giornico and accessed from two intermediate headings. It would be 45 km long with an overtaking track in the middle. Trains would travel through the tunnel at a maximum speed not much lower than is planned today: up to 200 km/h.

Excavating a crossover in the multifunction station at Sedrun

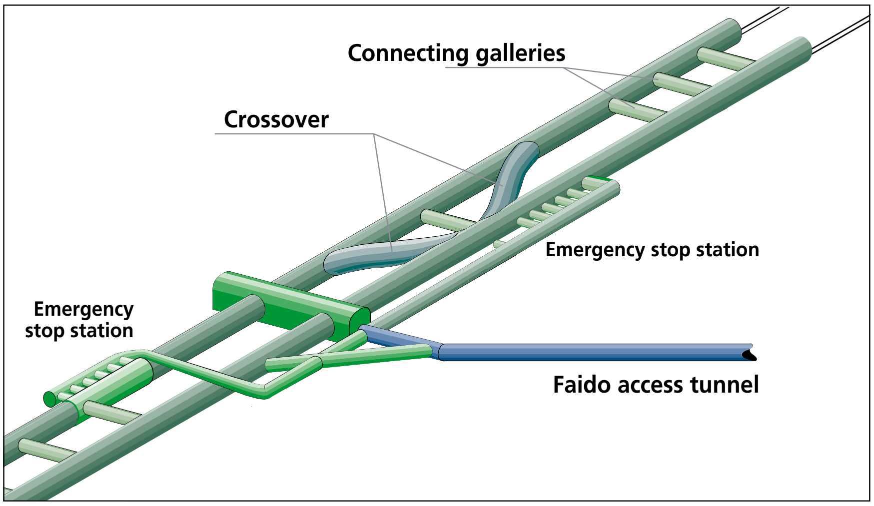
Other aspects of the first plan were radically changed. Lively discussion centred on the tunnel system. In a report published in 1971, the Committee for a Railway Tunnel through the Alps of the Swiss Federal Department of Environment, Transport, Energy and Communications concluded that a two-track tunnel, possibly with some sections split into two single-track tunnels, would be the best solution. The choice between a two-track tunnel with service tunnel or two single-track tunnels (with or without service tunnel) was only decided much later, in 1995.

The final winner was a combined solution: two single-track tunnels with no service tunnel but linked by connecting galleries about every 180 metres so that each tunnel can serve as an escape route for the other. There are also two multifunction stations and crossovers.

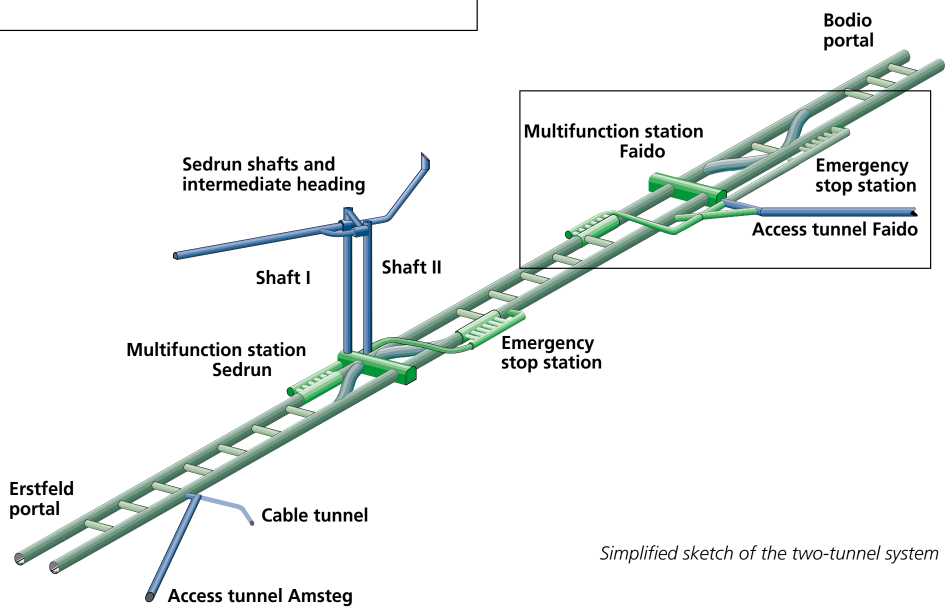
Two tunnels? That's not all!

The Gotthard Base Tunnel has two single-track tunnels which are linked to each other by connecting galleries. Two multi-function stations at the one-third-way points of the tunnel house crossovers, emergency stop stations, and technical installations for railway operations and ventilation.

In 1995, when the Swiss Federal Council approved the preliminary plan for the Gotthard Base Tunnel, it spoke in favour of a tunnel system with two single-track tunnels. The two rail tunnels are about 40 metres apart and joined approximately every 325 metres by connecting galleries. Two double crossovers allow trains to change from one tunnel to the other – which may be necessary to allow maintenance work or if an incident occurs. Trains can change tunnels in the multifunction stations at Sedrun and Faido. These stations also house ventilation equipment, technical infrastructure, safety and signalling systems, as well as two emergency stop stations which are directly linked by separate access tunnels.



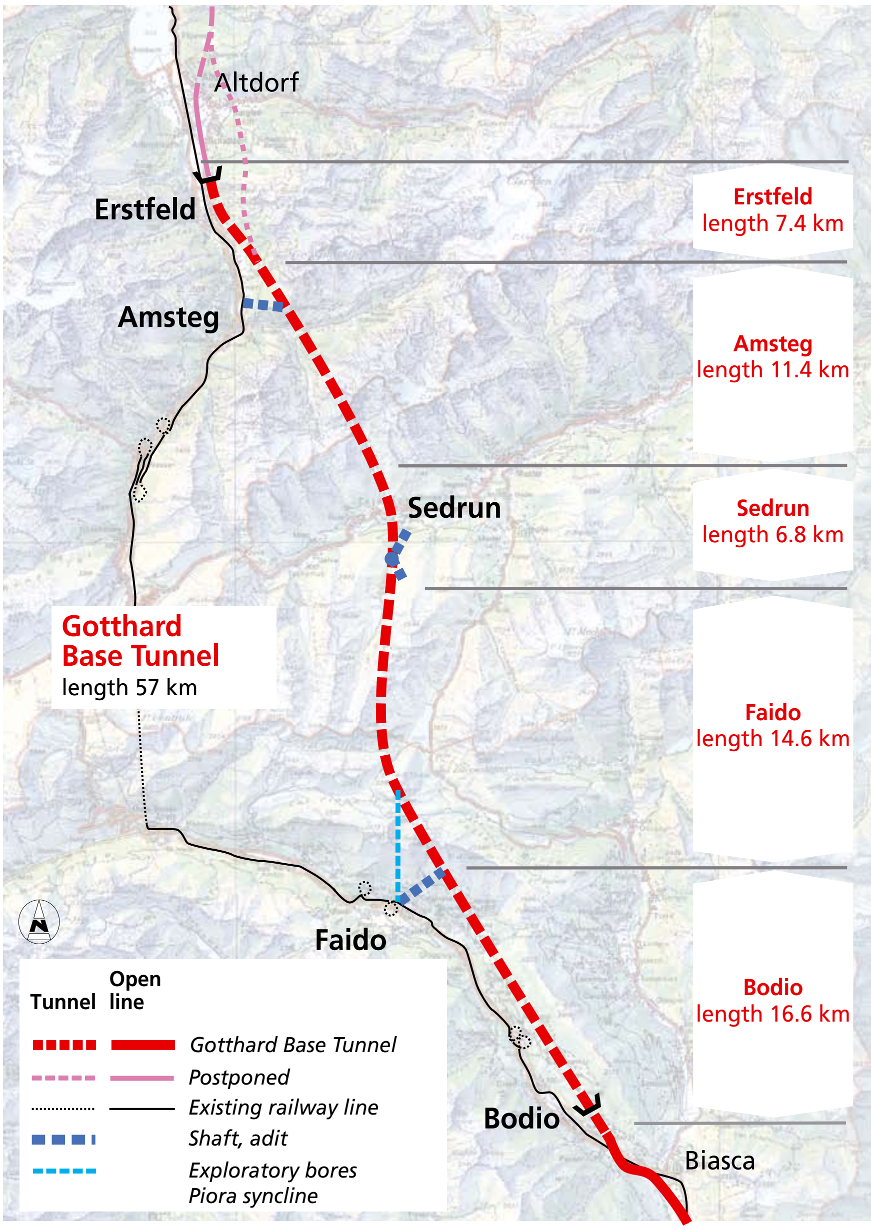
The emergency stop stations provide a place for trains to stop in an emergency from where passengers can escape and be evacuated. To reach the other railway tunnel, passengers do not have to cross railway tracks, climb steps, or use lifts. Should an incident occur, smoke is sucked out of the affected tunnel and fresh air blown into the emergency stop station through the side tunnels and connecting galleries. A slight overpressure is enough to prevent smoke entering the escape route to the unaffected tunnel. From the emergency stop station an evacuation train transports passengers out of the tunnel. If a train stops before it reaches an emergency stop station, passengers can use the connecting galleries to escape to the other railway tunnel.



Simplified sketch of the two-tunnel system

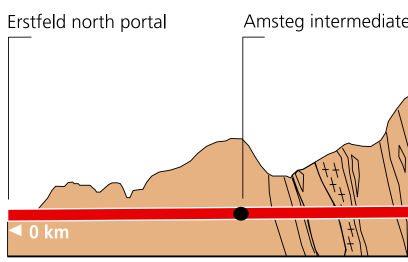
Through thick and thin in gentle curves

The best route between two points is not always a straight line. Many factors affect the choice of direction. One criterion influencing the optimal route for the Gotthard Base Tunnel was the geology. Forecasts by experienced geologists and sample bores give a reasonable degree of certainty. But what the tunellers actually experience at the rock face can never be predicted in advance.



Above ground, the choice of route is affected by concerns of local residents as well as political decisions. The Consulting Group for Landscape and Design – a team of architects, landscape planners and environmental specialists – is responsible for optimal adaptation to the landscape and aesthetic integration of the tunnel portals into their surroundings. Geographical aspects, such as the location of towns and villages, as well as hydro-electric reservoirs and access routes to the construction sites, must also be taken into account.

Below ground, the choice of route is no easier. Millions of years ago, where the Alps stand today, there was a prehistoric ocean in which marine sediments were deposited over a crystalline substratum. When the European and African tectonic plates collided, the rocks formed from the marine sediments were pushed together and lifted out of the sea. Then they were either twisted together or transported northwards on top of other rocks. The crystalline cores of the Aare and Gotthard massifs were squeezed together, while



the layers further south were squashed flat and piled on top of each other. In a process lasting tens of millions of years, the Alps were formed.

