The connecting line between Austrian Western, Austrian Southern and Donauländebahn Railways

Lainzer Tunnel

JANUARY 2009
The Lainzer Tunnel in the trans-European network

Trans-European Networks (TEN) are highly technical infrastructures, which will bring Europe together and enhance the economy. The objective of the establishment and development of these networks is to guarantee secured passenger and freight traffic within the European Union and their neighbours in the long term and to increase competitiveness.

For that, priority axes and projects for the following modes of transport were determined in the entire territory of the union:
- Rail
- Road
- Inland Waterway
- Ocean seafaring
- Aviation/Airports

The Lainzer Tunnel as part of the Danube axis

With the expansion of the Danube axis, the Austrian section TEN 17 – Railroad corridor "Paris-Strasbourg-Stuttgart-Vienna-Bratislava", ÖBB-Infrastruktur Bau AG makes a substantial contribution to European mobility. This section runs from the German border near Salzburg along the line Linz, St. Pölten and Vienna up to the Slovakian border near Bratislava.

The Lainzer Tunnel is a decisive part of this Danube axis with its function as the connection of Austrian Western Railway with Austrian Southern Railway and Donauländebahn.
Layout of the Lainzer Tunnel, as part of TEN corridor 17 – Axis Paris - Bratislava

- Connecting line between Austrian Western, Austrian Southern and Donauländebahn Railways (Lainzer Tunnel)
- Existing lines
- Wienerwaldtunnel

New line Vienna – St. Pölten

Existing line Vienna – St. Pölten

“Verknüpfung Westbahn”

13th district Hietzing

14th district Penzing

Train station Hüttenlohe
The Project

Lainzer Tunnel

The Lainzer Tunnel lies on the axis Paris – Bratislava (TEN corridor 17) and forms the essential element for the passage through Vienna from West to East.

Through the Lainzer Tunnel – the connecting line between Austrian Western, Austrian Southern and Donaulände Railway Railways in Vienna – freight and passenger trains will cross through Vienna or reach their intra-urban targets, the freight terminals and train stations, respectively, faster and more environmentally friendly than so far.

Released capacities on the Western and Southern Railway lines as well as on the connecting line may then be used for improvements of the local passenger traffic.

The project will be implemented in four sub-sections:

- "Verknüpfung Westbahn" ("Interconnection to Western Railway")
- "Verbindungstunnel" ("Connecting tunnel")
- "Anbindung Donaulände" ("Connection to Donaulände Railway")
- "Einbindung Südbahn" ("Integration of Southern Railway")

Improvements for the Abutters

- Increase of the customer comfort by modernisation of the stopping points
- Better connection to commuter traffic
- Substantial reduction of the train noise
- Shorter barrier closing times by the more concentrated suburban train traffic on the connecting line
The following will be achieved with the commissioning of the Lainzer Tunnel:

- Modern and efficient connection of Western Railway with Southern and Donauländebahn Railways
- Relief of the connecting line from long-distance freight and passenger traffic in the 12th, 13th and 14th district, and thus a substantial improvement of the noise situation for the abutters
- Use of the line capacities released at the surface for a more concentrated short-distance passenger traffic (suburban trains)
- Connection of the Western Railway line with the new Vienna Central Station
- Modernisation of the stopping points
  - Vienna Hadersdorf
  - Vienna Weidlingau
  - Sanatorium Purkersdorf
- New construction of the suburban train station Vienna Wolf in der Au
- Due to the broadening of the so-called “Meidlinger Einschnitt” (sub-section “Integration of Southern Railway”) from four to eight or nine, respectively, tracks, the level-free integration of the suburban railway line into the Southern Railway line is possible, and thus a substantial increase in capacity at the train station Vienna Meidling.

Project time frame

**Planning phase:**

- **1990** Transfer of planning to the then HL-AG (now ÖBB-Infrastruktur Bau AG)
- **1991-1992** Route selection procedure and route determination
- **1993** Route allocation by the Austrian Minister of Transport
- **1996** Assignment of the construction to the then HL-AG: Submission planning and official procedures for the approval according to the Austrian railway, nature conservation, water, road, waste management laws etc.
- **1996-1998** Property redemption and tendering planning

