UPGRADING OF SAFETY MEASURES IN THE ARLBERG RAILWAY TUNNEL / CONSTRUCTION OF ESCAPE ROUTES WITH CROSS-PASSAGES TO THE ARLBERG ROAD TUNNEL

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ABSTRACT

The Arlberg railway tunnel is a 10.6 km long tunnel, which was taken into operation in 1884. Almost parallel to this railway tunnel, the Arlberg road tunnel was built approx. 100 years later (at a distance of 400 m at a maximum), which was opened to traffic in 1978.

This paper deals with the upgrading of the safety measures in the railway tunnel. The most important measure consists in the construction of cross – passages at intervals of 1,700 m at a maximum, serving as "safe areas" between the road and the railway tunnel. The co-operation strategy between the different traffic systems and tunnel operators as well as the organisational measures shall be presented.

1 PRESENT SITUATION

The railway tunnel and the road tunnel, crossing the Arlberg mountain range in Western Austria, connect the Austrian provinces of Tyrol and Vorarlberg.

The Arlberg twin-track railway tunnel, which has a length of 10.6 km and a cross-section of 41 m², was taken into operation in the year 1884. Its equipment presently comprises a train radio system, a telephone system, and work lights in individual sections.

Adjacent to the Arlberg tunnel, two new railway tunnels were constructed in recent years. With these tunnels, the distance between the emergency exists and the safe areas was chosen to be 1.2 km at a maximum. The equipment meets the state-of-the-art technology standard stipulated for railway tunnels in Austria.

The Arlberg road tunnel, which is a bi-directional tunnel (14.0 km), was opened in the year 1978. The tunnel is equipped with a full transverse ventilation system, and a service access is located at one of the third points.

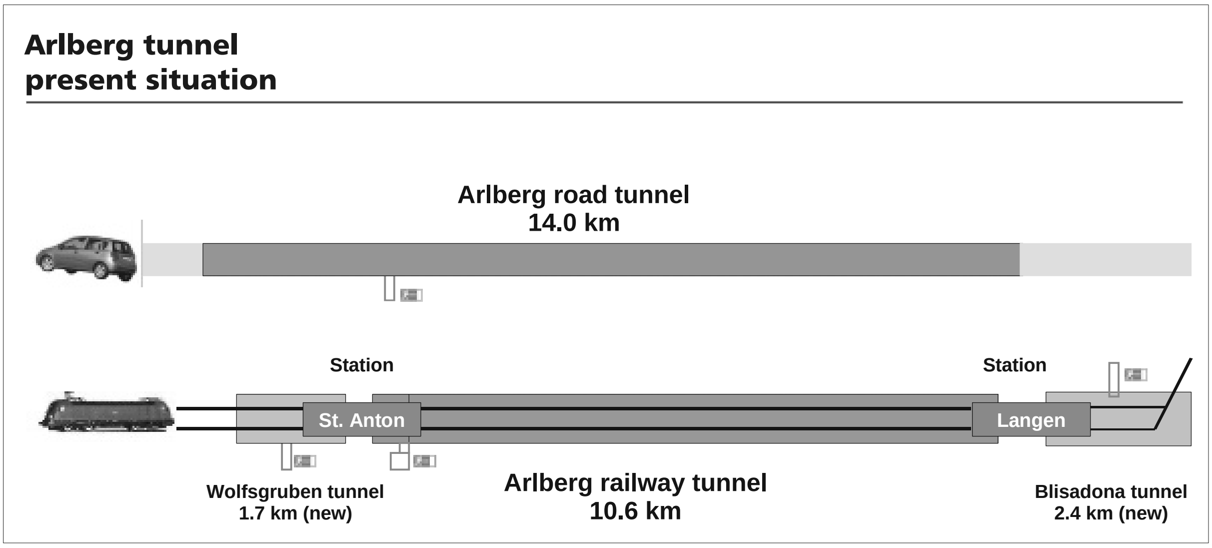

Fig. 1: Arlberg tunnel – present situation

The maximum distance between the Arlberg railway tunnel and the Arlberg road tunnel is 400 m and the maximum difference in height between these tunnels is 35 m.