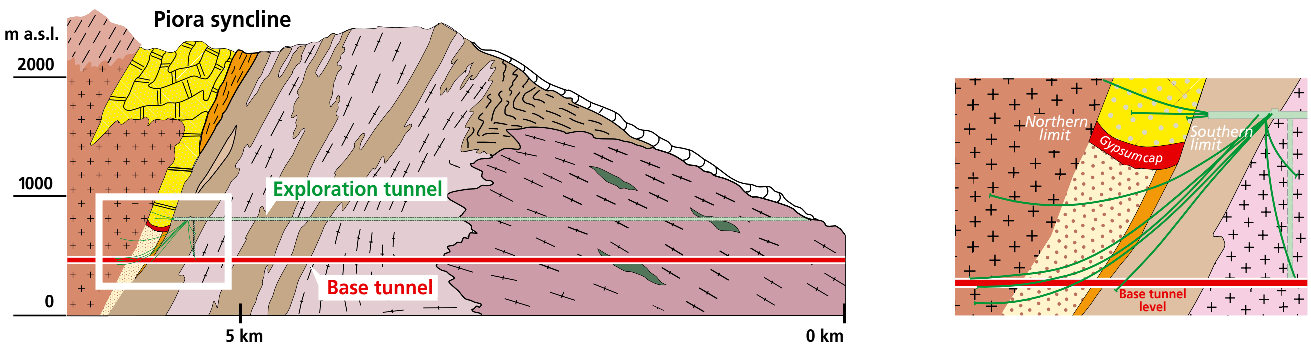
The Aare and Gotthard massifs are the backbone of the Swiss Alps. Both massifs consist mainly of gneisses and granites. Wedged in between are younger sedimentary rocks, some of which are massively fractured. Because of this, when constructing the Gotthard Base Tunnel, highly diverse rock strata must be traversed. They range from the tough Gotthard granites, through the highly-stressed pennine gneisses of the Leventina, to the butter-soft rocks of the Tavetsch intermediate massif.

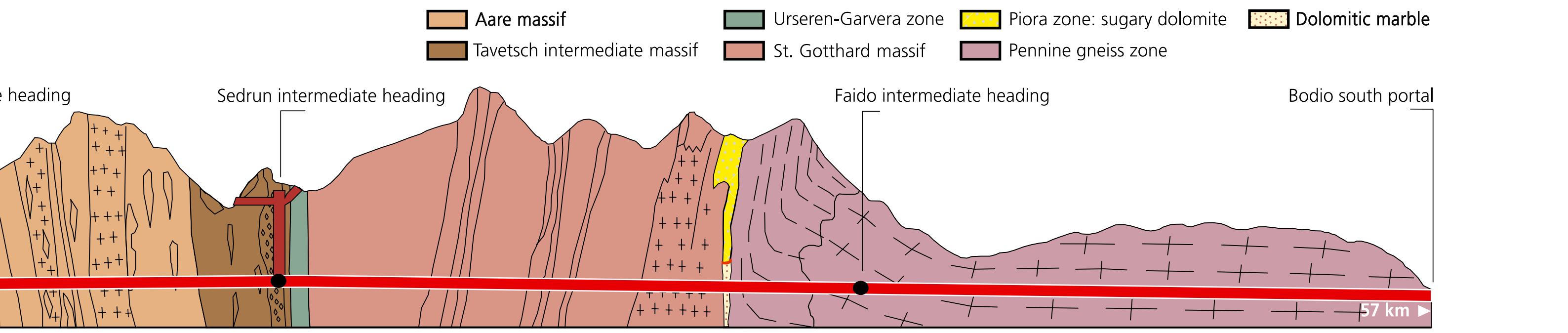
The Piora syncline was a key point in the geology, since its structure and extent were initially unclear. However, four inclined test bores down to tunnel level indicated that conditions at that depth are solid rock with no water pressure or circulation. Subsequent analyses of bore samples, as well as temperature measurements and seismic tests, confirmed these extremely favourable findings for construction of the tunnel.

Squeezing rock conditions in parts of the Tavetsch intermediate massif, on the other hand, require special methods of tunnel construction to be used.

Intermediate headings providing additional access to the tunnel from above (shafts) or from the sides (adits) shorten the construction time of long tunnels. The intermediate headings at Amsteg, Sedrun and Faido halve the construction time of the Gotthard Base Tunnel and divide it into five sections: Erstfeld (with the north portal), Amsteg, Sedrun, Faido and Bodio (with the south portal).

Above: Geology and test-bore system of the Piora syncline
Below: Geological section along the Gotthard Base Tunnel





Construction concept of the Gotthard Base Tunnel

The route of the new AlpTransit Gotthard between Erstfeld and Giustizia/Osogna was determined by the Swiss Federal Government in April 1995. To optimize time and costs, construction of the Gotthard Base Tunnel is proceeding simultaneously on five separate sections of different length.

In the planning phase of the project, answers were found to the questions of when, where, and in what sequence construction must take place to optimise construction time and costs. The concept for the Gotthard Base Tunnel is to drive five separate sections of different length simultaneously. For the construction project, two alternative approaches were developed using two methods of driving: tunnel boring machines or drilling and blasting.

Construction work began on the Piora test bore system in 1993, which in 1998 delivered clear results regarding the geology of the Piora syncline. Starting in 1996, all necessary adits and shafts were constructed. Now, the railway tunnels themselves, the cross-passages between them, and the multifunction stations are being built.

The north portal of the Gotthard Base Tunnel at Erstfeld is reached from the existing main line of Swiss Federal Railways via an overground approach line from Rynächt-Altdorf.

The Erstfeld section is the most northerly section of the Gotthard Base Tunnel. It includes an underground branch-off to allow future extension of the tunnel to the north without having to interrupt train services. The first part of the tunnel will be constructed by digging an open trench which will be covered over again after completion. The rest of the Erstfeld section will be cut with tunnel boring machines.

Shaft bottom at Sedrun

Amsteg

The Amsteg section is the second section from the north. A 1.8 km adit and a construction tunnel were driven by drilling and blasting to the position of the railway tunnels where assembly caverns were excavated. From these caverns, two tunnel boring machines started cutting south towards the Sedrun section in 2003.

The Sedrun section is reached from the surface through a 1-km-long access tunnel and two parallel vertical shafts 800 meters deep. This section is also the site of one of the two multifunction stations, which will house technical installations, emergency stop stations, and track crossovers. Excavation of the railway tunnels to the north and south from the bottom of the shafts began in 2004 using drilling and blasting. Tunnel boring machines cannot be used because of the geological conditions.

The Faido section is reached from the surface through a 2.7-km-long adit with a gradient of up to 13%, and for construction logistics is linked to the Bodio section. The second multifunction station is located in the Faido section. Because of the geological conditions, it is being constructed further south than originally planned. When the two tunnel boring machines cutting from Bodio arrive here they will be repaired and modified before continuing north towards the Sedrun section.

South portal at Bodio

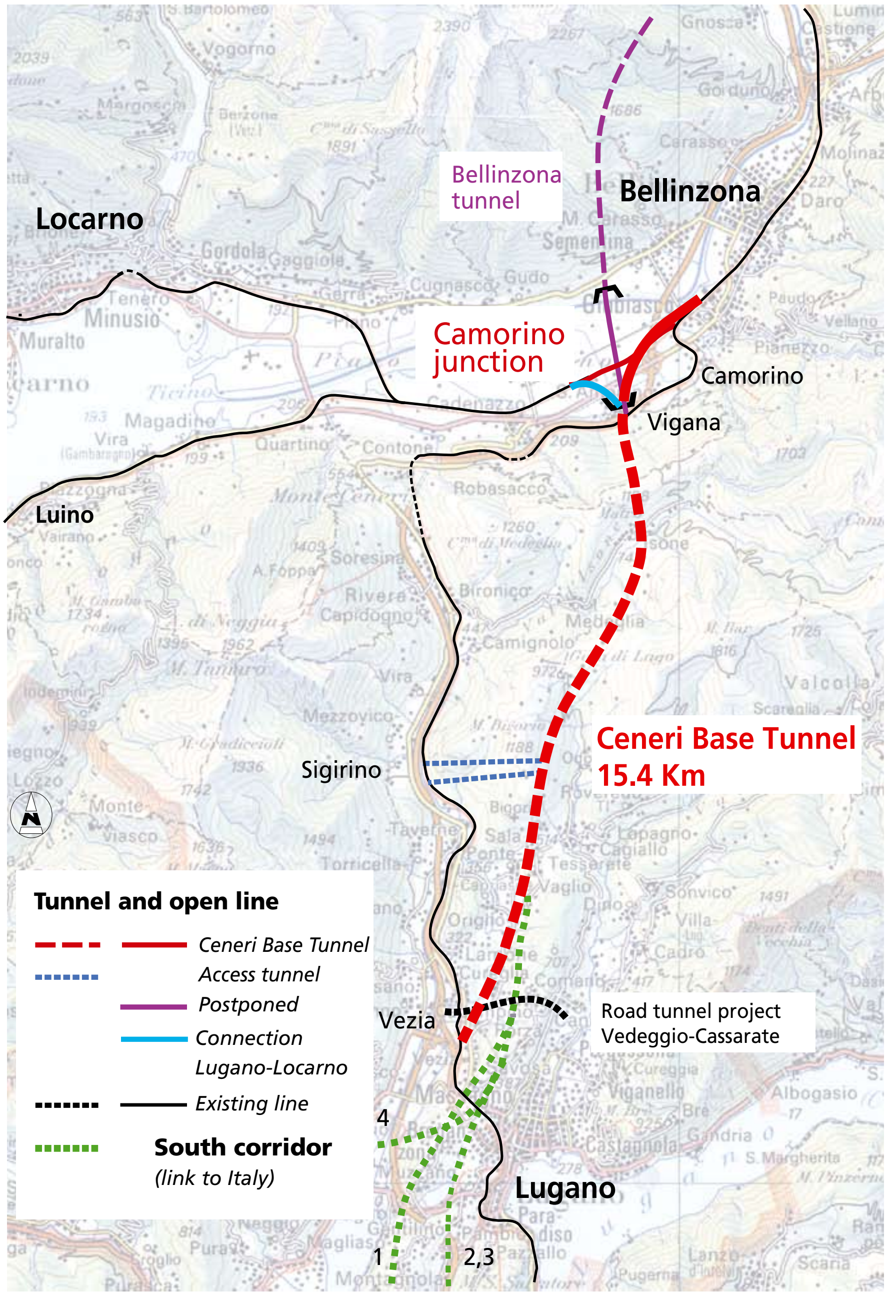
The Bodio section is the longest section of the Gotthard Base Tunnel. The first part of the section was constructed above ground, and then through loose rock, before sufficiently solid rock was reached to allow driving with tunnel boring machines. To allow faster construction of the underground assembly caverns for the tunnel boring machines, a bypass tunnel was dug round the site of the portal. From the assembly caverns, two tunnel boring machines started cutting north towards Faido in 2003.

From the south portal at Bodio, an overground approach line links the Gotthard Base Tunnel to the existing main line of Swiss Federal Railways at Giustizia/Osogna.

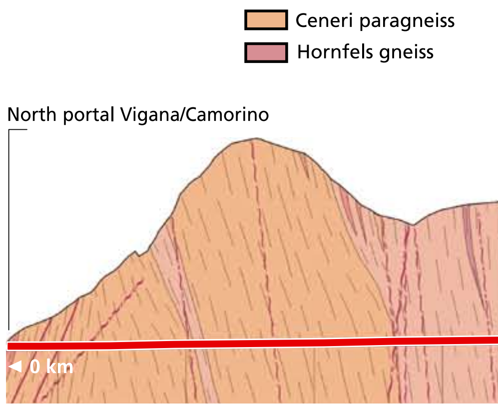
Faido

The Ceneri Base Tunnel – the logical continuation

Only with the Ceneri Base Tunnel will the new Gotthard route become a continuous flat rail link through the Alps with the corresponding advantages and desired economic benefits. In addition, the Canton of Ticino will benefit from massive improvements in regional transportation.