**Construction phases and commissioning:**

- **1999-2005** Preliminary construction work in sub-section “Einbindung Südbahn” (“Integration of Southern Railway”)
- **2004** Partial commissioning of the suburban railway underpass tracks 6 and 8
- **2005** Commissioning of the Southern Railway line tracks 1 and 2
- **2005** Commissioning of the connecting line track 10
- **1999-2005** Preliminary construction work in sub-section “Verknüpfung Westbahn” (“Interconnection to Western Railway”)
- **2004-2010** Preliminary construction work in sub-section “Verbindungstunnel” (“Connecting tunnel”)
- **2005-2008** Preliminary construction work in sub-section “Anbindung Donauländebahn” (“Connection to Donauländebahn Railway”)
- **2008** Partial commissioning of the so-called “Weichenhalle” (“Point switch hall”) in sub-section “Verknüpfung Westbahn” (“Interconnection to Western Railway”)
- **2010-2012** Equipment phase
- **2012** Overall commissioning of the Lainzer Tunnel simultaneously with the commissioning of new line Vienna – St. Pölten
- **2013-2014** New construction of the Donauländebahnbrücke bridge

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**FIGURES, DATA, FACTS**

- **Project length:** 12,8 km
- **Length of the tunnel:** 12,3 km
- **Tunnel length with connections:** 15,4 km
- **Overall length of the track re- and new constructions:** 25,3 km
- **Draft speed:**
  - 120 km/h for freight traffic
  - 160 km/h for passenger traffic

- **The following is constructed:**
  - 7 Access shafts and areas for tunnel advance
  - 4 Portals
  - 28 Emergency exits
  - 4 Service buildings
  - 4 Suburban train stations as new or re-constructions, respectively
  - 6 Road crossings as under- or overpasses, respectively
  - 10 Rail crossings as under- or overpasses, respectively
  - 5 Footpath or cycle path crossings as under- or overpasses, respectively
  - 2 Stream crossings
  - 3 Fixtures collectors for gas and water lines, power cables, channels, etc.
The sub-section
"Interconnection to Western Railway"

This sub-section connects the two existing long-distance traffic tracks of Western Railway with the new line Vienna – St. Pölten between the train station Vienna Meidling and St. Pölten central station and the lines towards Hütteldorf/Westbahnhof as well as the connecting tunnel.

Since 2006, the expansion has been taking place in this section. Completion and partial commissioning of this section took place in December 2008.

2nd section: The section consists of two single-track tunnel tubes with a length of approx. 750 and 900 m, respectively, which start at the connection structure in the area of the Mauerbach crossing, underpassing the foot of Bierhäuselberg hill, Linzer Strasse, the Western Railway line as well as the river Vienna. Here starts the approx. 300 m long double-track section up to Wientalstrasse or Bundesstrasse 1, respectively.

Course:

1st section: In the area of the Western Railway route between Vienna Wolf in der Au and the suburban train station Purkersdorf Sanatorium, over a total length of 3 km, two tracks of the Western Railway line are lead underneath the existing Western Railway line via ramp structures, where they are connected with the two tracks of the new line Vienna – St. Pölten in a four-track, so-called “Weichenhalle” (“point switch hall”), which has a length of approx. 550 m.

2nd section: The section consists of two single-track tunnel tubes with a length of approx. 750 and 900 m, respectively, which start at the connection structure in the area of the Mauerbach crossing, underpassing the foot of Bierhäuselberg hill, Linzer Strasse, the Western Railway line as well as the river Vienna. Here starts the approx. 300 m long double-track section up to Wientalstrasse or Bundesstrasse 1, respectively.
Special construction measures:

The two suburban train stations Vienna Haderdorf and Vienna Weidlingau have already been designed completely new and handicapped accessible. Furthermore, in the area of the train station Vienna Wolf in der Au, an additional suburban train station and a park&ride system were built.

Likewise newly erected were the overhead walkway across the railway — “Billasteg/Ha-Wei-Steg” - next to the Mauerbach stream, the bridges of the railway across Mauerbach stream and across Mauerbachstrasse as well as the road bridge Linzer Strasse. Lorenz-Stein-Strasse was expanded into a two-lane road. In the entire area, nine emergency exits were provided.

Construction methods

1st section: The structure underneath the existing Western Railway line was mainly build in open construction, in the dig-and-cast construction method. The unhindered railway operation was guaranteed on at least two Western Railway tracks in all the construction phases. Furthermore, a groundwater balancing system was installed in order to further enable the groundwater flow towards the river Vienna.