2 UPGRADING OF SAFETY MEASURES IN THE ARLBERG RAILWAY TUNNEL

For an upgrade of the safety installations in the Arlberg railway tunnel, on the one hand measures were devised, which are exclusively designed to improve the safety conditions in the railway tunnel, and on the other hand measures were developed together with the road tunnel operator which are intended to improve the escape route situation of both the railway tunnel and the road tunnel.

The decision on new safety measures to be implemented was taken based on the principle of proportionality. This implies that the existing tunnel structure is generally to be maintained (e.g. no cross-sectional enlargement) and longer interruptions in tunnel operation are to be ruled out.

In Austria, a risk-oriented approach for the selection of safety installations in railway tunnels is only adopted with intra-corporate priority ranking and decision making processes, since no generally accepted limit values have been established by the relevant permit application authorities.

The safety measures for the Arlberg railway tunnel were thus selected in compliance with existing guidelines, in line with up-to-date technical know-how, and in the light of the actual boundary conditions encountered at the Arlberg tunnel.

The individual measures were systematically checked for completeness and correct implementation, using the following reports and guidelines as a basis:

- Guideline ”Bau und Betrieb von neuen Eisenbahntunneln bei Haupt- und Nebenbahnen“ [“Construction and Operation of New Railway Tunnels ..“ of the “Österreichischer Bundesfeuerwehrverband” [Austrian Federal Fire Brigade Association] - Edition 2000
- Report “Safety in Railway Tunnels“, Final Report February 2002, commissioned by the UIC
- Study “Sicherheit in Eisenbahntunneln“ [“Safety in Railway Tunnels“], commissioned by the Austrian Federal Railways with the aim of assessing the potential for improvement in Austrian railway tunnels

Further pre-requisites for the upgrading of railway tunnel equipment are stipulated in the Health and Safety at Work Regulation for railways, in which the legislator defines requirements for walkways, emergency bays, lighting, power supply, and telephone systems.

The following structures and installations as well as equipment components will be retrofitted in the Arlberg railway tunnel:

- Overhead line disconnection system with remote transmission indicating the switching status inside the tunnel and in the adjacent areas outside the tunnel portals
- Track bed to be accessed on foot and by road vehicle
- Orientation lighting
- Escape route marking
- Electricity supply for the entire tunnel
- Fire water supply for the entire tunnel
- Emergency telephones with position identification in the train operation center
- Radio facilities for emergency response organisations
- Rescue areas and access ways
- Roller pallets

3 PROVISION OF "SAFE AREAS" BY CROSS-PASSAGES BETWEEN ROAD AND RAILWAY TUNNEL

A feasibility study was elaborated with the aim of reducing the distances between the emergency exits and the "safe areas". This study recommended the construction of cross-passages between the road and the railway tunnel at intervals of 1,700 m at a maximum. During the project planning for the permit application procedure, the reduction of the distances between the "safe areas" was once more discussed and reviewed. In the course of this process, a step-wise project implementation was considered to be necessary for constructional as well as for financial reasons. In co-ordination with the representatives of the fire brigade organisations, a decision was taken to first construct cross-passages at a spacing of 1,000 m - 1,700 m.

In a further step, a maximum spacing shall next be reduced to 850 m.