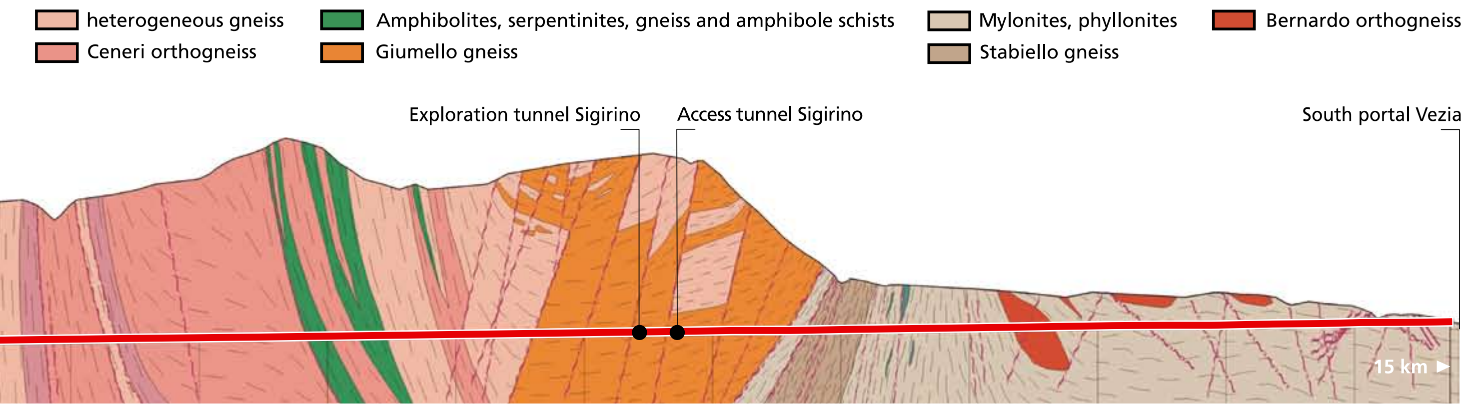
The ramps of the present-day railways through the Gotthard and Ceneri have gradients of up to 26 per thousand. The flatness and straightness of the base route – maximum gradient 12.5 per thousand overground and 8.0 per thousand in the base tunnels – allow productive deployment of long, heavy trains through elimination of time-consuming shunting operations. Today, a heavy freight train travelling north-south over the Gotthard and Ceneri mountain routes requires a pushing locomotive because of the steep gradients. The goal of freight trains hauling more than 2000 tonnes travelling through Switzerland without stopping at Erstfeld or Bellinzona, and without mid-train or pushing locomotives, can only be accomplished when both the Gotthard and Ceneri base tunnels are completed.



Freight train near Bellinzona

The continuous flat route will allow fast, economical freight transportation services to be offered which are the precondition for achieving the desired transfer of freight off the roads onto the railways. The Ceneri Base Tunnel also allows passenger journey times between Zurich and Milan to be shortened by the amount necessary to assure optimal connections in both the Swiss and Italian timetable systems.

In the Canton of Ticino the Ceneri Base Tunnel and the two connections in the north towards Bellinzona and Locarno will allow construction of a rapid-transit system. Fast, frequent, direct connections between the urban centres of Bellinzona, Locarno, Lugano, Mendrisio-Chiasso, Como and Varese will be possible. The Ticino-Lombardy (TILO) regional rail system will cut journey times to half of today's duration. For example, when completed it will eliminate the detour via Bellinzona on the trip between Lugano and Locarno and shorten the journey time from today's 50 minutes to only about 22 minutes. In addition, a direct link to the Ceneri Base Tunnel will also integrate the area around Locarno into the new TILO system.



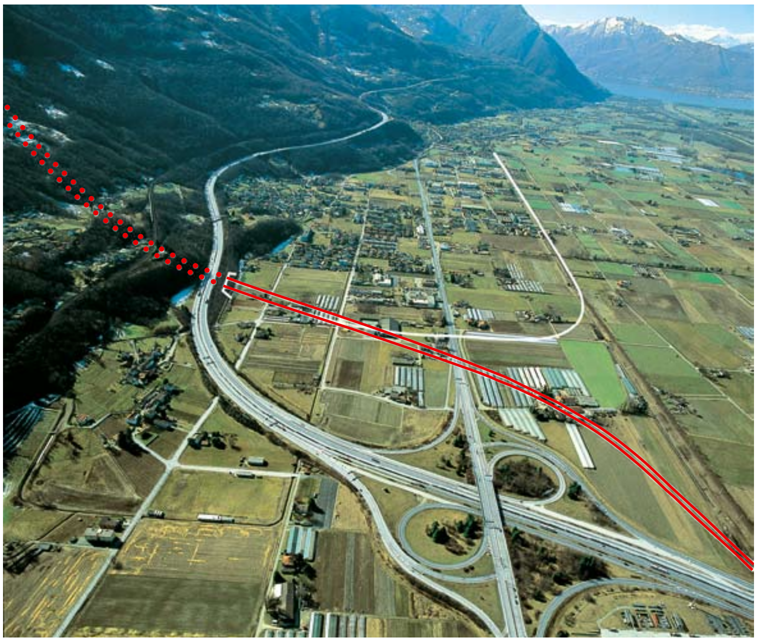
Geological section along the Ceneri Base Tunnel

Construction concept of the Ceneri Base Tunnel

In 1999, the Swiss Federal Government approved the preliminary project for the 15.4 km Ceneri Base Tunnel between Camorino, near Bellinzona, and Vezia, near Lugano. Construction of the two single-track tunnels will start in 2006. Opening of the tunnel is scheduled for 2016.

After the preliminary project was approved in 1999, the Swiss Federal Office of Transport (FOT) commissioned AlpTransit Gotthard Ltd. to prepare a detailed project for construction of the Ceneri Base Tunnel. In 2001, mainly for reasons of safety, the Swiss Federal Government decided that the Ceneri Base Tunnel should also have two single-track tunnels connected together by cross-galleries. The public application for planning permission was made in April 2003. The required credit was approved by the Swiss Council of States in December 2003 and the National Council in June 2004. Construction of the Ceneri Base Tunnel can therefore start in 2006.

A tunnel system comprising two single-track tunnels with connecting galleries is not only safer. With this system, the cross-section of the one dual-track tunnel which was originally planned is spread over two smaller single-track tunnels. These tunnels can be excavated faster by using tunnel boring machines in addition to drilling and blasting. Relative to the original construction plan, this shortens the tunnelling time by two to three years. The Ceneri Base Tunnel is scheduled to become operational in 2016. A further benefit of the selected system is that subsequent underground extension of the tunnel to the south, or crossing of the Magadino plain to the north, can be undertaken without interruption of rail traffic in the Ceneri Base Tunnel.



Magadino plain and site of the north portal at Vigana/Camorino

Site of the south portal at Vezia

Sigirino with exploratory tunnel (left) and excavated material (right)

Sigirino exploratory tunnel

The Ceneri Base Tunnel traverses many different layers of rock between the north portal at Camorino, near Bellinzona, and the south portal at Vezia, near Lugano. Two single-track tunnels will be constructed which are linked at intervals of 300 m by connecting galleries. Because the Ceneri Base Tunnel is only 15.4 km long, it will have no crossovers or multifunction stations. On the other hand, underground branch-off caverns will be built close to the north portal in both single-track tunnels. From there, connecting ramps will lead into a later crossing of the Magadino plain. There will also be an underground branch-off about 2.5 km before the south portal, at Sarè. This will allow future extension of the tunnel to the south.

At Sigirino – just about in the middle of the tunnel – a 3.1-km-long exploratory tunnel was excavated between 1997 and 2000. This provided valuable information regarding the geology to be expected when cutting the tunnel. In preparation for driving the Ceneri Base Tunnel, an access tunnel will be constructed at Sigirino. Underground caverns ('caverna operativa') at the end of the access and exploratory tunnels will serve as the starting points for excavation of the main tunnels to the north and south. As in the Gotthard Base Tunnel, as much as possible of the excavated rock will be recycled, or used for landscaping the area around the construction site to avoid long transportation distances.

Construction sites will be set up not only at Sigirino but also at the north and south portals of the tunnel. These are required to drive the tunnel sections near the portals and for construction of the portals themselves. In addition, at Camorino in the north, the Ceneri Base Tunnel must be linked to the existing railway lines as well as various other installations.

Partially excavated « caverna operativa » at Sigirino

Installations and connections

What needs to be done before the tunnel boring machines can start their work? Construction of a tunnel demands meticulous and environmentally compatible planning of the surface installations for access, supply and disposal.

On the various construction sites of the tunnel, enormous volumes of construction material and excavated rock must be handled. Delivery of the construction materials and disposal of the excavated rock must be done with due respect for the environment. Operation of the surface site, as well as the construction work itself, requires electricity and water in such quantities that they cannot simply be tapped off the local supply networks. Precisely defined requirements for electric power must be ordered from the electricity supply companies, and the availability of water has to be carefully investigated. The needs of the workers and other questions also arise: Where will the tunnellers' living quarters be built? How much soiled water will be produced? How will the water from the tunnel be purified? How will waste water from the surface site be transported to the local water purification plant?

Water supplies on construction sites are classified as drinking water or industrial water. Drinking water can be taken from the local supply network. About 300 l are required per person per day. Industrial water is required in far greater quantities – up to 500,000 litres per day at each site. However, the water does not have to be of such high quality. It is usually obtained from a separate source, such as a river or groundwater, so as not to overload the local supply. This water is used on the surface site and in the tunnel: for concrete production, cooling, or simply washing the machines. To provide sufficient water for fire-fighting, water reservoirs are built on the construction sites. Purified waste water is returned to the natural cycle.

Above: Water purification plant at Amsteg

Below: The Val Bugnei railway bridge was specially built to access the Sedrun site

Electric power for construction must be planned well in advance. For example, on peak days the construction site at Amsteg requires a power supply of around 11 megawatts. That is exactly double the demand of the town of Sedrun at Christmas, when the hotels are full and the ski lifts running. So it is clear that the local supply to the town cannot also provide the electric power for construction. Even if there were sufficient capacity, it would be impractical to use it, since much of the machinery used in tunnel construction requires a high-voltage supply. For example, a tunnel boring machine requires a power supply of 5 megawatts. This corresponds to simultaneous use of approximately 2 500 cooker hotplates or about 50 000 light bulbs. Power is therefore supplied to the construction site via high-voltage lines. Which means that existing lines have to be extended, branch lines planned, permits obtained, switching stations expanded and new transformer stations built.

Above: Transformer at Arniberg power station supplies the Amsteg construction site
Below: Surface site at Sedrun with tunnellers' accommodation in the foreground

The layout and construction of the facilities should not just ensure optimal construction activities but also protect the local population from noise and dust. Construction of a surface site, including access and connections, takes from three to six months. Existing utility lines have to be relocated and new connections made. Roads and paths must be adapted to meet new needs. Vegetation and topsoil are removed. Work can then begin on building living quarters, concrete production plants, workshops and warehouses, etc. Only when the conditions for smooth and environmentally friendly construction site operation have been created can work begin on building the tunnel.