2nd section: The two single-track tunnel tubes were built in a closed construction method.
The sub-section "Connecting tunnel"

This double-track sub-area with a length of approx. 6.6 km represents the actual connection of the "Interconnection to Western Railway" with the "Integration of Southern Railway" and the "Connection to Donauländebahn Railway", respectively. The construction of the "Connecting tunnel" started in 2004. Following the completion of the preliminary construction work in 2010, the finishing of interior work is to start immediately.

Course:

From the undercrossing of Bundesstrasse 1 in the Wiental valley, about 200 m into town from the junction of Westautobahn, the tunnel starts underneath the Lainzer Tiergarten wildlife preserve, crosses the district area of Ober St. Veit, the area of Roter Berg hill as well as the district area of Lainz, and then from the underpass of Lainzer Strasse, at the junction of Speisinger Strasse, turns underneath the route of the connecting line.

After approx. 1.5 km, roughly at the intersection of Jägerhausgasse into Schläglgasse, the tunnel route leaves the area of the existing connecting line route and continues further underneath the former route area of the connecting line. Following the undercrossing of Schönbrunner Allee and Strohberggasse, about 100 m before Altmannsdorfer Strasse, the tunnel leads into the branching structure of
the connection of Donaulände Railway line and the integration into the Southern Railway line, respectively.

**Special construction measures:**

The only parts of the tunnel construction, which over the entire section will be visible at the surface, are the actual exits of the 11 emergency exits. The depth of the tunnel tracks underneath the ground level is between 15 and 130 meters.

**Method of construction:**

One half of the connecting tunnel is advanced in loose rock, the other in solid rock. In the loose rock section, the entire tunnel section lies at groundwater level. Therefore, these levels have to be relieved prior to the actual tunnel work by means of groundwater lowering. The tunnel advance in this area is achieved in the so-called wall heading method (see closed construction method). The solid rock section passes the so-called "Wienerwaldflysch", and here the conventional calotte-bench-invert advance method is used.

The tunnel advance takes place from the starting shafts. The starting shafts Klimtgasse, Lainzer Strasse and Hofjagdgasse will be developed into emergency exits at the end of the construction period.
The sub-section
"Connection to Donauländebahn Railway"

Course:
The route starts underground in the area of Altmannsdorfer Strasse, passes underneath the Southern Railway line, Breitenfurter Strasse and the premises of the company Henkel, formerly company Grundig, and then passes underneath the Donauländebahn Railway line and Grießergasse up to the Stüber-Günther-Gasse shaft. Immediately after that, the routes of the U6 as well as of the Wiener Lokalbahn Railway line are undercrossed.

The double-track tunnel then turns underneath the Donauländebahn Railway line to the northern side of the railway route, ascends next to the transformation substation Umspannwerk Süd and ends immediately after the undercrossing of Eibesbrunnergasse. Then follows a ramp line up to the bridge across Gutheil Schoder Strasse, to the end of the project.

Special construction measures:
In Eibesbrunnergasse, the same level railway crossing for pedestrians was replaced by an overhead walkway.
The railway bridge across Gutheil Schoder Strasse was newly erected.
In this sub-section, four emergency exits are provided.

Method of construction:
The branching structure in the Strohberggründe area, underneath Altmannsdorferstrasse and underneath the former train station Unterhetzdorf, was built in an open construction method / dig-and-cast construction method using diaphragm walls for the lateral and central tunnel walls.

The base plates, tunnel ceilings and inner shells in this area, which partially is close to...
neighbouring buildings, are particularly solid for reasons of avoiding vibration and structure-borne sound emissions. Thus, the base plates have a thickness of 1.80 m, the T-beams of the tunnel ceiling have a height of 3.0 m and the inner shell on the side towards the neighbouring buildings has a thickness of 1.20 m.

The line from the former train station Unterhetzendorf up to the crossing of the U6 was built in a closed construction method.

From the crossing of the U6 up to Eibesbrunnergasse, the dig-and-cast construction method was then used again – using bored piles with a diameter of 120 cm.
The sub-section
“Integration of Southern Railway”

This sub-area with a length of approx. 1550 m realises the level-free integration of the tracks of the Lainzer Tunnel into the Southern Railway line between the train station Vienna Meidling and the stopping point Hetzendorf. In this connection, there is an improvement of the entry situation of the suburban train traffic into the train station Vienna Meidling from the Southern Railway line and from the connecting line. The preliminary construction work took place between 1999 and 2005.

