

Modernization of the Technological Equipment of Tunnels D8 – Panenská and Libouchec

Vít Strejček

Subterra, a.s., Division 4, Prague

Michal Robek, DiS., Ing. David Svoboda

Subterra, a.s., Division 4, Prague

ABSTRACT: The D8 motorway represents a key connection between the Czech Republic and Saxony, and thus to the whole of northern Europe. Its critical points are the Panenská tunnel (the longest motorway tunnel in the Czech Republic, 2,160 m long) and the Libouchec tunnel (520 m). Since these structures have been in operation since 2006, their technological equipment has reached the end of its service life.

The comprehensive reconstruction carried out last year (2025) was not merely a “light bulb replacement”. It involved a complete upgrade of the “brain and nervous system” of these structures – meaning a total reconstruction of the technological equipment, including the control system for technology and traffic, as well as the main technological components: tunnel lighting and ventilation.

1. INTRODUCTION AND DESCRIPTION OF THE MAIN REASONS FOR RECONSTRUCTION

The D8 motorway, passing through the Ore Mountains (Krušné hory), is one of the most scenic yet also most demanding sections of the Czech motorway network. The key elements of this corridor are two significant motorway tunnels – Panenská and Libouchec. Both were commissioned in 2006 and, after nearly twenty years of intensive operation, underwent major modernization of their technological equipment in 2025.

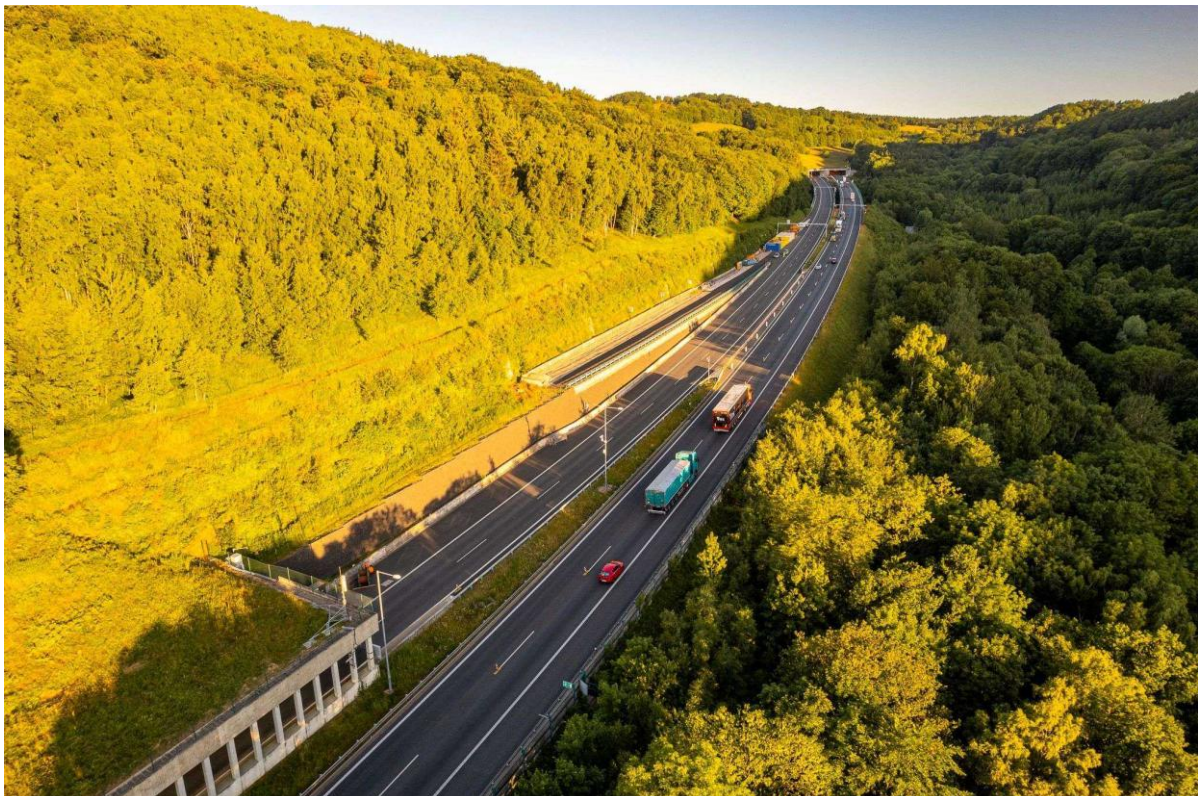


Figure 1: D8 motorway passing through the Ore Mountains. Section between Libouchec and Panenská tunnels