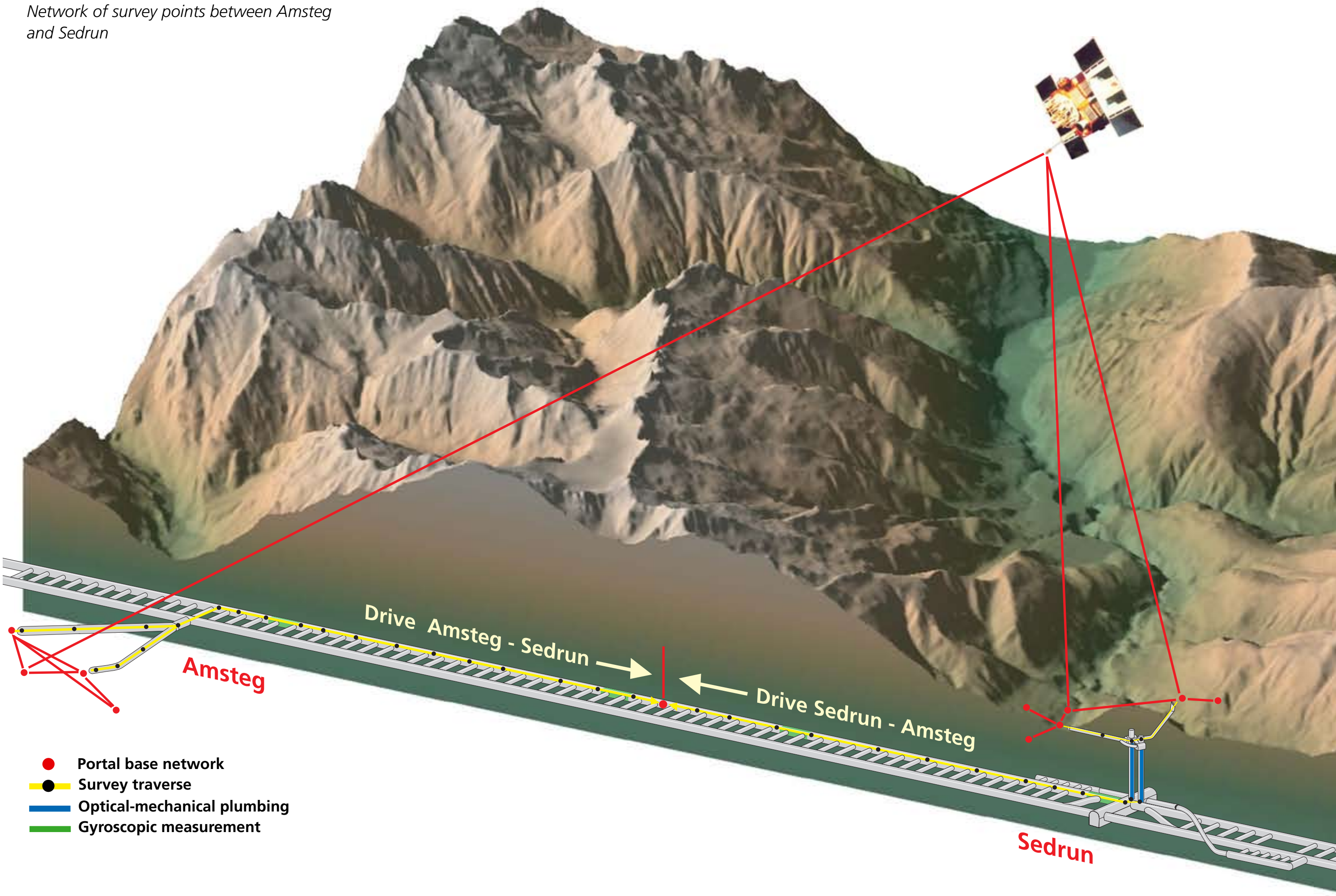
Accurate to the centimetre through the mountains

Highly accurate surveying techniques guarantee that the tunellers always drive in the right direction and meet exactly where they should. The surveyors ensure that the flat track will meet the demanding needs of high-speed trains.

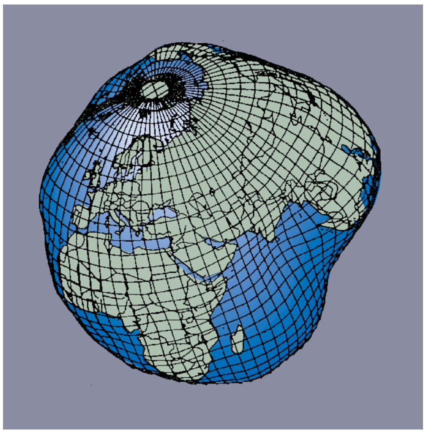
The routes of the Gotthard and Ceneri Base Tunnels had been decided. Before construction of the tunnel could begin, all its components had to be accurately marked out, not only above ground but also deep under the mountains. The surveyors of the old Gotthard and Lötschberg tunnels had to mark out the planned line of the tunnel above ground to confirm their calculations. However, modern simulation programs are sufficiently accurate to make overground marking out unnecessary. Use of several different surveying techniques and independent cross checks highlights any errors in surveying and makes the direction of driving more reliable and accurate.

The surveyors used satellite systems to create a grid of reference points covering the entire area of the projected tunnel which serve to link the plans with the ground surface. The quality they achieved is amazing: The length and height of the line between the portals at the north and south of the 57 km long Gotthard Base Tunnel was mapped out accurately to within one centimetre. In the past, surveyors had to map out the route using triangulation points on mountain peaks and ridges. The surveying campaigns and subsequent calculations – in those days without computers – took several months. Today, a few weeks are enough**.**

Network of survey points between Amsteg and Sedrun



Levelling at the shaft bottom in Sedrun



The earth is a geoid (irregularities x 15 000)
Shape of the Earth
(geoid altitudes magnified 15 000 times)

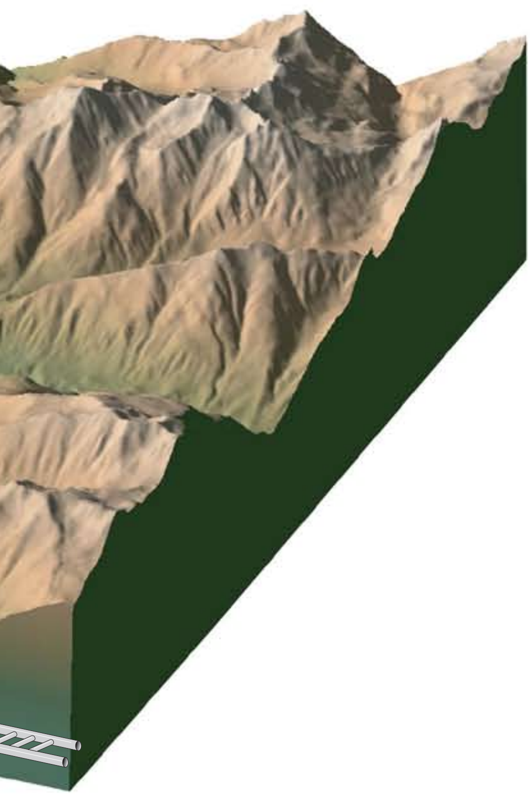
Long underground structures such as the Gotthard Base Tunnel cannot be marked out with normal surveying techniques because the stars, points on mountain tops, or points set with satellite systems are not visible. Instead, to determine the direction underground, a rapidly rotating gyroscope with a horizontal axis is used which always points north as the earth rotates. A magnetic compass is not sufficiently accurate.

High-precision plumbing instruments were developed to transfer the coordinates down the 800 m deep shaft at Sedrun.

Minute sources of error, which in normal engineering surveying would be of no significance, had to be taken into account. The huge masses of rock in the Gotthard massif cause discrepancies in the plumb line due to the difference between the mathematical shape of the earth, which is an ellpsoid of revolution, and its actual shape, which is a geoid. The measuring beam is also deflected by temperature differences in the tunnel.

Simulation of all the planned measurements by a computer model has indicated that with 95% certainty the individual tunnel bores will meet with a maximum alignment error of 20 cm. That's about as much as the width of this page!

The Alps are still moving today, even though they appear to be stable. Besides a general upward movement of the Alps of about 1 mm per year, geotechtonic displacements between individual mountain formations can also be detected, which could affect construction of the Base Tunnel. Surveyors monitor these movements at various overground measuring points and in existing tunnels. The information obtained in this way is then used by civil engineers to plan measures for protecting the future railway lines.



Data management – so everyone's working on the same project

On a construction project as big as the new Gotthard Rail Link, which has such long planning and construction phases, care must be taken that everyone works with the same planning data and always knows the up-to-date status of the project. Also, when the project is complete, the future owner and operator of the tunnel must be given thorough documentation of the construction.

At AlpTransit Gotthard Ltd. this information is created, managed and exchanged among people involved in the project in digital form. Essential paper plans needed on the construction site are produced from this data.

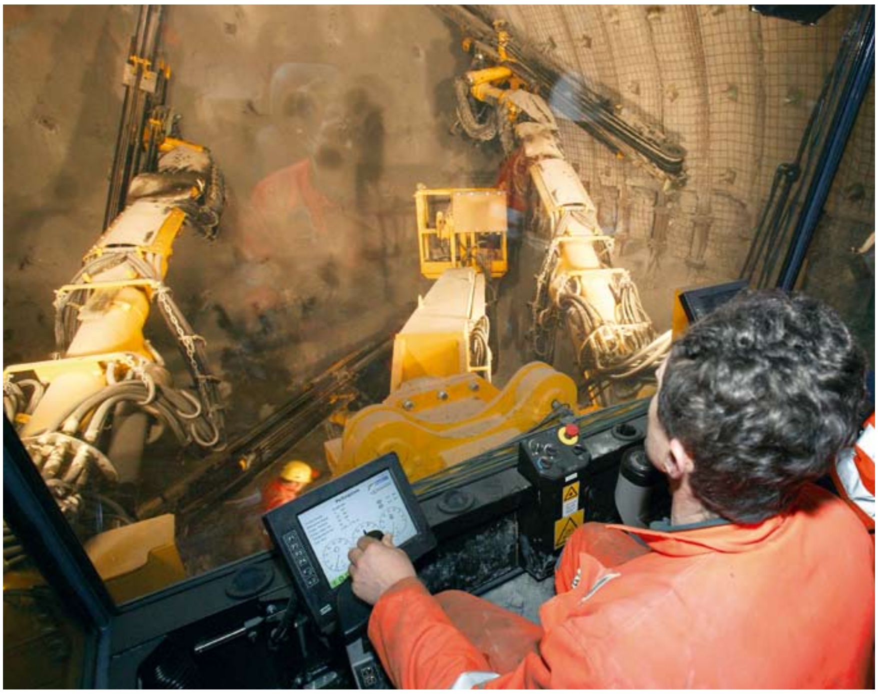
Of classes, shifts and people

The rate of advance depends mainly on the geology. The speed of excavation, on the other hand, depends on the performance of the machines used, the people who operate them, and the number of shifts worked.

The geological forecast provides information about the rock conditions to be expected below ground. Based on this forecast, the engineers divide the rock into classes. The class of rock determines the rate of advance which can be expected. In good classes of rock, daily advance rates of more than twenty metres can be achieved, but if the rock class is poor, the rate may drop below one metre per day.