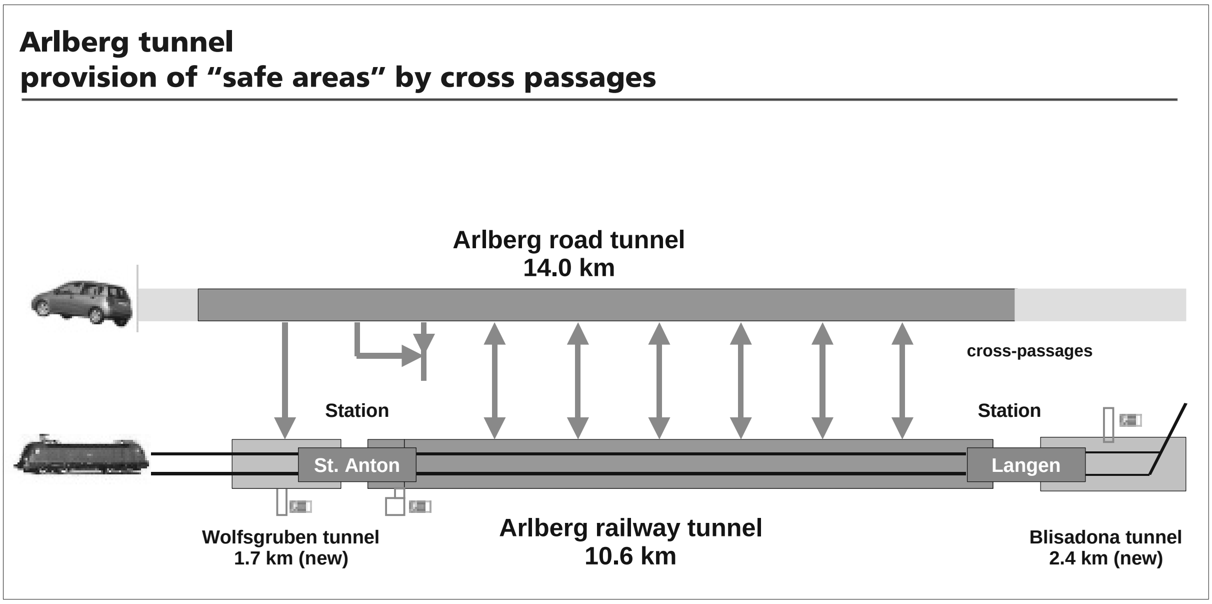

Fig. 2: Arlberg tunnel – Cross-passages between road and railway tunnel

Due to the difference in elevation of these two tunnels, two different cross-passage types were designed:

- inclined tunnel with a maximum longitudinal gradient of 10 %
- inclined tunnel with a central shaft structure, which houses a spiral-type ramp with a maximum longitudinal gradient of 10 %