1.1 MAIN REASONS FOR THE RECONSTRUCTION

The technological systems installed twenty years ago had reached the end of their service life. Many components were no longer repairable – spare parts were unavailable, the original technology no longer met current safety standards and European norms (in particular Directive 2004/54/EC and its subsequent updates). Without modernization, there was a risk of gradual decommissioning of systems, necessitating permanent speed restrictions or even closure of one tube. The main reasons for the reconstruction were especially:

- End of service life of most technologies (technological equipment typically has a 15–20 year lifespan)
- Impossibility of obtaining spare parts for the original systems
- Need to meet current requirements for fire safety, detection, and evacuation
- Opportunity to increase the permitted speed from 80 km/h to 100 km/h

1.2 SCOPE OF THE RECONSTRUCTION

The reconstruction, commissioned by the Road and Motorway Directorate (ŘSD), included a comprehensive renewal of almost all technological subsystems. The most important included:

- Lighting – complete replacement with modern LED technology with dynamic intensity control and emergency mode
- Fire detection and signalling – new linear temperature sensors, multi-sensor smoke and heat detectors, modern camera system with fire detection
- Ventilation and air handling – replacement of jet fans, update of control logic
- Operational and traffic signage – new variable message signs (LED matrix), information panels, acoustic and optical alarms
- Data networks and control system – transition to modern optical networks, new tunnel control system
- Camera system and monitoring – higher resolution, improved night vision, integration with the ŘSD central dispatch
- Electrical distribution and backup power – reinforcement and modernization of UPS and diesel generators

The works also included remediation of certain structural elements (drainage, insulation, local lining repairs).