The slower advance rate is mainly because of the work involved in supporting the excavated section. The more measures that are needed to provide support, the longer it takes until the next metre of tunnel can be tackled. Whereas in compact gneiss the tunnel can be advanced and supported simultaneously, in poor rock every metre that is blasted or bored has to be supported immediately. Inserting steel arches is very time-consuming, and if the rock is particularly brittle, a thicker layer of shotcrete has to be applied.

State-of-the-art technology allows driving the tunnel to be largely mechanized. However, this also places greater demands on the tunellers who operate the machines. Specialists are needed. It is no longer enough to have a feeling for the rock and to know how to use explosives. New technical machinery must be operated: computer-controlled tunnel boring machines (TBMs), drilling jumbos with multiple drilling heads, muck vehicles, laser instruments and hydraulically operated steel tunnel liners.



Control cab of a multi-head drilling jumbo at Faido

The right specialists in the right places work together in shifts as a strong team. Shift operations are planned to the last minute of a 24-hour day.

The choice between drilling/blasting and TBM depends on the expected rock conditions.

Drilling and blasting is a highly flexible construction method. The length of excavation and use of supporting means (e.g. shotcrete, anchors, steel inserts, reinforcing mesh) can be continuously adapted to the conditions encountered. With drilling and blasting, an average advance rate of between 6 and 10 meters per working day can be achieved.

Driving by TBM is substantially more difficult to adapt to changing conditions. The complete driving unit (TBM and backup train with a total length of up to 400 m) is a permanently assembled, largely rigid unit with mostly standardised procedures**.**

The drilling and blasting cycle

Three shifts are worked of 8 hours each.

Drill, charge, detonate, ventilate, support/muck: under good rock conditions, these operations are completed in one eight-hour shift. In poor conditions, particularly the support phase requires more time, and the removal of muck (blast debris) can only start when supporting work is complete. The cycle may then spread over several shifts.

In good rock conditions, a TBM can cut from 20 to 25 metres per working day. In constructionally more difficult conditions, daily rates of progress are much slower. In some cases, only a few metres per day can be cut and supported. Not infrequently, additional measures may also be needed.

The investment costs for a TBM are much higher than for driving by drilling and blasting. Procurement and installation of a TBM also generally take much longer than the equipment for drilling and blasting.

The decision whether to excavate a section by drilling and blasting or with a TBM therefore depends mainly on the range of constructional conditions expected, the length of the section and the total amount of time available for construction. The greater the diversity of constructional conditions and the shorter the section, the greater the advantages of drilling and blasting, and vice versa.

The geology remains an unknown no matter how much exploration is done, and can present surprises right up to the last metre. Despite the high degree of mechanisation, taking the right decisions inside the tunnel still depends on people. The experience of experts – whether geologists, blasting specialists or shift workers – is irreplaceable.

Assembly of a tunnel boring machine at Bodio

The tunnel boring machine cycle

Three shifts are worked of 8 hours each.

Shifts 1 and 2
The TBM bores a length of two metres and automatically clears out the cut rock. Supporting with anchors, shotcrete or steel arches is done from the machine itself. Then the machine moves forward by the length it cut. This cycle is repeated several times each shift.

Shift 3
The TBM is cleaned, serviced and repaired. Worn cutters are replaced.

The mountain from under the Alps

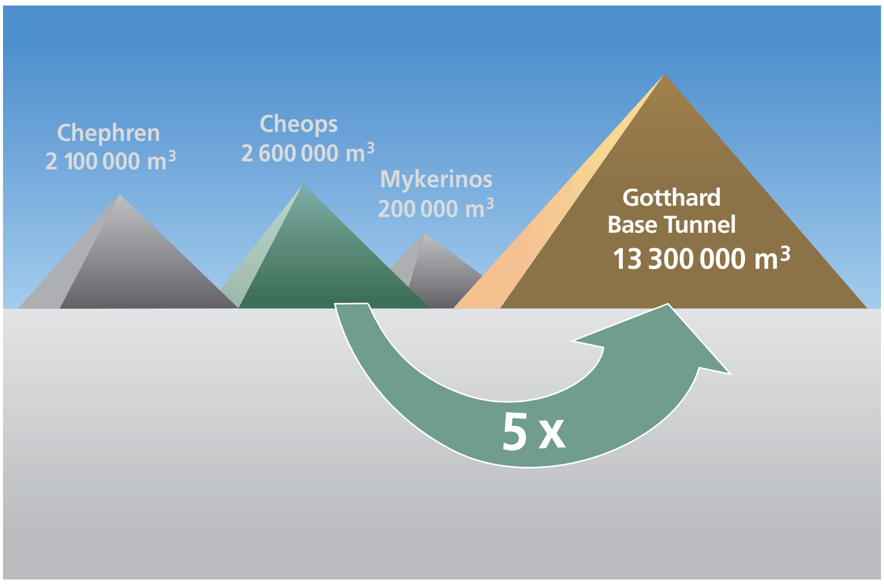
Construction of the Gotthard Base Tunnel is producing millions of tonnes of excavated rock – a veritable mountain from under the Alps. This enormous volume is potentially of great value as raw material for construction purposes. To exploit the benefits, innovative techniques of concrete production are required.

To build a railway under the Alps, very long tunnels have to be dug which produce huge quantities of excavated rock: 24 million tonnes, or 13.3 million cubic metres, from the Gotthard Base Tunnel alone. At the same time, quarrying the richly available gravel deposits in the Swiss midlands is becoming increasingly difficult. Given this situation, the rock excavated from the tunnel presents a valuable alternative for concrete production.

In modern tunnel construction, excavation is increasingly done with tunnel boring machines (TBMs). By comparison with conventional gravel from the Swiss midlands, the rock cut by the TBMs is very finely grained and distinctly chip-like. Because of this, it does not comply with important standards for concrete aggregate, and until recently was therefore unacceptable for the manufacture of high-quality concrete. Instead of being recycled, it was used for embankments or as landfill for disposal sites.

Shoreline remediation in the Lake of Uri

The volume of excavated rock compared with the pyramids of Gizeh



For the AlpTransit Gotthard project, this situation was regarded as unsatisfactory from the beginning. A major programme of experiments was already launched in 1993. After four years of collaboration with universities, research institutes and the concrete industry, with research in laboratories and tests on construction sites, it was finally proved that the rock chips from the tunnel boring machines can indeed be used to produce high-quality concrete. To do so, however, requires state-of-the-art plants for aggregate production and leading-

Technical Terms

Conversion
Rock excavated from the tunnel is crushed, washed and screened to give it the shape and quality needed for recycling.

Concrete aggregate
The raw materials used to make concrete are cement, water and different sizes of gravel – which is called aggregate.

A trainload of excavated rock at Flüelen wharf on Lake Uri

Faido material processing plant

edge concrete technology. In addition, an innovative testing system ensures that the successfully tested product fulfils the high standards required for tunnel concrete.

High-quality excavated rock is being converted into around 5 million tonnes of concrete aggregate. The conversion is done locally on the construction sites. As a by-product, the conversion process will yield about 0.8 million tonnes of extremely fine slurry which can be used by the brick-making industry.

Excavated rock which is surplus to requirements is offered to external customers. Great emphasis is placed on environmentally protective transportation. Rock excavated from Erstfeld and Amsteg is transported by rail and barge to the nearby Lake of Uri for shoreline remediation in the delta of the river Reuss. Surplus material from Sedrun is used to satisfy local requirements for gravel. The remaining quantity is deposited in the Val Bugnei and Val da Claus valleys. Surplus material from Faido and Bodio which cannot be used for embankments along the new railway line is transported by belt conveyor to landfill nearby quarries at Cavienca und Buzza di Biasca.

These modern methods of recycling have dual benefits: as well as substantially cutting costs, they also conserve valuable natural resources.

Supports and linings – *solid and lasting*

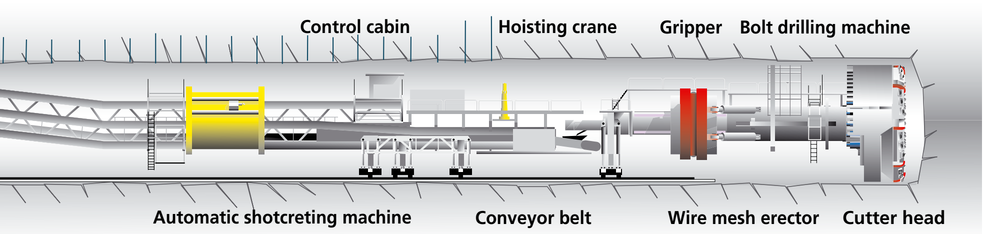
A railway line under the mountains requires a higher standard of materials technology because repairs cost much more than for an overground line. The construction materials for the new Gotthard Rail Link must therefore have a long lifetime.

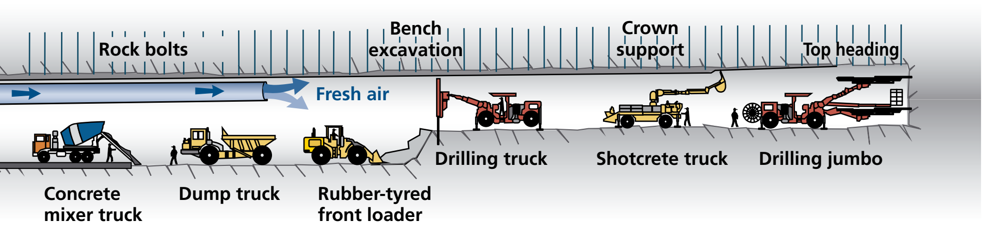
The correct choice of materials for supporting, sealing and lining the tunnel is vital to ensure the safety of the tunnellers at all times as well as trouble-free operation for 100 years.

Faults and other areas which make tunnel construction difficult can be prepared before excavation of the tunnel itself begins. When driving through rock, injections are frequently used. The injections are usually of cement, and serve to bind the rock before it is excavated, as well as reducing its permeability to water. They also provide long-term stability.

Initial supports prevent rock falling from the roof before the permanent supporting measures are installed. Depending on the geology, tunnel constructors have a range of supporting means at their disposal: anchors, shotcrete and steel arches can be combined in variable numbers and strengths.
The initial support is in direct contact with the rock, and therefore suffers the greatest exposure to the effects of rock and groundwater.

