

Arna-Bergen double track

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Arna Station with the two tunnel portals in the background. The new tunnel is to the left. This is a preliminary illustration which may not be an accurate representation of the finished result.

Project background

- ▶ The section between Arna and Bergen is very heavily trafficked. The current single track has insufficient capacity, and track doubling of this section will improve the situation for goods and passenger services.
- ▶ The biggest part of the section passes through a tunnel under Mount Ulriken. Jernbaneverket is now constructing a new, parallel tunnel in order to increase capacity.
- ▶ The double track will also permit faster speeds and improve traffic management flexibility.

Photos and illustrations: Front page: Jernbaneverket and Norconsult, p. 2 Tolstrups 3D studio, p. 4-5 Jernbaneverket, p. 6-7 Herrenknecht, p. 8 Norconsult and p. 12, 13 and 15 Jernbaneverket.



New Ulriken Tunnel

Starting from the Arna side of Ulriken, tunnel construction is carried out using both conventional blasting and a tunnel boring machine (TBM). This is the first time a TBM is used for a railway tunnel in Norway.

▶ Blasting work

The first 765 metres of the 7.8 kilometre tunnel have been blasted in the conventional manner. This is for the tunnel to be wide enough to accommodate extra passing tracks, which means that the cross section here must be significantly bigger. The cross section of this part of the tunnel varies from 144 to 300 square metres, while it is 68 square metres in the rest of the tunnel.

In addition, two diagonal tunnels have been blasted between the old and new tunnel, allowing trains to cross between tunnels. Each of these are 150 metres long. An additional 16 smaller cross-passages will also be blasted between the tunnels for evacuation routes and technical installations.



▶ Excavation with tunnel boring machine

The remaining 7 kilometres of the new tunnel will be excavated with a tunnel boring machine (TBM).

There are many benefits to using a TBM rather than blasting:

- Progress can be much faster, averaging an estimated 15 metres per day.
- An accurate excavation profile, reducing overbreak to a minimum.
- Automated tunnelling operations means that the work process is more continuous.
- Better working environment and safety for tunnel workers.
- Less damage to surrounding rock, reducing the need for rock support.
- Bored tunnels generally have a longer lifespan than blasted tunnels.
- Less dust and vibrations.



The tunnel boring machine Ulrikke

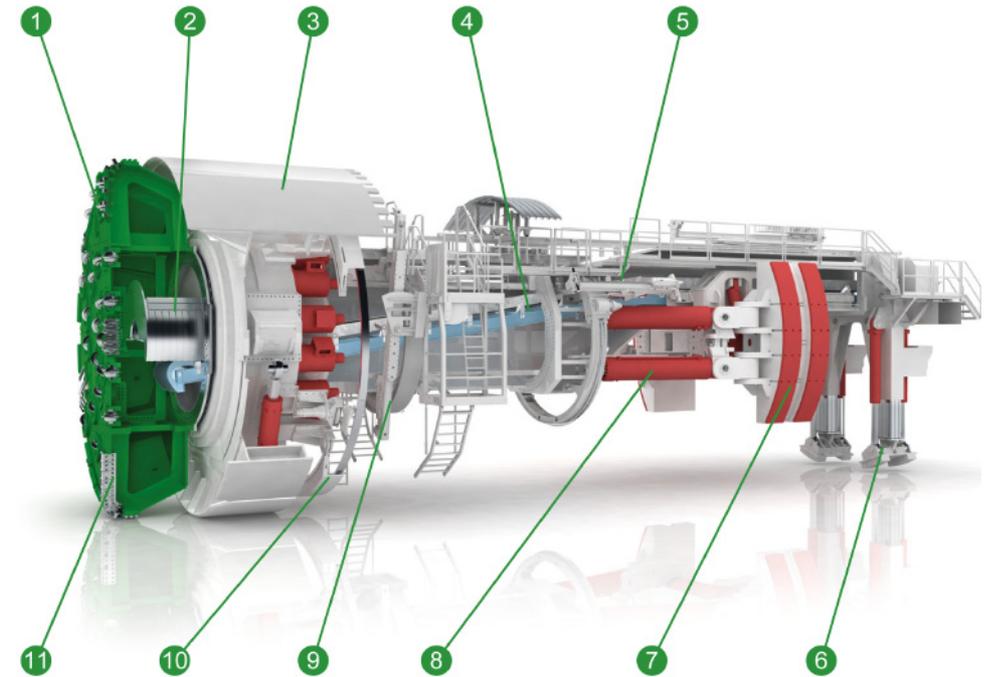
The TBM Ulrikke arrived in parts from the factory in Germany, and was assembled over the course of three months at the construction area next to Arna Station. Excavation of the 7 kilometres to Fløen is expected to take around 18 months.