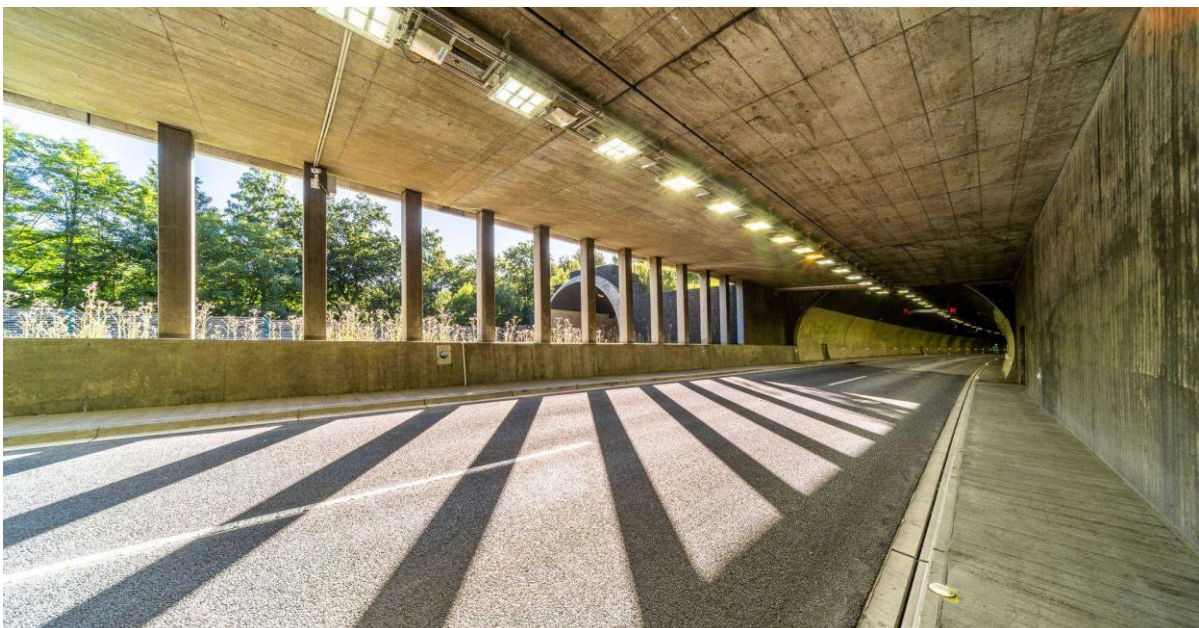


Figure 2: Roadway gallery of the Libouchec tunnel with modern LED lighting

2. SCOPE OF WORKS DELIVERED BY OUR COMPANY

The main contractors were SPEL and METROSTAV TBR. Our company SUBTERRA participated significantly in the overall scope of works. We delivered complete lighting, ventilation, and modifications to power systems and main power distribution, including replacement of principal protective devices.

3. LIGHTING AND POWER DISTRIBUTION

3.1 LED LIGHTING AND ADAPTIVE CONTROL

This is the change drivers notice most. The placement of luminaires is determined by lighting-technical calculations.

- **Entrance adaptation:** At the tunnel entrance, light intensity is highest to allow the driver's eyes to adapt to the transition from bright sunlight to darkness (preventing the "black hole" effect). Outside these adaptation zones, continuous roadway lighting luminaires are used, operating permanently.
- **Luminance sensors** (luminance meters): Installed before the portals, these measure external brightness and adjust the power of the internal LED panels in milliseconds accordingly.

We carried out a complete reconstruction of tunnel lighting using modern high-efficiency LED luminaires. The tunnel lighting fixtures are from the renowned European manufacturer PHILIPS. They are made entirely of stainless steel in accordance with the technical documentation and ŘSD quality requirements for technological equipment, including mounting systems. The luminaires feature plug-in connections, allowing quick replacement of a faulty unit without prolonged tunnel closure.

In the accommodation lighting zone (entrance adaptation), new full stainless-steel load-bearing structures with fire resistance were installed to meet current Czech standards and regulations for safety and fire resistance.

Fire-resistant and non-fire-resistant cables from PRAKAB were used for cabling – a supplier with proven reliability. The manufacturer now produces cables in the "plus" version, resistant to humid environments with AD 7 rating, meaning they can even be installed outdoors without degradation.



Figure 3: Completed new LED lighting in the entrance adaptation zone

3.2 EMERGENCY LIGHTING

For emergency tunnel lighting, we used the proven ARTECHNIK Praha escape route emergency luminaire, compliant with TP 98 – Technological Equipment of Road Tunnels (2004). We now use an all-glass luminaire without aluminium parts, with a stainless-steel cover plate. The luminaire features a positioning blue LED and, in case of fire, white LEDs light up on the sides and bottom, achieving the required 2 lx illuminance on the protected escape route..



Figure 4: Emergency lighting luminaire with positioning blue LED

3.3 GUIDANCE LIGHTING

During the reconstruction, the SMARTSTUD inductive guidance lighting system was installed. It fully complies with TP 217 – Enhanced Optical Elements on Roads. This inductive system was chosen for easy replacement of damaged units (e.g. after vehicle impact).



Figure 5: Inductive guidance lighting – detail of the luminaire



Figure 6: Tunnel tube with inductive guidance lighting

3.4 REPLACEMENT OF PROTECTIVE DEVICES

A large number of protective devices were replaced as part of the modernization of electrical installations, power supply, and safety systems. Main power distribution circuit breakers were also renewed. ABB withdrawable air circuit breakers (deons) rated for higher currents (usually 630 A and above) were used. These are among the most important elements of distribution networks, designed for industrial and demanding applications where high reliability is essential.



Figure 7: Power circuit breakers (deons) in withdrawable design

3.5 REPLACEMENT OF BACKUP POWER SOURCES

Based on less-than-ideal experience with rotary UPS systems (e.g. in the Klimkovice tunnel), modular n+1 battery UPS units with Li-Ion batteries were installed in the Libouchec tunnel. These do not require air-conditioned environments and have a service life exceeding 12 years.