In order to maintain the traffic on the Southern Railway and connecting lines, this work had to be performed in a total of 58 different track construction phases.

Course:

The route of the Lainzer Tunnel starts at the train station Vienna Meidling and descends following the undercrossing of the Philadelphiabrücke bridge between the two tracks of the Southern Railway line. The portal of the Lainzer Tunnel is located immediately following the undercrossing of Donauländebahnbrücke bridge. The route then runs underground underneath the former train station Unterhetzendorf towards the west, undercrosses Altmannsdorfer Strasse, follows the route of the connecting line, which was put out of service in 1974, and shortly before the undercrossing of Wienerbergbrücke bridge.

Portal of the suburban train underpass towards the train station Vienna Meidling

Work at the broadening of “Meidlinger Einschnitt”
Strohberggasse street passes into the sub-section "Connecting tunnel".

**Special construction measures:**

In the so-called "Meidlinger Einschnitt", the expansion measures result in a broadening from 4 to 8 or 9 tracks, respectively. The Wienerbergbrücke bridge was newly constructed and shifted towards Philadelphiabrücke bridge. The existing Flohberg tunnel of the connecting line was removed over a length of approx. 50 m. The existing Donauländebahnbrücke bridge will be newly constructed from 2013/14 on, due to the required almost double span width following the completion of the Lainzer Tunnel.

**Method of construction:**

This construction lot was built in an open construction method. The lateral limiting walls of the new, wider "Meidlinger Einschnitt" were constructed using reinforced concrete bored piles with a diameter of 120 cm. The lateral limiting walls of the ramps and tunnels were built as diaphragm walls.
"Open construction method"

There are various forms of the "open construction method". For the Lainzer Tunnel, the so-called dig-and-cast construction method was chosen to:

- keep the disturbance of the abutters during the construction phase as low as possible
- be able to maintain the present railway operations above the tunnel to be constructed in all the construction phases.

The following graphics show at the example of the construction lot LT 23 in Hadersdorf (sub-section "Interconnection to Western Railway"), how the tunnel is built in the dig-and-cast construction method. In the future, the trains will run in the tunnel as well as at the surface (commuter traffic).

**METHODS OF CONSTRUCTION**

For the Project Lainzer Tunnel, two construction methods are applied:

- The so-called "open construction method" is largely performed in the dig-and-cast construction method
- The "closed construction method" is performed according to the principles of the New Austrian Tunneling Method (NATM).

Approximately 35% of the Lainzer Tunnel is built in the "open construction method" and about 65% in the "closed construction method". Which tunnel construction method is chosen mainly depends on the line routing, the topography, the existing neighbouring buildings, the geology, and on the depth of the tunnel.
“Closed construction method”

In the "closed construction method", the tunnel is excavated using excavators. The outer shell of the tunnel is produced with shotcrete. The expansion measures are determined according to the rock conditions actually present and according to the results of the routine control measurements in the tunnel and at the surface, respectively.

In the loose rock sections, a previous groundwater relief is required as a prerequisite for the subsequent tunnel advance. I.e. the groundwater level in the deep-lying groundwater body is relieved (lowered) that far by means of wells that the tunnel advance may take place without any problem and risk, while the near-surface water conditions remain unaffected.

For the double-track tunnel areas in the loose rock sections, the so-called "wall heading" was chosen due to the intra-urban location and the track routing underneath the existing tracks, respectively.

For wall heading, there is a subdivision of the entire cross-section of the excavation (approx. 130 m²) into four individual advances. Thus, it is guaranteed that no substantial or only minor deformations or settling, respectively, occur at the surface.

The four individual advances are started offset in time. Construction starts with the so-called "advancing wall heading 1". This is followed by the advances "subsequent wall heading 2", "calotte core 1" and "bench/invert core 2".

These four sub-advances are respectively excavated in sub-cross-section: for the wall headings 1 and 2 with calotte, bench and invert, for core 1 with calotte 1 and bench 1. Core 2 is excavated in a subdivided manner if required only.

Following the introduction of the inner shell with a thickness of 50 cm, the groundwater lowering is stopped, upon which the original groundwater level returns naturally.