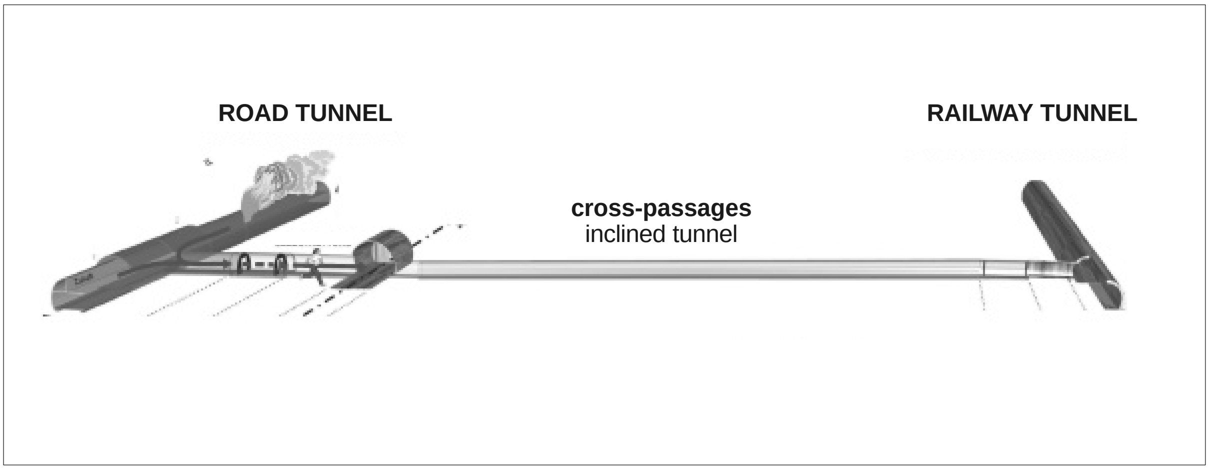

Fig. 3: Cross-passage as inclined tunnel

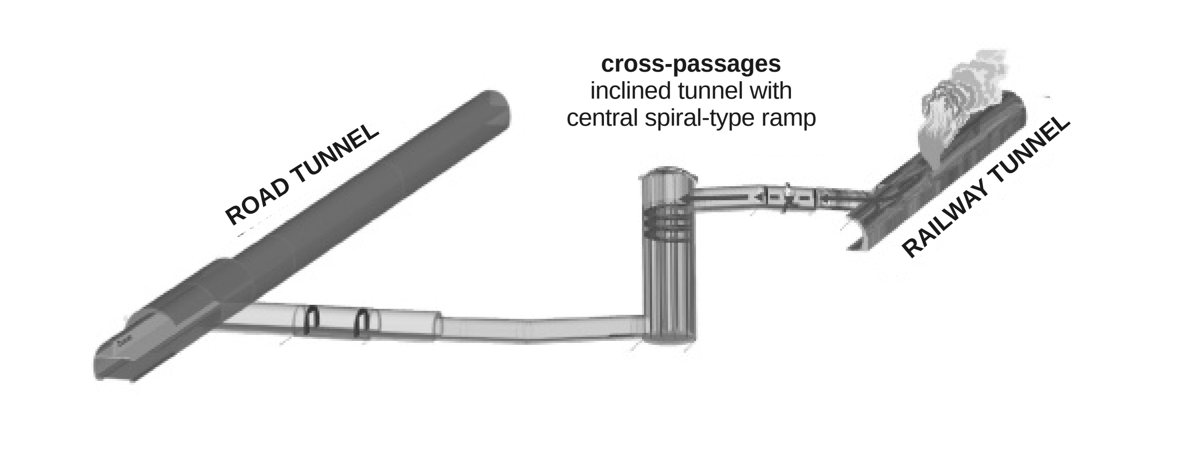

Fig. 4: Cross-passage with spiral-type ramp

With the two tunnels being run by different operators, it might well be that a tunnel user trying to escape from one tunnel might still not be granted access to the other tunnel. In order to provide sufficient room under these circumstances, a waiting cavern shall be integrated in the inclined tunnel. For the cross-passages featuring a spiral-type ramp, this ramp area shall serve as waiting room.

These waiting areas shall - in combination with respective markings - furthermore help to reduce the walking speed.

4 HANDLING OF ROAD AND RAILWAY TUNNEL ACCIDENTS

Accidents inside a tunnel (fire, collision, ...) may lead to the following scenarios:

- The extent of the accident is entirely limited to one tunnel tube with no need for tunnel users to seek refuge in the cross-passages.
- The impact of the accident is basically restricted to one tunnel tube with the cross-passages only serving as short-term gathering rooms. A self-rescue effort involving a subsequent assisted evacuation through the second tube is not necessary.
- The magnitude of the accident requires a self-rescue effort into the cross-passages and a subsequent assisted evacuation through the second tube. Both tunnel tubes are affected.

This paper shall only address accidents which involve both tunnel tubes.

4.1 RESCUE CONCEPT

The rescue concept in both tunnels is based on the assumption of a self-rescue effort in the first phase, with the tunnel users seeking to escape the danger zone on their own initiative and the cross-passages serving as “safe areas“.

This self-rescue initiative is followed by an assisted rescue campaign in the second phase involving fire and rescue service personnel as well as operating personnel. The assisted rescue campaign serves the purpose of finding all those persons who were unable to leave the danger zone during the self-rescue phase.

4.2 UTILIZATION OF CROSS-PASSAGES AS “SAFE AREAS“

The cross-passages may at any time be accessed from both the railway tunnel and the road tunnel. The access consists of doors with a total width of 2 m, which open in the escape direction (from the tunnel to the cross-passages). The access is designed as a lock system with two doors.