Figure 8: New UPS with Li-Ion batteries

4. VENTILATION SYSTEM RECONSTRUCTION

The main elements of the ventilation reconstruction were:

- **Repair and unification of escape route ventilation:** unification of ventilation systems with fire dampers, ensuring better coordination during emergencies
- **Replacement of fans and installation of sensors:** all jet fans replaced with new models equipped with vibration, bearing temperature, and speed sensors for real-time continuous monitoring
- **Integration with other systems:** ventilation connected to the modernized control system, electronics, cameras, sensors, and dispatch centre. During testing, fire simulations using smoke verified rapid activation of ventilation, closure of fire dampers, and alarm triggering. The tests confirmed immediate and effective system response, significantly improving safety for drivers and emergency servicy.

4.1 MAIN VENTILATION

The original jet fans were replaced with new jet fans mounted on the tunnel crown. Installed in pairs, they serve both normal operational ventilation and fire ventilation.



Figure 9: Condition of the original jet fans after nearly 19 years of operation

Each fan is equipped with a soft starter to reduce inrush currents. Ventilation output is controlled by switching individual fans on/off. It provides both normal and fire ventilation (in case of fire). Fresh air is drawn from the tunnel portals.

In case of fire, fire ventilation must create a continuous airflow of 3 m/s so that smoke stratifies at the crown, leaving a smoke-free layer above the roadway for evacuation.

The fire ventilation capacity is designed for a 30 MW fire. ZITRON (Spain) fans were selected – a renowned manufacturer supplying hundreds of such units annually in Europe. The fans are entirely stainless steel, including impeller and blades.

The fans are equipped with sensors. There is a motor temperature sensor, a bearing temperature sensor, a speed (RPM) sensor, and a vibration switch (or trip sensor). Each fan is also fitted with predictive fault diagnostics / predictive maintenance capability. Before ordering the fans, including all the associated sensors, it was necessary to thoroughly review and go through all sensor interconnections to the control system so that everything would communicate correctly in every operating mode.