▶ The TBM is of the open type, meaning that there is no protective shield against the surrounding rock.

This type of machine is well suited, because the rock in Ulriken is mostly hard and stable. As a consequence it is generally not necessary to stabilise the rock prior to boring, merely to stabilise with bolts, steel arches and sprayed concrete as the tunnel progresses.

▶ Facts about the TBM:

- Length: 155 metres, including the backup system
- Total weight: 1,800 tonnes
- Diameter of drilling head: 9.33 metres
- 62 cutters
- Motor power: 5,250 kW
- Equipment for bolting, injection, exploratory drilling and concrete spraying



The parts of the TBM:

- | | | |
|-----------------|------------------------|-----------------------|
| 1. Cutterhead | 5. Probe drilling unit | 9. Roof bolting unit |
| 2. Muck ring | 6. Machine support | 10. Ring beam erector |
| 3. Roof shield | 7. Gripper shoes | 11. Buckets |
| 4. Machine belt | 8. Thrust cylinders | |

▶ The stages of the boring cycle are as follows:

1. The gripper pads are extended to lock the machine in place against the tunnel walls.
2. The machine's thrust cylinders, which are located between the main beam and gripper pads, push the cutter head and cutters against the rock.
3. The machine continues to cut into the rock until the thrust cylinders are fully extended.
4. Support legs are extended to support the machine's main beam.
5. The gripper pads and thrust cylinders are retracted, after which a new cycle can begin.



Illustration of Arna Station with Mount Arnanipa in the background.

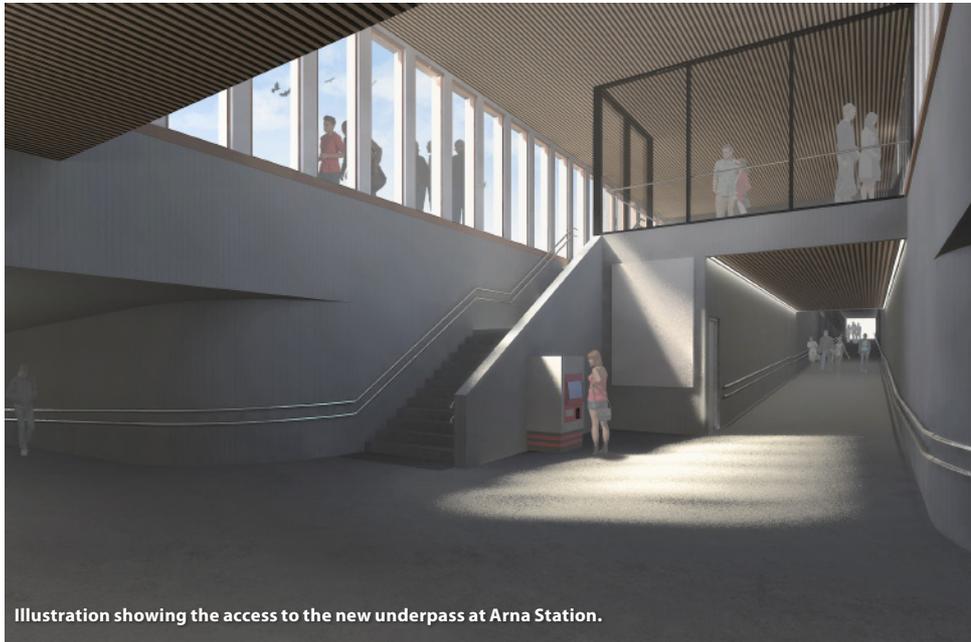


Illustration showing the access to the new underpass at Arna Station.

Arna Station

Extensive alterations will be made at Arna Station. Train passing manoeuvres at the station are currently limited by the length of the tracks. Extending the passing loop into the new tunnel will enable long goods trains and regional trains to pass. This will contribute to a more efficient traffic flow. New platforms will also be built at the station to accommodate both local and regional trains.