As soon as a tunnel user enters a cross-passage, the light and the pressurized ventilation system automatically come into operation. A message is dispatched to the responsible control centre and the video system is activated.

In order not to endanger any tunnel user by traffic in the second tunnel, the doors from the cross-passages to the unaffected tunnel are locked. This strategy was chosen, since – as a result of the different traffic systems and tunnel operators – the procedures to bring traffic to a halt require more time and intensified communication between the tunnel operators. A locking of the doors to the second tunnel is possible due to the great width of the cross-passages (waiting areas).

The following door lock arrangements have been chosen as basic setting:

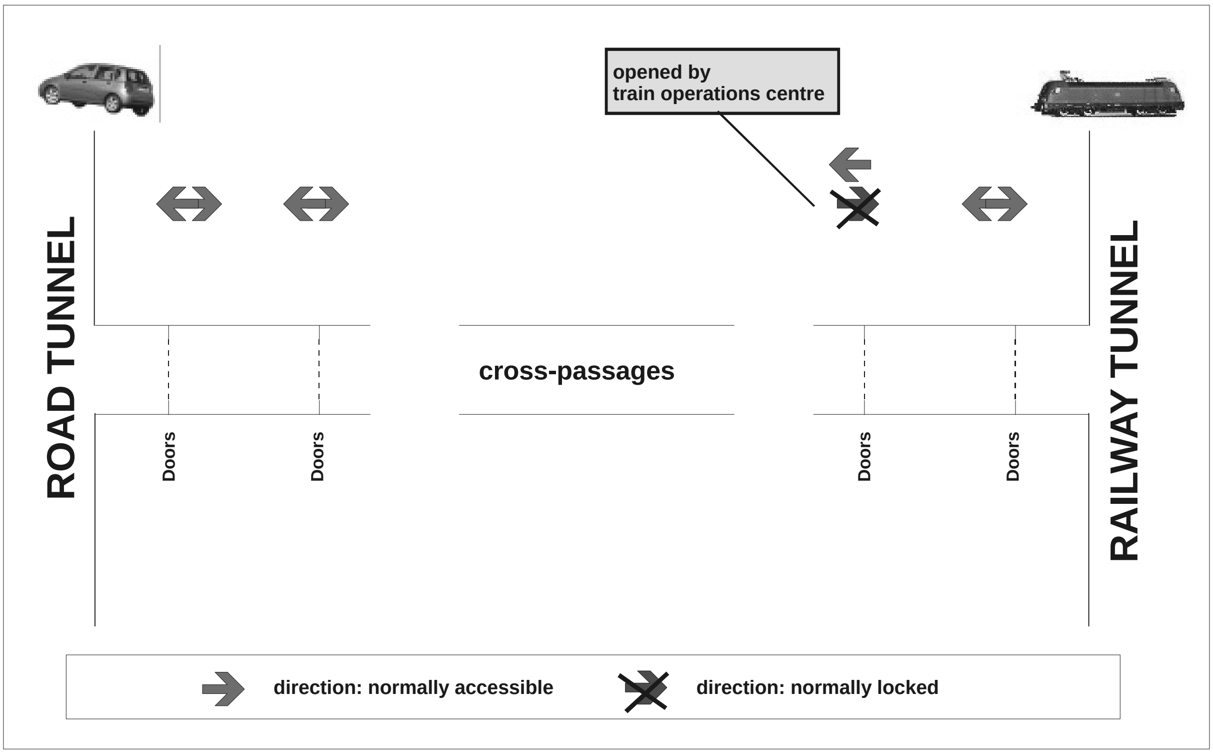

Fig. 5: Door opening options – basic setting

In view of the fact that the cross-passage structure and the equipment will be maintained by the road tunnel operator, the basic setting envisages the road tunnel doors to be accessible in both directions. As a result, the maintenance personnel may always rely on an unlocked escape route to the road tunnel. For maintenance personnel and for persons trying to escape from the road tunnel, the access to the railway tunnel is blocked by a locked door.