Above: Installing steel arches at Faido





Below: Driving with a tunnel boring machine (TBM) (above) and blasting (below)

Tunnel sealing at Bodio

Technical terms used in tunnelling

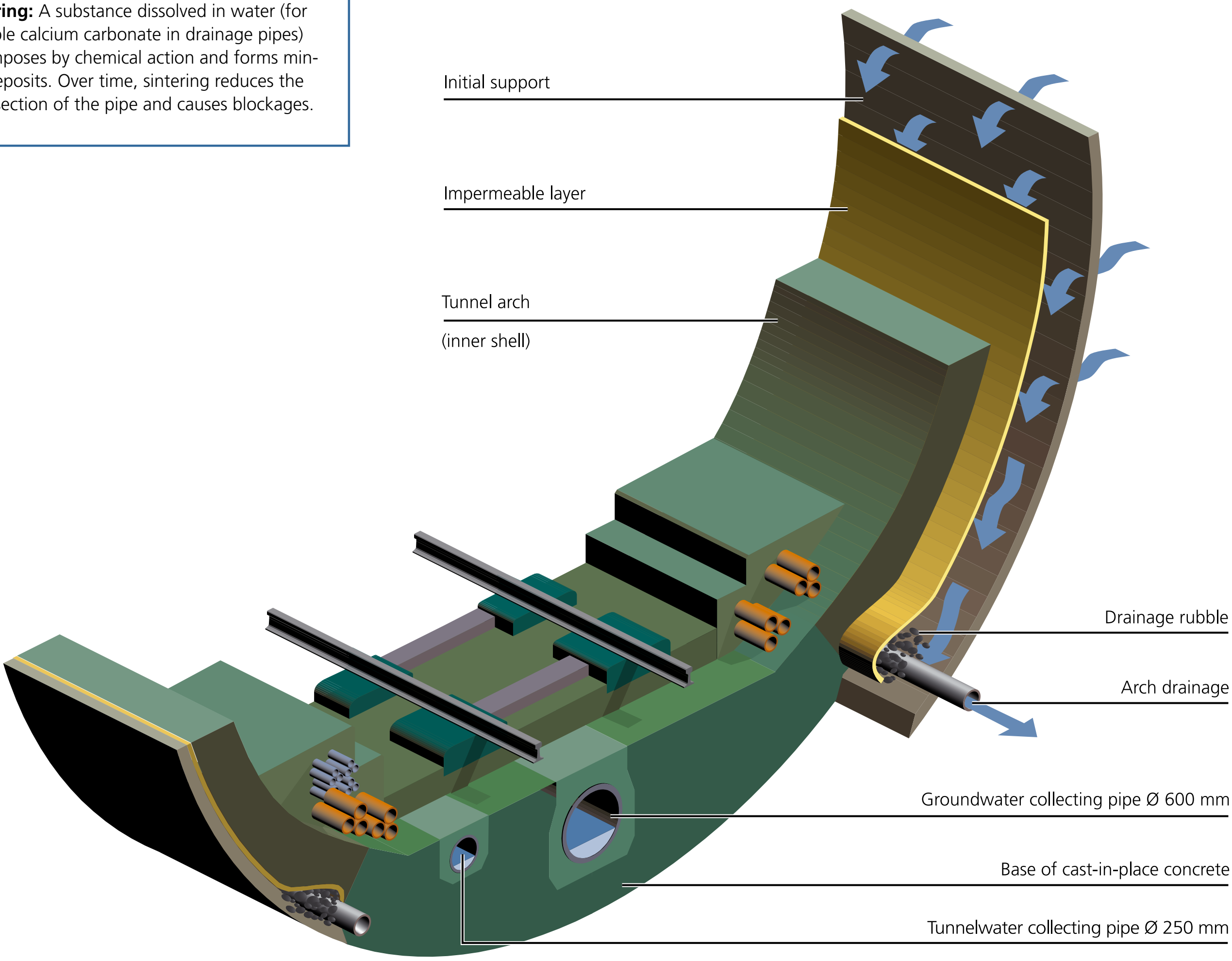
Rock pressure: Creation of a hollow space inside the mountain causes a shift in stresses. High overburdens in soft rock cause deformation of the hollow space. To prevent squeezing of the hollow space when a tunnel is constructed, anchors, shotcrete and steel arches are used to create a counterpressure.

Corrosive groundwater: Groundwater containing chlorides or sulphates which impair the durability and usability of construction materials. Concrete exposed to water containing sulphates swells unless special cement is used. Anchors are corroded by chlorides unless they are appropriately protected.

Sintering: A substance dissolved in water (for example calcium carbonate in drainage pipes) decomposes by chemical action and forms mineral deposits. Over time, sintering reduces the cross section of the pipe and causes blockages.

The water management system in the Gotthard Base Tunnel directs groundwater via surface drainage into drainage pipes and prevents direct ingress of water into the tunnel by means of a sealing foil. This system meets railway engineering requirements at the same time as preventing a build-up of groundwater pressure.

The high speeds of the trains require a smooth inner lining of concrete. Because the initial support only provides support for a limited period of time, the inner lining must assure safe support on its own and therefore be at least 30 cm thick. In areas where the inner lining is subjected to heavy stresses, it is reinforced with steel.



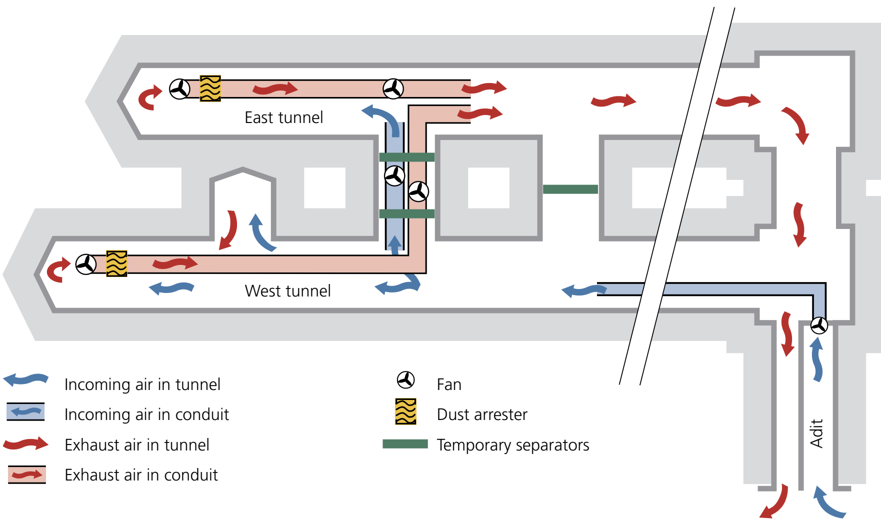
Safety at work has top priority

The safety of everyone involved in constructing the new Gotthard Rail Link has top priority. For AlpTransit Gotthard Ltd., safety at work is a central issue of the project. Consideration of work safety in the planning phase, when inviting tenders, and in work contracts, as well as strict enforcement of contractual and legal regulations, creates an exemplary safety culture with low accident rates on the construction sites.

At the end of the 19th century, many tunnellers died when constructing the great Alpine crossings. They were killed underground by falling rocks, surprised by water bursting into the tunnel, or maimed through incorrect handling of explosives. Others died later of silicosis, an insidious, incurable disease of the lungs caused by unprotected inhalation of quartz dust.

Ventilation installations at Faido

Fortunately, those days are gone! The driving concepts used on the project, as well as the ventilation and cooling systems, give maximum attention to questions of health. Work safety is increased by already including a large number of constructional, technical and organisational preventive safety measures in the planning phase. Work safety was, and continues to be, an important aspect of the work contracts awarded by AlpTransit Gotthard Ltd. The contractual and legal stipulations are implemented, monitored and enforced on the construction sites in collaboration with the Swiss Accident Insurance Fund (SUVA). Key factors for ensuring health and safety in the tunnel are ventilation and cooling.



Tunnel ventilation system during the construction phase

Ventilation system

Forced ventilation: In most sections worked by AlpTransit Gotthard Ltd. forced ventilation systems are employed. Fresh air is sucked in at the portals and intermediate headings, and blown through ducts to the tunnel-face workplaces. Pollutants in diluted form are carried by the stream of air through the tunnel cross-section back to the portals either automatically or assisted by fans. The ventilation system uses one of the railway tunnels to supply fresh air and the parallel tunnel to extract used air.

Ventilation dilutes the pollutants which are released by blasting and by the vehicles which are used to remove the excavated rock. Permissible values are clearly defined by law. Dust concentrations at the workplace can be reduced further by spraying water onto the excavated rock. Today, lung diseases such as silicosis are no longer an issue.

A particular hazard in tunnel construction is presented by gas. When methane and oxygen are mixed in certain proportions they form an explosive gas called firedamp. Since 4% of methane in the air is already sufficient to cause an explosion, firedamp is a feared hazard in tunnel construction. Here too, ventilation to dilute the concentration of methane gas to below 1% is the only countermeasure. Gas sensors at the tunnel face ensure that any occurrence of gas can be detected and monitored immediately.

The temperature of the rocks increases with increasing depth below ground. Since the Gotthard Base Tunnel has more than 2000 m of overlying mountain, rock temperatures up to 45 °C are expected. Additional heat is generated by the increasingly numerous and powerful machines used for constructing the tunnel. It would therefore be unacceptably hot for the tunnellers unless measures to cool the workplace are implemented. A certain amount of heat is removed by the ventilation system. However, to reduce temperatures to the level allowed by the Swiss Accident Insurance Fund (SUVA), extra cooling has to be installed at the tunnel faces. This takes the form of water which is circulated in a system of pipes to remove heat from the rocks and machines. Using this method the atmosphere can be cooled to 28 °C.

For maximum safety, AlpTransit Gotthard Ltd. collaborates with the Swiss Accident Insurance Fund (SUVA) and the main contractors in "Stop Risk" campaigns on the construction sites. These aim for complete and intensive sensitization of everyone involved.

All these measures contribute to minimizing work-related accidents as far as possible. There is still a residual risk to the health and life of the tunnellers – but observance of the regulations and safety measures ensures that working conditions are as good as they can possibly be under the prevailing circumstances.

Construction work at Bodio

Protecting the environment

Environmental considerations are integrated into plans for the AlpTransit Gotthard by means of an environmental management system as well as three-stage environmental compatibility testing. Consistent implementation of environmental measures on the individual construction sites is monitored by on-site environmental representatives within an overall environmental coordination system.

Environmental protection measures were specified by the Swiss Federal Government when it authorised construction of the tunnel. The environmental representative at each individual construction site is responsible for the on-site implementation of these measures. The same person must also ensure that correct measures are taken should an incident with potential environmental impact occur. Consistent measures are defined within the overall coordination system.

The responsible bodies of the Swiss Federal Government and the cantons are periodically invited to environmental audits. Regular information is also provided to environmental protection organisations. Throughout the entire construction phase a wide range of environmental protection measures are implemented on the individual construction sites. These include, for example, temporary storage of topsoil as embankments to provide noise protection. All installations such as concrete production plants, workshops, warehouses and even belt conveyors are deliberately enclosed.

Air pollution from construction activities is kept as low as possible. As a basic principle, all transportation of bulk materials is by belt conveyor, rail or water. To minimize the emission of pollutants into the air, all vehicles on the construction sites of AlpTransit Gotthard Ltd. must – with few exceptions – be fitted with particle filters.

Water from the mountain and tunnel is polluted by traffic and operations on the construction site. It is purified according to legal regulations, cooled, and fed into rivers in compliance with strict rules. Regular monitoring ensures that the purification systems are optimised. When construction is complete, the surface sites will be restored to their original condition. The land surface will regain its former agricultural and ecological function.