The station building's architectural expression is protected. The exterior façades will therefore be retained, while the interior will be completely renovated and rebuilt.

Extensive work in and around the station building will improve access for all user groups. The underpass beneath the tracks will be renovated and widened.

The area between the underpass and the station building will be opened up, making the ramps more gently sloping and allowing more light into the underpass.

The public areas will also be upgraded, with features including better lighting, new benches and new shelters.

The water culvert for the river Storelva beneath the station will be widened to withstand a 200-year flood event.

A new technical building and new technical railway systems will also be constructed.

Bergen-Fløyen

In addition to installing double tracks on the section between Bergen Station and Fløyen, necessary railworks and substructure upgrades will be carried out. A new interlocking system, which will be capable of controlling both Bergen and Arna

Main work on the Bergen-Fløyen section:

- ▶ Construction of double track from the new Ulriken Tunnel at Fløyen to Bergen Station.
- ▶ Upgrading of technical systems for the new double track and modifying existing systems.
- ▶ Upgrading of the track substructure, including drainage systems, cable conduits and ballast.
- ▶ Construction of new technical buildings.
- ▶ Installation of new Class B interlocking system.
- ▶ Modifications to provide direct access for trains from the goods terminal.



Monitoring of the environment

Railway improvements affect the environment and surrounding area in various ways. An environmental programme is prepared for every single construction project, which sets the standard for safeguarding environmental aspects.



For example, fish migration in the river Storelva at Arna is a key concern in the Arna-Bergen project. Storelva is the only salmon river in Bergen municipality, and it is emphasized that the impact on fish migration is kept to a minimum while the water culvert beneath the Arna Station area is widened.

Observations have also been made of endangered bird species that nest alongside the railway line in Arna, and these must not be disturbed during the breeding season from April to August.

Throughout the construction period there will be a strong focus on emissions to air and discharges to ground and water. This applies to unwanted emissions of pollutants and dust, as well as controlled discharges of tunnel and construction water.

An action plan for polluted ground provides an overview of the environmental condition of the soil in the construction areas. Polluted

«Construction and life-cycle environmental impact shall be minimized.»

excavated material must be delivered to an approved receiving station, and the deliveries documented by the contractor.

Jernbaneverket has permission to discharge tunnelling and construction water into Arna's public mains and into lake Store Lungegårdsvann in Bergen. All discharges will be cleaned in our own treatment plants to meet the requirements of the environmental authorities.

Waste is also generated when buildings and structures are demolished. The project has established demolition and waste management plans which specify the types and quantities of waste generated. All waste must be delivered to approved receiving stations and the deliveries documented.

Jernbaneverket's construction works may also affect the surrounding area in other ways. For example, any lowering of groundwater levels can cause settlement and damage

to buildings, or draining of marches and wetlands. In order to prevent this, tunnels are systematically sealed and the groundwater level along the route is monitored continuously.

Boring, blasting and transporting excavated material generate both vibrations and noise. Jernbaneverket acts in accordance with applicable regulatory guidelines and monitors noise and vibration levels continuously.

Project schedule

- ▶ Blasting of the first part of the tunnel and the diagonal passing tunnels, totalling 1,275 metres: November 2014 – October 2015
- ▶ Start of TBM works: January 2016.
- ▶ The TBM emerges at Fløen: summer 2017.
- ▶ The 16 evacuation tunnels between the two tunnels will be blasted while the TBM is cutting its way through the rock.
- ▶ After installation of tracks, electrical systems and the signalling system, the new tunnel will be ready for operation in 2020.
- ▶ When the new tunnel is opened for traffic, the old tunnel will be closed for approximately one year for renovation.
- ▶ The renovation and upgrading of Arna Station will take place in two stages between 2017 and 2021.
- ▶ Technical railway work and signalling system: 2017–2021.
- ▶ The double track with the parallel tunnels will open when all other works have been completed.

Visitor Centre in Arna

- ▶ The project receives many enquiries from people who would like to visit the construction site.
- ▶ For technical and safety reasons, access to the tunnel boring machine will be strictly limited when the machine is operating.
- ▶ We have therefore established a visitor centre, where a model of the tunnel boring machine and a video presentation of the project are among the exhibits.
- ▶ The Visitor Centre's is situated at Ådnavegen 56 in Arna.

