

PREVENTIVE OPERATIONAL MEASURES FOR ROAD TUNNELS

Ulla Vesterskov Eilersen

Safety Manager, Oeresundsbro Konsortiet I/S - Sund & Baelte Holding A/S, Denmark

ABSTRACT

To implement and maintain a high safety level in tunnels during operation requires commitment from all involved parties and continuous training, coordination and improvement. All parties shall understand their role in prevention of fires in tunnels and strategies have to be prepared in close co-operation with the emergency services. During daily operation procedures for operation with degraded functionality or with traffic restrictions during maintenance work have to be implemented and adhered to. Procedures and test of equipment must be checked regularly in a simulation test system. In the case of an accident a reliable computer based alarm system is essential. To ensure the safety quality continuously evaluation must be performed, not only after incidents and accidents but also on the entire tunnel operation. This paper summarizes some of the recommendations in the work done in relation to the European Thematic Network "Fire in Tunnels".

1. INTRODUCTION

A lot of efforts from various organizations, in preparation of recommendations and regulations for tunnels are seen in these years in order to ensure tunnel safety. Among experts there is a common understanding that the primary safety effort (and economically the most efficient one) shall prevent critical events from occurring. Secondary, the consequences of an accident shall be reduced e.g. by creating good possibilities for self rescue and good working conditions for emergency services.

The safety level in a tunnel depends very much upon the following factors:

- Infrastructure
- Tunnel Operator / Operation (procedures)
- Users (behaviour)
- Emergency Services
- Vehicles (conditions)

This paper is dealing with preventive operational measures, intended for road tunnels, and focuses on the co-operation between the tunnel operator, the emergency services and the users as well as on the factors which in daily operation have most influence on safety. The physical safety level related to the infrastructure in itself as well as safety factors related to vehicles and trains are not discussed.

The knowledge of safety related to a specific tunnel and the responses in case of an accident will basically differ among the tunnel operator, the emergency services, and the users.

The tunnel operator will know and understand the safety features available and should in that perspective take appropriate action to implement procedures, which will minimize the risks to users and workers.

The operator and the called in emergency services are educated in general to follow a contingency plan. Furthermore, the emergency services ought to have knowledge of the tunnel infrastructure and operational possibilities in order to take control of a fire accident and perform the rescue operation with maximum safety. The users should be aware of the specific driver behavior when driving in tunnels such as keeping distances and follow signs thoroughly. These issues are addressed in the paper.

It is of utmost importance that all parties involved do realize and admit to their responsibilities.

2. CO-OPERATION AND SAFETY FACTORS

It is important to state that operation of a tunnel at a high safety level and handling of an incident/accident in an efficient way can be achieved only in a close co-operation between the three involved parties the tunnel operator, the emergency services and the tunnel users.

The three involved parties can be symbolised by the gear wheels getting the machine to run in a safe way – as shown in figure 1. The “lubricant” ensuring the smooth running of the machine is the combination of the six safety factors important for all three involved parties.