The double-track area in the solid rock section with approx. 130 m² and the single-track areas with a cross-section of excavation of approx. 85 m² are produced with three sub-cross-sections (calotte, bench, invert).
Protection against noise and vibration

For the Project Lainzer Tunnel, numerous measures are taken in order to reduce the noise and vibration values below the limit values specified in the legal railway approval procedure:

- Production of a solid tunnel shell with a minimum thickness of 80 cm. This consists of at least 30 cm of shotcrete for the tunnel construction work as well as the inner shell with a thickness of 50 cm.
- With the installation of a mass-and-spring system, the secondary noise insulation is optimised, and thus it is avoided that perceivable vibration effects can be felt at the surface.
- In the design of the ramps and the tunnel portals, respective construction measures provide for the minimisation of the noise effects.
- At exposed locations, noise protection walls are erected at the surface along the Lainzer Tunnel, or object-side noise protection measures are supported.
Mass-and-spring system

Following the completion of the preliminary construction work, the tunnel finishing takes place. This also includes the installation of a mass-and-spring system, which optimises the damping of structure-borne noise. Perceivable vibrations at the surface are thus prevented. There is a light, medium and heavy, respectively, mass-and-spring system.

Which of these systems is installed depends on the depth of the tunnel, the proximity to residential buildings, and the geological conditions. Details are determined following the analysis of the results of Vibro-Scan tests. In this test, a truck-like vehicle generates vibrations at the tunnel invert and simultaneously vibrations occurring at the surface or in the buildings, respectively, are measured.

Due to its high mass, concrete is inert. Therefore, the tracks are laid on a concrete block, which with approx. 5 to 12 tons per metre of tunnel acts as the “mass”.

This mass is then hardly vibrated by the rail traffic in the tunnel. With the installation of a bearing structure between the concrete block and the tunnel invert, it is additionally prevented that residual vibrations travel into the ground.

This bearing structure – called “spring” – for heavy mass-and-spring systems consists of individual bearings on the tunnel invert and vertical lateral bearings. For medium and light mass-and-spring systems, it consists of area mats on the tunnel invert and vertical mats in a lateral position.
Tailored safety without compromise

For a new rail project, especially for tunnel areas, a tailored safety concept is prepared together with the rescue forces. In that, the high safety level of a modern railway tunnel must be achieved independent of the selected tunnel system.

The most essential objective of the safety strategy is to give the people affected by a possible incident a real chance to get into a safe area, the “safety lock”, as quickly as possible. Functioning information and communication systems provide for that just as respective structural facilities.

The implementation of the respective safety concept takes place in two stages for each new railway tunnel. The first stage concerns the determinations in the legal railway construction approval for the construction concept and functionality of the safety measures in case of an incident.

In the second stage, any detail determinations in respect of installation in the tunnel, equipment of the rescue forces, or organisational measures in case of an incident are made.

All these measures form the entire safety package, a decisive basis for the grant of the operating approval.

**Structural fire protection**

Within the course of submission planning, the professional fire brigade of the City of Vienna made a number of additional requests to the safety concept in respect of the fire resistance of the tunnel structure.

The measures to guarantee the structural fire protection were developed and determined according to international experience.

This particularly affected the following:
- the definition of protection objectives and protection zones
- the development of a defined fire curve or temperature-time curve, respectively, for the Lainzer Tunnel
- the development of specific static and structural approaches for the realisation of the fire protection of the load-bearing structure (fire tests, material tests, etc.)
- the structural analysis for this defined fire load.

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1. Lainzer Tunnel
2. “Safety lock” in the cross-cut/connecting tunnel
3. Emergency exit
4. Emergency door (w/ self-closing fire protection door)
5. Escape routes/ Side paths
6. Orientation lighting
7. Illuminated handrail
8. Escape route marking
9. Fire waterline, filled
10. Tunnel hydrant
11. Elevator
12. Ventilator for smoke extraction
13. Fresh air supply
14. Road/Access

*Equipment of an emergency exit (schematic representation)*
Emergency exits

In the Project Lainzer Tunnel, a total of 28 emergency exits at a maximum distance of 599 m are provided. That means that in case of an incident, the passengers would have to cover a maximum distance of 300 metres in order to reach the next emergency exit.

From the tunnel, the emergency exit is accessed via the connecting shaft/cross-cut, which is equipped with two tight, self-closing fire protection doors as “locks”.

Any exit structures are equipped with lifts and stairs. Via the staircase or the lifts, respectively, the exterior is reached at the surface. There the doors are equipped with so-called panic locks, i.e. they can be opened from the inside with low effort.