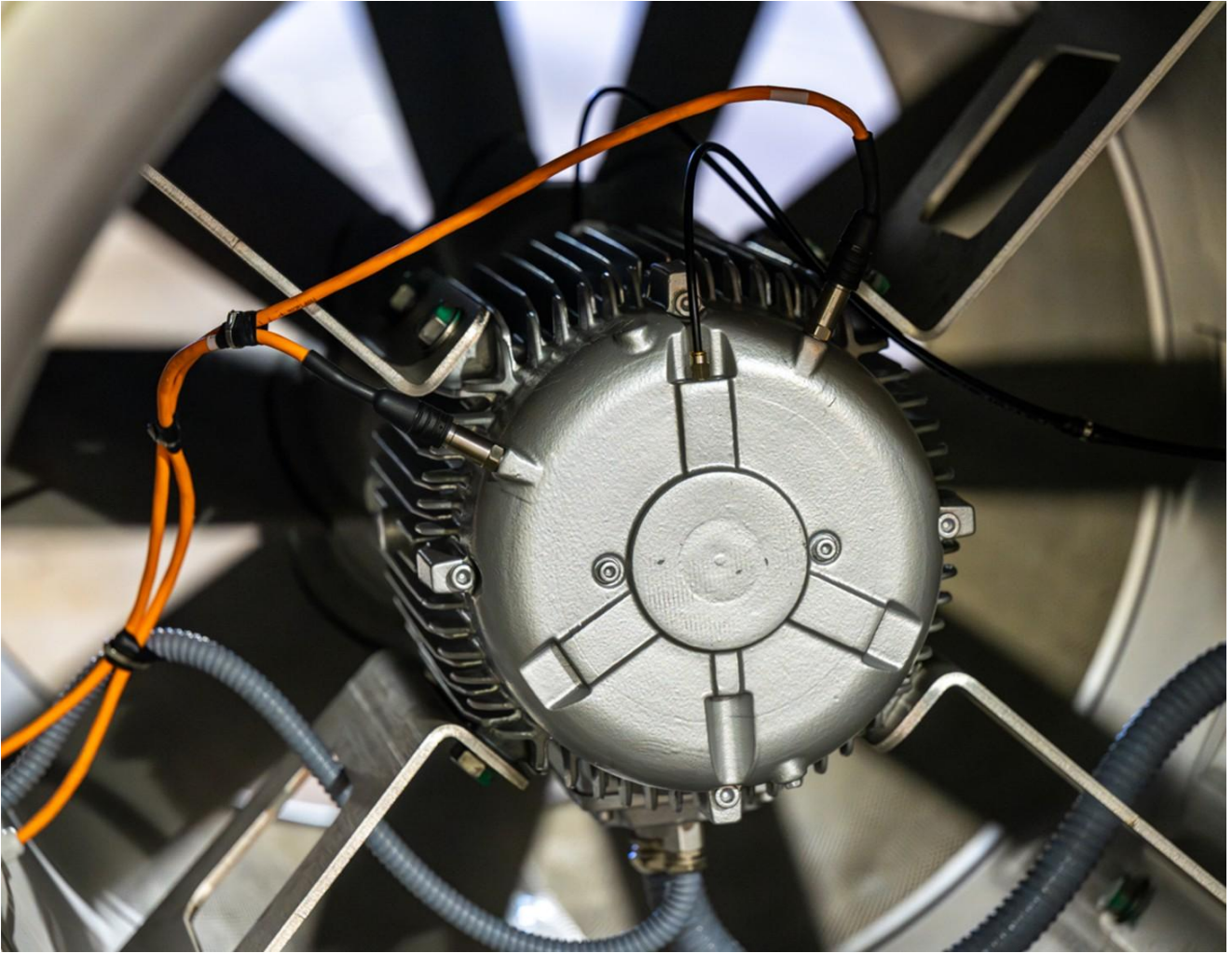


Figure 10: ZITRON jet fan electric motor including sensors



Figure 11: Newly installed ZITRON jet fans

4.2 ESCAPE ROUTE VENTILATION (TUNNEL CROSS-PASSAGES)

Cross-passages serve for evacuation from the tunnel tube in case of fire. During a fire, fresh air is drawn from the unaffected tube through ventilation grilles and open fire dampers into the cross-passage.



Figure 12: Condition of cross-passage ventilation equipment after nearly 19 years

In case of fire, a 50 Pa overpressure must be maintained in the cross-passage relative to the affected tube. If escape doors are opened from the affected tube, air must flow outward against the direction of evacuation to prevent smoke ingress.



Figure 13: Newly installed cross-passage ventilation equipment

4.3 RECONSTRUCTION OF COOLING FOR OPERATIONAL-TECHNICAL BUILDINGS

Cooling systems in the operational-technical objects (PTO) were also replaced due to their unsatisfactory condition. Split-type units were installed.



Figure 14: Newly installed PTO cooling

5. CONCLUSION

Following their reconstruction, the Panenská and Libouchec tunnels now rank among the most modern tunnels in Central Europe. New technology enables better predictive maintenance and faster responses to emergency situations, ultimately resulting in fewer closures and increased safety for everyone traveling toward Dresden and vice versa.

Upon completion of the reconstruction (October 8, 2025), the tunnels were put into full operation with a speed limit of 100 km/h (previously 80 km/h) and significantly higher reliability of all safety systems.

6. ACKNOWLEDGEMENTS

In closing, I would like to thank the colleagues who also participated in the preparation of this paper. Last but not least, thanks are due to our investor a joint venture of the companies SPEL and METROSTAV TBR for placing their trust in us during the demanding reconstruction of both tunnels..

Vít Strejček

SUBTERRA a.s., Koželužská 2246/5, 180 00 Praha 8 - Libeň

vstrejcek@subterra.cz

Michal Robek, DiS

SUBTERRA a.s., Koželužská 2246/5, 180 00 Praha 8 - Libeň

mrobek@subterra.cz

Ing. David Svoboda

SUBTERRA a.s., Koželužská 2246/5, 180 00 Praha 8 - Libeň

dsvoboda@subterra.cz