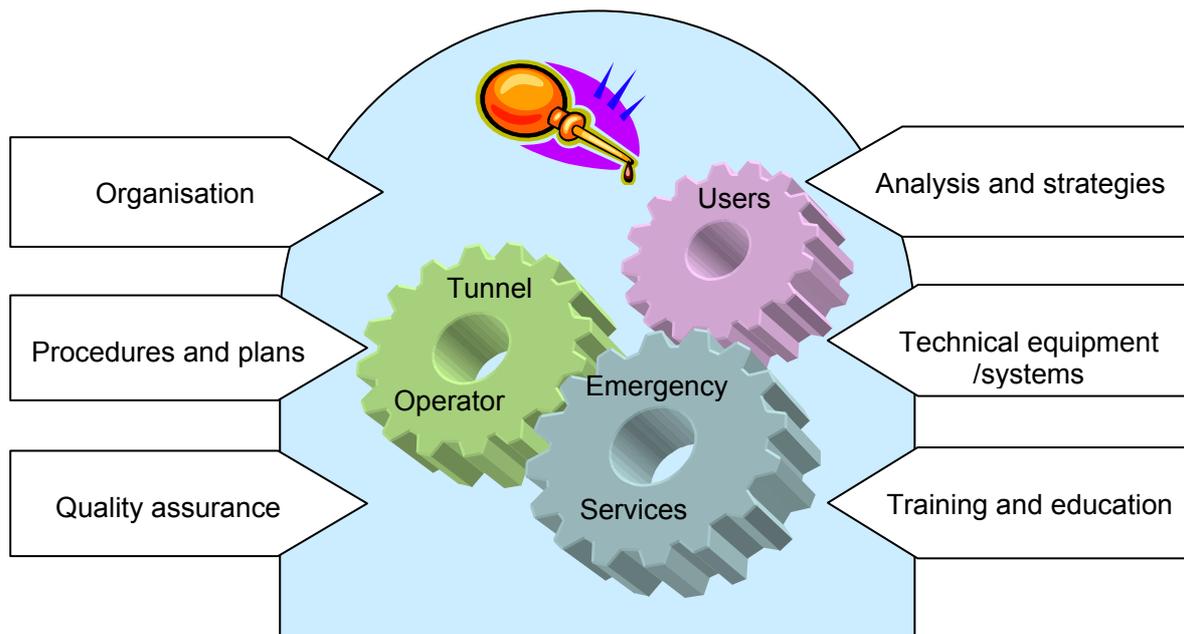


Figure 1 Safety factors important to all parties involved

The identification of safety factors as described in this paper has been performed as a listing of possible safety improving measures. No consideration has been taken to differences in infrastructure conditions e.g. different tunnel lengths and traffic volumes.

3. ORGANIZATION

Responsibilities and authorities for different functions in the organisation shall be clearly described by the tunnel operator and made well known to all employees as well as collaborators. The organisation must be imbued with a high safety spirit.

In order to maintain a continuous focus on safety matters independent of all other activities, it is important that a safety manager is appointed by the tunnel operator. The safety manager shall supervise all safety aspects related to tunnel operation, secure that proper preventive actions are taken when necessary and that all incidents/accidents are evaluated and followed by necessary corrective actions.

A manned control room makes it possible to supervise and control traffic and technical systems and to create an overview of all situations particularly in case of an accident. For a specific tunnel there shall be only one single control room in order to avoid conflicting actions. A redundant (partly or total) control room shall be available. The traffic operator staff shall live up to a set of qualifications assuring they have a proactive attitude and are capable of handling situations of crisis. The qualifications shall be maintained by regularly training and exercises. A service group has to be available round-the-clock in order to take care of technical defects affecting the safety.

To further improve safety a 24 hours' road assistance service with the mission of assisting or removing vehicles stopped in the tunnel as soon as possible should be established. A road patrol with the mission of regular inspections of the tunnel looking for dropped goods, damages to structures and installations etc. is likewise needed. Another mission for the road patrol is to set up fixed signs and safety barriers when introducing traffic restrictions for e.g. maintenance work.

The tunnel operator and the emergency services must have a frequent and organised dialogue. The agenda for the dialogue shall cover all aspects related to safety such as occurred incidents/accidents, changes in traffic volumes, changes in technical systems affecting the tunnel rescue strategy, education and exercises. Common understanding and confidence are essential aspects.

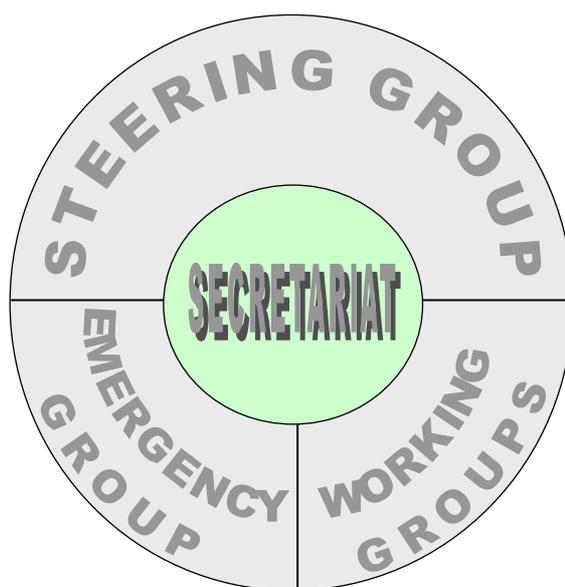


Figure 2 Organization for emergency preparedness in the operational phase

Figure 2 shows an example of an organisation for the emergency preparedness in the operational phase. The tunnel operator as well as the emergency authorities must be represented in all groups. A small secretariat with participants from the tunnel operator and from one or more of the emergency authorities can ensure frequent follow up on safety and administration of meetings etc.

When different emergency organisations (from different organisations or countries) shall co-operate, special attention shall be paid to decisions concerning who is in charge and to different organisation structures and cultures.

A great part of the tunnel users are organised in Motorist- and Transport Associations. The tunnel operator as well as the emergency services shall exert influence on the Associations to make them active concerning communication on tunnel safety in order to improve driver's tunnel behaviour.