### TUNNEL SAFETY CONCEPT FOR THE LAINZER TUNNEL

#### 1. Structural measures
- **Escape routes in the tunnel**
  - footpaths on both sides (width approx. 1.2 m)
  - average escape route length approx. 240 m, fire protection doors
  - handrails along the tunnel wall
  - orientation lighting (indication of the direction of escape)
  - modular structure of the equipment elements of the lighting

- **Emergency exits**
  - 28 emergency exits
  - distances between the emergency exits max. 599 m, on average approx. 380 m
  - equipment of the lock with tight fire protection doors
  - lifts (operated by fire brigade)
  - 2.0 m wide steps with large platforms

- **Precautions for rescue forces**
  - at the surface, hydrants in the proximity of each emergency exit
  - in the tunnel, stationary fire water supply lines
  - wall hydrants on both sides of the tunnel every 50 m
  - transport aids
  - a special alarm and risk defence plan for the rescue forces
  - regular instructions of the rescue organisations and special training

#### 2. Communication in the tunnel
- train radio
- emergency telephone
- radio channel for rescue forces
- bilateral positioning of the antenna cables (failsafe system)

#### 3. Technical rail measures
- train protection (distances between trains) and route protection
- combined locating systems in the form of train run checkpoints (locating of hot boxes and locked wheels, track scales, clearance gauge measurement, derailment detectors)
- point switches with movable frog for a smoother run and lower stress of the wheel

#### 4. Operational measures
- control centre for checking and monitoring
- complete identification of the freight
- clear handling instructions for employees of the railway undertakings
- comprehensive training of the train crew in case of an emergency

#### 5. Measures for rolling material
- trains with emergency brake override
- bogies and bodies must maintain their running order also in case of a fire for at least 15 minutes
Construction consistent with nature

Any larger construction project involves interferences with nature and habitats. It is our objective to perform these interferences as gentle as possible in any case. Environmental aspects are considered with equal importance as technology and economy right from the start of planning on.

Beside any other environment-relevant measures, nature conservation is being focussed on in the course of the planning considerations and construction activities, which take place over the length of the Lainzer Tunnel.

The measures for nature conservation comprise in particular:

- the protection and preservation of rare plants or animal populations
- the protection of nature conservation-relevant areas

Before the start of construction

In sub-areas of the project, relocations of protected animal and plant species into safe areas took place before the start of construction, which after completion of the construction work will be re-settled in their original habitats. Examples for this are the beaver, for animals, and the watercress, the Spar-ganiaceae and the bulrush, for plants.

During construction

During the construction measures, the compliance with the nature conservation measures is monitored by an ecological site supervision. Start of construction and construction times of the individual construction phases in sensible areas are adapted to the breeding and spawning seasons of birds and amphibians, respectively. Construction site areas and access roads to the construction sites are limited to the absolutely required extent. Barriers separate sensible areas from the construction areas and protect them against impacts. If necessary, amphibian fences are likewise integrated into these barriers.

Following completion of construction

Following completion of construction, any construction site areas are restored into their original condition and re-cultivated with local plants suited for the location.

For the habitat of protected animal and plant species in the Vienna river retention basins, after the completion of the construction work at the construction lot “Wiental”, a four-year ecological monitoring programme was started. The programme concerns the subject areas mammals, birds, amphibians and reptiles.

Rail transport

During the construction of the Lainzer Tunnel, a total of approx. 3 million cubic metres of excavation material is produced. In accordance with an agreement with the City of Vienna, more than 50 % of which is transported off by rail.

The rail transport decisively reduces the otherwise required truck rides in the urban area. A train with 10 wagons transports, e.g., 300 cubic metres of excavation material. This corresponds to 30 truckloads with six-wheelers.
Contact:

ÖBB-Infrastruktur Bau AG

Projektleitung Lainzer Tunnel
1150 Vienna, Sparkassaplatz 6
Austria
Tel.: +43 1 93000 45701
Fax: +43 1 93000 45709
E-mail: pr-pllt@bau.oebb.at

Ombudsmann
DI Wolfgang Schönlaub
1130 Vienna, Pacassistraße 17
Austria
Tel.: +43 664 133 78 99
Fax: +43 1 804 10 81
E-mail: ombudsmann@schoenlaub.at

Projektinformationsmanagement
1120 Wien, Vivenotgasse 10
Austria
Tel.: +43 1 93000 45857
Fax: +43 1 93000 45994
www.oebb.at/bau

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