In order to permit a flexible emergency response and to grant maintenance personnel access to the railway tunnel under special conditions, this door may – via a remote control opening mechanism - be opened by the responsible train operations centre.

As communication devices, emergency telephones will be installed at the doors.

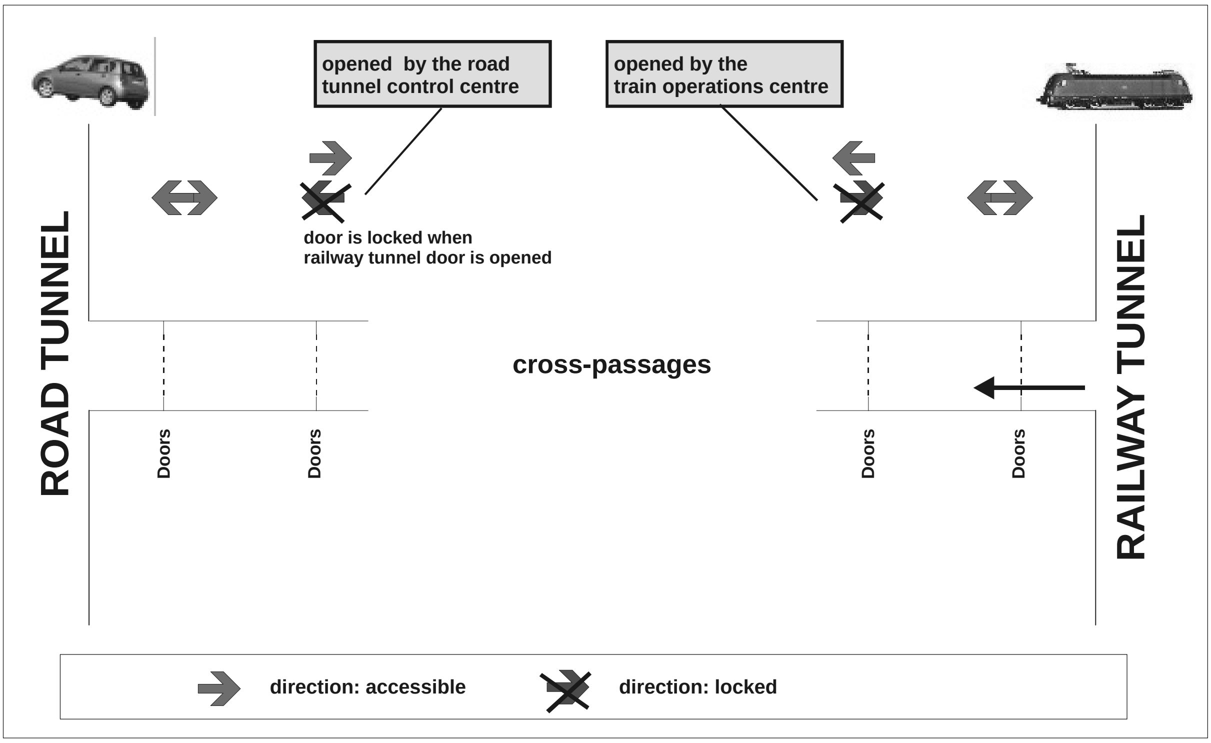

Fig. 6: Door opening options – accident in railway tunnel

If, upon occurrence of an accident in the railway tunnel, the railway tunnel door is opened, the corresponding road tunnel door to the cross-passage is locked.

To ensure a flexible emergency response also in this case, the road tunnel door may – via a remote control opening mechanism – be opened by the responsible road tunnel control centre.

In order to keep the safe areas smoke-free, a ventilation system is planned to be mounted, through which fresh air from the tunnel, which is not affected by the accident, shall be blown into the cross-passages.