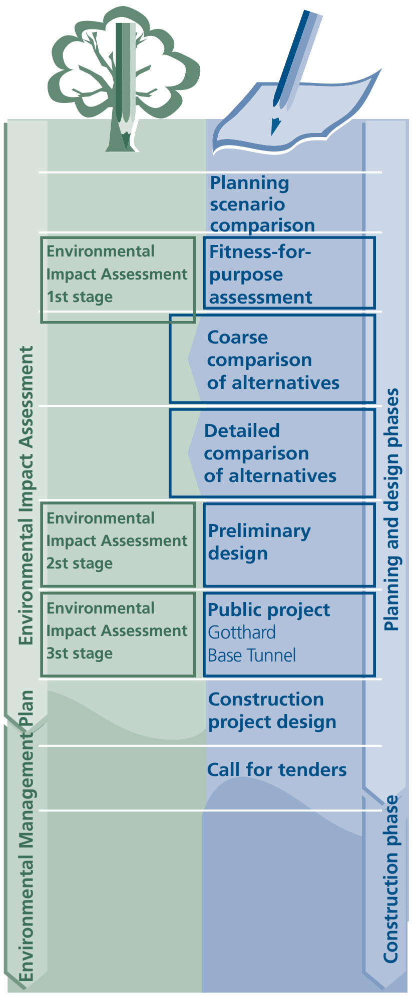
Monitoring water quality at Amsteg

Enclosed belt conveyors at Sedrun

The landscape is changed by the new rail link along parts of the route. To ensure that above-ground installations blend inconspicuously into the landscape, the Consulting Group for Landscape and Design specifies corresponding guidelines. Construction work affects the habitats of animals and plants. In some cases they are only temporarily affected, but in other cases their use is permanently changed. Where the effects are only temporary, restoration measures are planned, while for some areas whose use is changed permanently, replacements are found before construction work begins.

Environmental protection laws require installations which could pollute the environment to undergo environmental compatibility tests (ECT). Plans for the new Gotthard Rail Link undergo ECT in three stages. The first stage was within the scope of the report on the New Rail Link through the Alps of May, 1990; the second stage evaluated the conceptional projects; and the third stage is applied to the projects in the form they are advertised for tendering.

The 3 stages of environmental compatibility testing



The Insla at Sedrun: an environmental compensation measure

The environmental policy of AlpTransit Gotthard Ltd.

- AlpTransit Gotthard Ltd. as constructor of the NRLA Gotthard axis realizes an environmentally friendly flat rail link through the Alps while giving environmental issues a very high priority.
- AlpTransit Gotthard Ltd. plans and realizes sustainable project solutions which are ecologically and economically compatible and have an optimal cost-benefit ratio.
- AlpTransit Gotthard Ltd. strives to minimise emissions and other adverse environmental impacts and to conserve resources.
- AlpTransit Gotthard Ltd. complies strictly with the environmental protection laws and stipulations and provides open information on environmental matters.

Prepared for *every situation*

Because the Gotthard Base Tunnel is so long, safety is exceptionally important. The goal is for a well-balanced level of safety, but even after all safety precautions have been taken, a residual risk remains.

Operation of the future Base Tunnel is not entirely free of hazards. These must be countered with appropriate safety measures. A balanced mix of constructional, technical and operational measures is vitally important. For example, a risk analysis was performed on the necessary number of emergency stop stations and cross passages as well as other components of the project. It showed that the risks in the tunnels of the new lines are substantially less than on the existing lines of Swiss Federal Railways.

Swiss Federal Railways – in collaboration with other European railway operators and supervisory authorities – have defined safety goals for the operation of their new transportation facilities. Safety planning will be successively refined right up to the time when the Gotthard Rail Link goes into operation, and experience of incidents like the fire in the Channel Tunnel will be taken into consideration.

Four goals underlie the measures being planned. The main emphasis is on incident prevention. Should an incident occur, the priorities are then containment, self-rescue, and external rescue. Suitable evacuation routes, emergency stops and trackside pathways are provided for self-rescue. Efficient external rescue requires well-organised rescue teams and an operationally practical rescue concept.

There is regular exchange of experience with the project teams of other major European tunnels (the Lötschberg, Brenner, Mont d'Ambin, Semmering and Channel tunnels). In particular, this has confirmed the practicality of a tunnel system with two single-track tunnels and no service tunnel for the long railway tunnel under the Alps.

Fire-fighting and rescue train

Rescue vehicle of the fire-fighting and rescue train

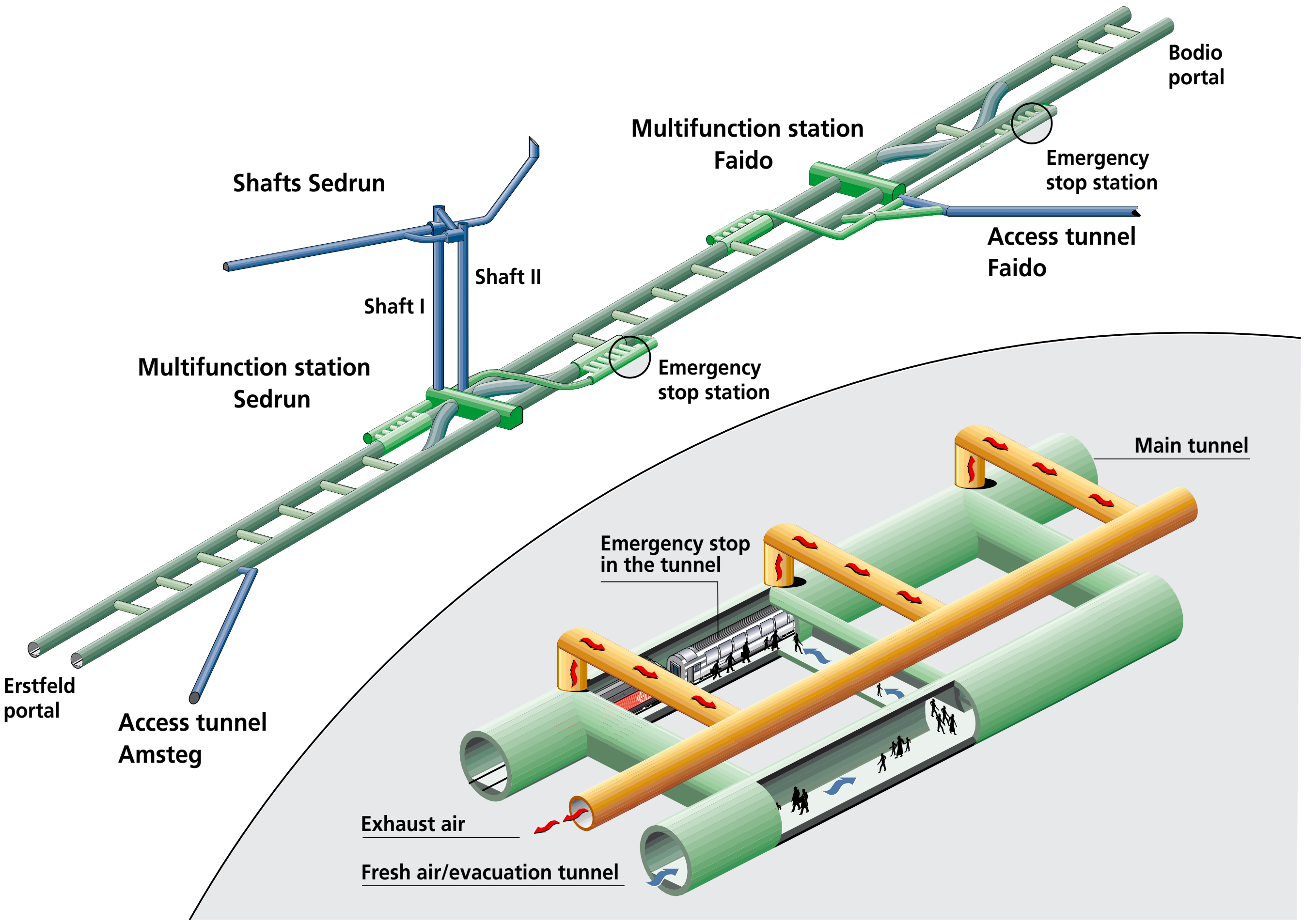
So anyone hoping for an exciting adventure when crossing the Alps by train will find the journey disappointing. Thanks to the safety measures in the tunnels of the new Gotthard Rail Link, incidents are practically ruled out.

Special aspects affecting safety

Special aspects affecting the safety of the new Gotthard Base Tunnel:

- The length of the tunnels (Gotthard 57 km, Zimmerberg 20 km, Ceneri 16 km)
- The great depth of overlying rock in some places (up to 2300 m in the Gotthard Base Tunnel) causing exceptional rock pressure and climatic conditions
- Speeds up to 250 km/h
- A moderate to high train density with a large proportion of freight trains
- Its major international importance as a transalpine rail link which calls for exceptionally high standards of reliability and safety

Safety concept in the Gotthard Base Tunnel



Engineering for the future

The tunnel operating concept is based on simple, clearly structured processes and an infrastructure which is restricted to the essentials. The railway equipment must ensure safe long-term operation.

The technical equipment in the Gotthard Base Tunnel allows practically automatic operation, so that human intervention is reduced to a minimum. The minimalist principle is also applied to the equipment installed in the tunnel: everything which does not absolutely need to be in the tunnel is installed outside. The result is high availability and a low incidence of faults.

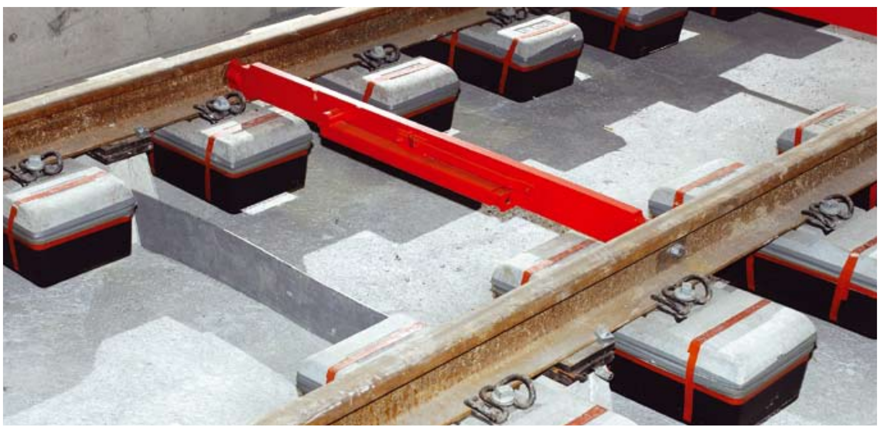
The items of railway infrastructure can be grouped into the following main categories:

- superstructure: tracks, points, points mechanisms, slab
- safety and automation systems: track-release signalling systems, driver's cab signalling and signals, control centres, points monitoring systems
- telecommunication systems: mobile radio, data transmission and switching, power information system
- traction current systems: catenary, switching stations at 15 kV/16.7 Hz level
- electrical systems: lighting, 50 Hz power supply, cable systems.

The superstructure is also designed for maximum availability and minimum costs as well as best possible prevention of incidents. In pursuit of these goals, three principles are applied:

- smallest possible number of points
- straightest possible line
- ballastless track in the tunnel for maximum stability.

An important component of the railway infrastructure are the safety installations. The control centre sets and monitors the points and gives the trains permission to proceed via trackside signals or displays in the driver's cab. Driver's cab signalling uses state-of-the-art technology to ensure that the train does not travel beyond the boundaries set for it by the control centre. AlpTransit Gotthard will be equipped with the new standardised European Train Control System (ETCS) Level 2 which will also be introduced on other European railway networks at the same time.

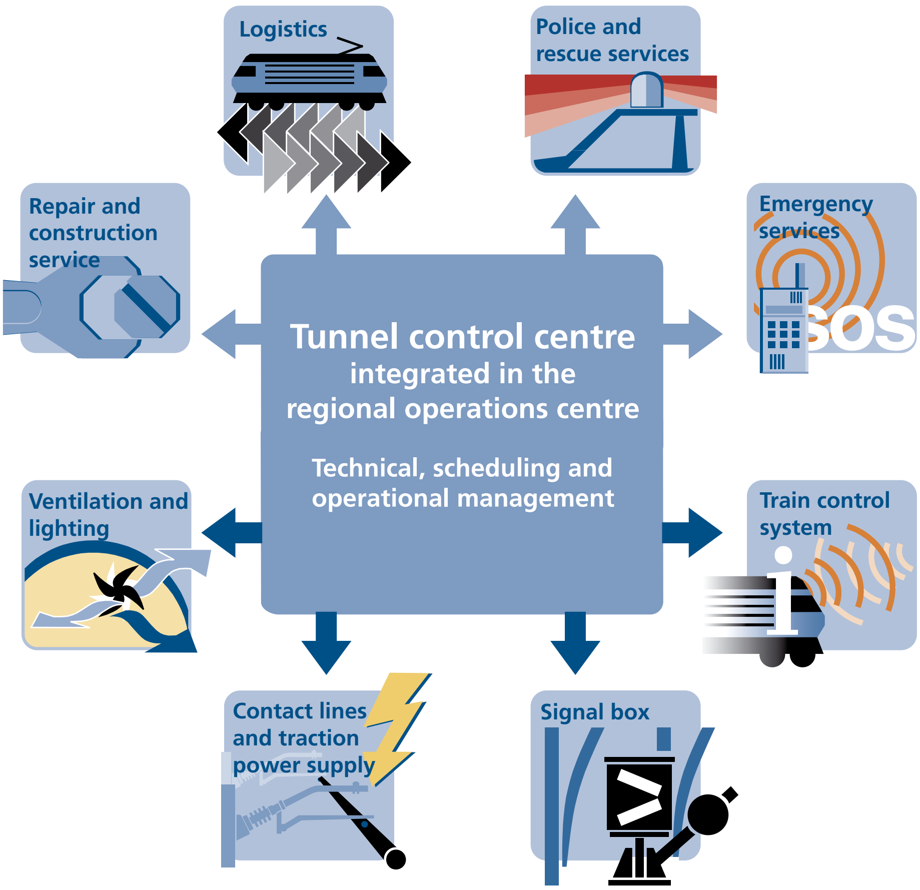


Installing ballastless track

The safety and automation systems of the AlpTransit Gotthard have the following characteristics:

- uninterrupted monitoring of the trains on the new lines through driver's cab control signalling
- few faults thanks to high availability of the track and train equipment
- inter-operability with the other railways in Europe thanks to standardised signalling systems
- simplified track infrastructure through data transmission by digital radio
- central operations management and automation of railway processes by remote control from the tunnel control centre integrated in the regional operations centre.

Tunnel control center



Installing the catenary

The production and delivery of the traction current is known as traction current supply. The catenary serves for the fine distribution of traction current. It is a highly important system component which cannot be duplicated. Its availability is optimised by

- the use of proven technology adapted to the conditions in the tunnel;
- division of the catenary into sections: as few sections as possible, as many as necessary;
- a sufficiently large distance between the tops of the vehicles and the contact wire to reduce the likelihood of damage or a short circuit through the trains.

The traction current is supplied from the power stations via substations, where the maximum voltage of the transmission lines is reduced by transformers to the 15 kV of the contact wire, and then to the catenary. The substations are so dimensioned that in the event of total failure of one of them, the line can still be supplied by the others.

The electricity supply system supplies electricity to fixed equipment at the side of the track as well as in the control centre. The electricity is used mainly for the points and communication systems as well as air conditioning and lighting. The electricity is distributed through cables which are usually installed alongside the track in conduit blocks or cable channels. These are designed for reliability and availability since they indirectly affect safety.

Maintenance, temperature and humidity

The temperature and humidity in the tunnel influence the ageing process. Optimal temperature and humidity avoid system faults and thereby reduce maintenance work. The frequency of maintenance work affects the capacity of the new rail link. Maintenance should therefore be kept to a minimum.

Concrete tunnel lining at Bodio

The maintenance concept of the Alp-Transit Gotthard is quite different from that on existing lines of Swiss Federal Railways:

- Each section of track is either open for trains to pass over or closed for maintenance work.
- On sections of track which are closed, maintenance work is carried out as a coordinated operation by the various specialist services.

This concept brings a sharp increase in efficiency through lower costs, and in safety through fewer work-related accidents. Simplification of the infrastructure reduces the extent of the maintenance work, the investment costs and the frequency of faults. The separation of train traffic from maintenance activities increases safety. Speed and quality of work are improved by the absence of interruptions and disturbances from passing trains.

A further important element of the maintenance concept are preventive constructional measures to control the temperature and humidity of the air in both the Gotthard and Ceneri base tunnels. The temperature inside the tunnel is the result of many interrelated factors. Not only is the rock deep under the mountains much hotter, but further heat is added by the locomotives. If there is no exchange of air in the tunnel, the temperature soon becomes very high. The necessary exchange of air is created by the piston effect of the trains themselves.

An important decision taken at the planning stage was to construct the Gotthard Base Tunnel with a continuous inner lining of cast-in-place concrete. This lining lowers the air resistance, which lessens the amount of heat generated by the trains. The lining also improves the natural air circulation in the tunnel, reduces humidity and limits seepage of groundwater into the tunnel.

Optimal temperature/humidity

The following values should not be exceeded for more than short periods or distances in the tunnel:

Temperature:	35 °C
Relative humidity:	70%
Water seepage:	35 g/s per km through the tunnel lining

Travel fast, travel safely, arrive relaxed

Today we travel more comfortably, more punctually, and above all faster than in the past. But when choosing how to travel, efficiency is not the only consideration. Safety is also increasingly important. And high-speed rail travel is statistically the safest means of transport.

The chances of being involved in an accident while travelling have gone down enormously in the last century. Today, the risks of being involved in an accident when travelling by train or aeroplane are very low – much lower than for travel by car. And safest of all is travelling by high-speed train: high-speed rail travel is almost 100 times safer than travelling by road!

There are several reasons for this. When planning and constructing high-speed railway lines, and the rolling stock which runs on it, carefully thought-out measures are included to optimise safety and prevent accidents. For example, high-speed lines are designed so that certain causes of accidents are eliminated right from the start: there are no level crossings, few points, and a wider distance between the pairs of tracks than with normal lines. This reduces the danger of collision with other vehicles, derailment, or an incident involving trains travelling in opposite directions. The trains themselves are equipped with an automatic safety system: it is impossible for them to exceed the maximum speed limit or overrun a stop signal.

Switzerland's new railway lines are not pure high-speed lines but carry mixed passenger and freight traffic. However, thanks to optimal planning and comprehensive safety measures, they are more reliable than the rest of the railway network. Because of their international importance, it is vital for the new lines to function smoothly.

In the Gotthard and Ceneri base tunnels, certain types of incident simply cannot occur. For example, trains travelling in opposite directions cannot collide because they travel in two separate single-track tunnels. Additional all-round safety is provided by a highly sophisticated package of technical measures. And even if something does happen, passengers in the tunnel are not simply left stranded: emergency stop stations and connecting galleries provide immediate escape routes and ensure fast and safe evacuation of the tunnel.

So travellers can feel safe in the high-speed trains. They can enjoy the quick journey and arrive at their destination completely relaxed.

The railway of the future: attractive and reliable

The new rail links through the Alps are Switzerland's link with the future. They enable the railways to provide attractive services at the heart of the international passenger and freight transportation system – under the motto «fast, economical, safe». The new high-speed lines are an impressive comeback for the railways in Europe: the means of transport of the future.

More than one hundred years ago Europe's first transalpine railway system was built. The idea of having tunnels at their highest points, as well as spiral tunnels on daringly routed approach lines, was regarded as revolutionary. Penetration of the Gotthard, Lötschberg and Simplon heralded a new era for transalpine traffic.

This system is now being adapted to the changed needs of passenger travel and freight transportation today. Modernising the system is no less spectacular than originally building it. It is based on clearly defined, simple and consistent planning principles combined with state-of-the-art technology which is standardised across Europe. As a result, the new lines attain unprecedented levels of reliability, safety and economy.

Additional new lines whose routes are defined in the overall AlpTransit plan will one day extend and connect with the base tunnels under the Zimmerberg, Gotthard and Ceneri. Gaps now being studied between Lugano and Milan or Arth-Goldau and Erstfeld will be closed. That will cut the journey time between Zurich and Lugano to one hour, from Zurich to Milan to one-and-a-half-hours, and between Munich and Milan to under four hours.

The fastest trans-Europe connections will cross Switzerland like the famous trains of history: the Orient Express (London – Paris – Lausanne – Istanbul) and Arlberg Express (Paris – Zurich – Vienna). Other regular connections of the past such as Hamburg – Stuttgart – Zurich – Milan and others will become reality again. But journey times will dramatically overtake the leisurely speeds of the belle époque.

The railways are capturing a new position in the European transportation market. For Switzerland to be integrated into the railway network of modern times, lines must be built which can carry high-speed traffic. Building the new Gotthard Rail Link is laying the foundation stone for Swiss railways of the future – upgrading the approach lines will complete the construction project of the century.

Design study for the Cisalpino high-speed tilting train

Public involvement through open information

The new Gotthard Rail Link is the most far-reaching environmental project Switzerland has ever known. Public interest is correspondingly strong. As constructor, AlpTransit Gotthard Ltd. aims to provide competent, complete and transparent information on developments, progress, milestones, challenges and solutions at all times.

The Internet is the fastest medium for exchanging information. AlpTransit Gotthard Ltd. maintains an extensive multilingual website which is continuously updated. At **www.alptransit.ch** latest information on the status of work will be found, along with many fascinating details about construction of the new Gotthard Rail Link.

Brochures and leaflets provide comprehensive background information in printed form. Several times a year, information flyers about the status of work on the individual construction sites are published and sent directly to local residents. They can also be obtained via the Internet or directly from the secretariat of AlpTransit Gotthard Ltd.

Construction site visits are a favourite way for adults to gain on-site information about the status of work. Interest is so strong that visits have to be notified and reserved in advance. The construction sites at Amsteg and Bodio have visitor trails with information boards. These easy walks allow visitors to explore the construction sites without guides. Further details and contact addresses are on the website.

Open days are held once yearly at all construction sites. Experts give competent information, and refreshments are available. Children accompanied by adults may also go underground on these days. The dates are published on the Internet.

The visitor centres offer not only chargeable guided tours of the construction sites but also extensive exhibitions covering several hundred square metres. Audiovisuals, models and original objects turn construction of the new Gotthard Rail Link into an experience. Entrance to the exhibitions is free of charge. Opening times and contact addresses are on the website.

Documentary films with thrilling, intensive scenes show progress on the new Gotthard Rail Link and the frequently tough and challenging work underground. Further films will be produced each year until the Gotthard Base Tunnel is opened. They can be purchased or ordered at the visitor centres. Information about ordering is also contained on the website.

Construction site open day at Amsteg

Photographs

Alain D. Boillat, Swiss Federal Railways Photo Service, Berne
Pages 3, 8, 9, 10, 21, 38, 40, 41 top, 42, 44, 45
Guy Perrenoud, Swiss Federal Railways Photo Service, Berne
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