The ventilation system is symmetrical and consists of intake ducts with fans, control equipment, air ducts and of positive pressure fans. The fans are equipped with fire dampers to meet the fire protection standard for the doors.

For the ventilation direction to be determined, the following challenges are to be met:

- the railway tunnel is not equipped with a fire alarm system
- if controlled via the door opening, problems might occur as a result of operating or rescue personnel entering the cross-passage from the wrong side
- the tunnel in which the accident occurred is to be defined by one of the two tunnel operators

For ventilation control, the following sequence has thus been chosen:

- the ventilation system is activated as soon as a door is opened
- the air intake is automatically effected via the fresh air duct of the road tunnel
- only if a fire alarm in the road tunnel is registered, fresh air is supplied via the railway tunnel

4.3 DEFINITION OF COMPETENCIES IN CASE OF AN ACCIDENT

The two tunnels are monitored by the responsible railway or road tunnel operator in the respective control centre. The corresponding control centres are located in the East portal areas, approx. 4 km apart.

In case of an accident inside one of the tunnels, the control centre of the respective tunnel operator performs the following tasks:

- Clear the tunnel and prevent vehicles from entering the tunnel
- Send alarms to the fire brigade, the rescue service, and the police department
- Communicate with the emergency telephones
- Initiate the self-rescue measures (if required)
- Prepare the assisted rescue measures (if required)
- Act as co-ordination centre for the rescue teams

This allocation of tasks is also in compliance with the standard applicable in the adjacent road/railway section tunnels and thus allows a uniform system to be maintained.

For the cross-passage areas, the following responsibilities have been defined:

Road tunnel control centre:

- Monitor lighting system, emergency telephones, and door contacts of emergency exit doors
- Monitor cross-passages by video system
- Perform manual control of ventilation system (if required)
- Provide information and instructions to persons inside the cross-passages by loudspeaker system
- Monitor and open locked road tunnel doors

Train operations centre:

- Monitor and open locked railway tunnel doors

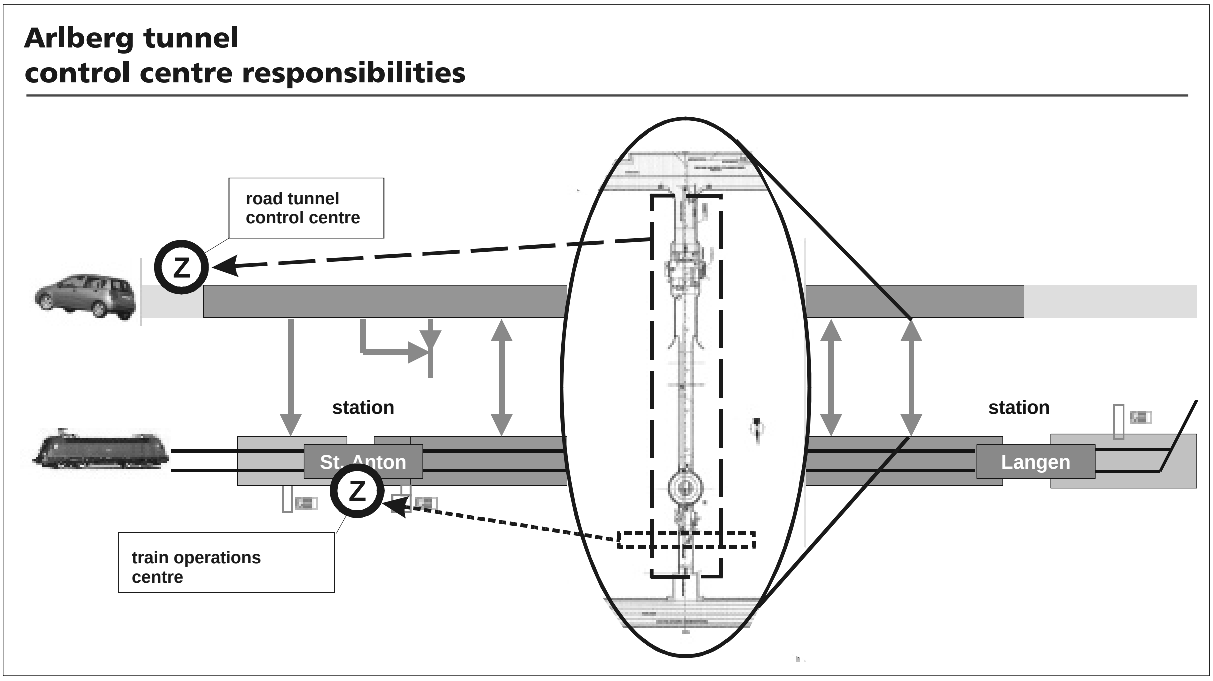

Fig. 7: Control centre responsibilities with respect to cross-passages

This very simple solution of locking the doors to the cross-passages makes it possible to entrust one control centre with the monitoring of the cross-passages.

Between the two control centres, a direct telephone connection shall be established which allows accident messages to be communicated and emergency response measures to be co-ordinated.

4.4 EVACUATION OF PERSONS INSIDE THE TUNNEL TO THE OPEN AIR

The two tunnel operators have come to the following task sharing arrangement:

- In case of a railway tunnel accident, the persons who managed to flee to the cross-passages will be organised and evacuated by the road tunnel operator
- In case of a road tunnel accident, the persons who managed to flee to the cross-passages will be organised and evacuated by the railway tunnel operator

The evacuation is effected by road vehicles (e.g. vans) or, in case of the railway tunnel, possibly by rail vehicles. The alarm to mobilize these vehicles is activated by the control centre, which is not affected by the accident.

For the acceptance and medical care of injured persons, both the fire and the rescue service shall drive into the unaffected tunnel all the way to the cross-passages.

In the vicinity of the portals, the control centres may – depending on the situation encountered at the scene – make arrangements for a different procedure to be adopted.

4.5 ASSISTED RESCUE CAMPAIGN BY FIRE AND RESCUE SERVICES

The meeting point of the officers-in-charge shall be the control centre of the tunnel, which is affected by the accident.

Special portal fire brigades shall be assigned to both portals. In line with the fire brigade's rescue plan it is intended that in the first phase, rescue activities shall always commence at both portals of the tunnel, which is affected by the accident.

The fact that the entire track area in the railway tunnel is also suited for the use of road vehicles, allows the fire brigade to enter both, the road and the railway tunnel with the same fire-fighting vehicles.

The option of using the cross-passages for the fire brigade's rescue campaign, is only intended in the second phase to prevent a situation, in which persons seeking to escape and fire fighters trying to enter might get in each other's way.

The rescue team shall only proceed into the unaffected tunnel.

5 RESULTS OF PERMIT APPLICATION PROCEDURE

The concept for the construction of the cross-passages and the upgrading of the safety measures was submitted to the railway authority for approval.

In July 2003, the site negotiations in connection with the permit application procedure took place. No major objections, neither with respect to the planned construction works nor with respect to the planned safety measures were raised by the authority experts or the fire brigade representatives.

The permit is expected to be obtained in the next few months. The cross-passages will be constructed within the next few years.

6 CONCLUSION

In order to improve the escape route situation, unconventional measures, such as cross-passages between road tunnels and railway tunnels, may also offer professional, financially feasible, and efficient solutions.

With escape routes, which involve two different traffic systems with different control centres, special emphasis is to be put on the risk to which persons seeking to evade a dangerous situation might be exposed due to traffic in the second tube, since not all operational and organisational measures are monitored and controlled in one location.

The responsibilities for the installations inside the cross-passages are thoroughly to be considered already in the initial design phases and are ultimately to be defined based upon possible strategies designed to overcome conceivable accident scenarios.

Especially if faced with the complex interaction of different traffic systems (road and track), great store is to be set by a simple organisation structure and a clear allocation of responsibilities.

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