4. ANALYSIS AND STRATEGIES

The tunnel operator's safety attitude has to start in the boardroom. The safety priority and accepted risk levels shall be based on an overview of all aspects related to safety in maintenance and operation of the tunnel. Risk management shall be implemented and approved by the board.

Risk analysis shall be performed and regularly reviewed by the tunnel operator on basis of occurred incidents/accidents and changes in the infrastructure and traffic conditions. If found necessary improvements shall be introduced. In addition to risk analyses separate risk reduction evaluations must be performed on e.g. restrictions of hazardous goods transports, speed restrictions, rules for minimum distances between vehicles and no overtaking. On the basis of risk analysis necessary strategies shall be prepared. The strategies needed depend on the specific tunnel but should at least incorporate those shown in figure 3.

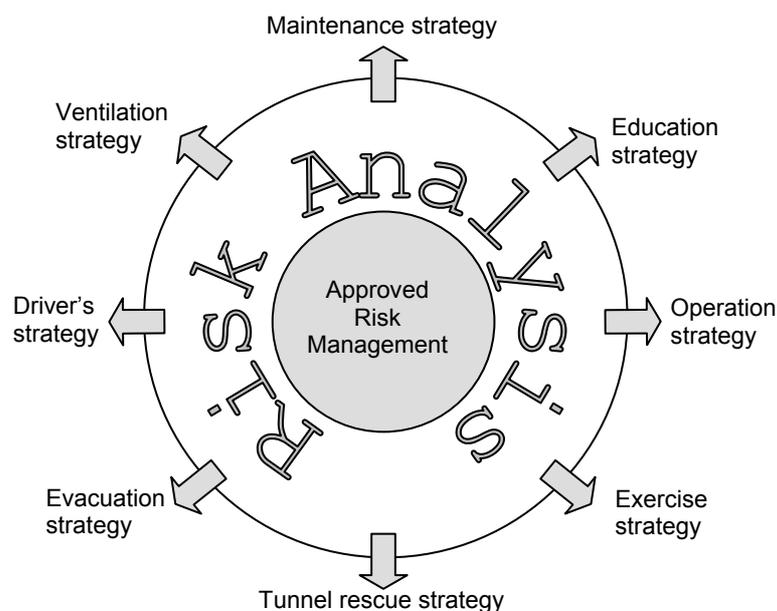


Figure 3 Strategies based on Risk Analysis and approved Risk Management

A common trend for most of the strategies is that they ought to be prepared in co-operation with the emergency authorities or at least be accepted by them.

A maintenance strategy balancing between preventive and corrective maintenance and taking safety aspects into consideration e.g. minimum requirements for safe traffic operation shall be implemented. The strategy shall reflect the high importance of the safety issue in all maintenance activities and traffic restrictions and taking the actual traffic volume into consideration.

An education and exercise strategy shall be adapted addressing general requirements to e.g. frequencies between repeated educations, theoretical and practical exercises on an individual traffic operator level.

In order to make self rescue possible for tunnel users and to create an environment making it possible for emergency services to perform a safe rescue effort a ventilation strategy shall be implemented in co-operation with the emergency authorities. Also an evacuation strategy with proper signage and lighting shall be agreed upon and implemented.

Tunnel rescue strategy for different scenarios shall be discussed in details, tested and implemented in the emergency services organisation. The rescue strategy shall be co-ordinated with the tunnel operator's interventions concerning ventilation, traffic barriers activation etc. As communication in tunnels often has limitations compared to open land, it is important to include this issue in the strategy. The rescue strategy shall continuously be followed up in co-operation between the tunnel operator and the emergency services throughout the operational phase.

Access times for the emergency services and substitute forces shall be analysed. Also risk exposure/limits for rescue staff entering an accident place where tunnel resistance can be influenced must be identified.

Safety strategies for users, on how to drive during normal tunnel conditions, how to behave under unusual conditions and in case of an accident, shall be developed by the tunnel operator and communicated to users.

A dialogue between representatives from the users (e.g. a commuter association) and the tunnel operator shall be organised in order to collect useful information from drivers and in order to improve the user effectiveness of safety behaviour.

5. PROCEDURES AND PLANS

The tunnel operator must prepare the necessary procedures and plans in order to operate and maintain the tunnel in a safe way.

All procedures and plans are linked to each other in one or another way and must be prepared in close co-operation within the tunnel operator organisation as well as with external parties.

The structure might be as shown in figure 4.

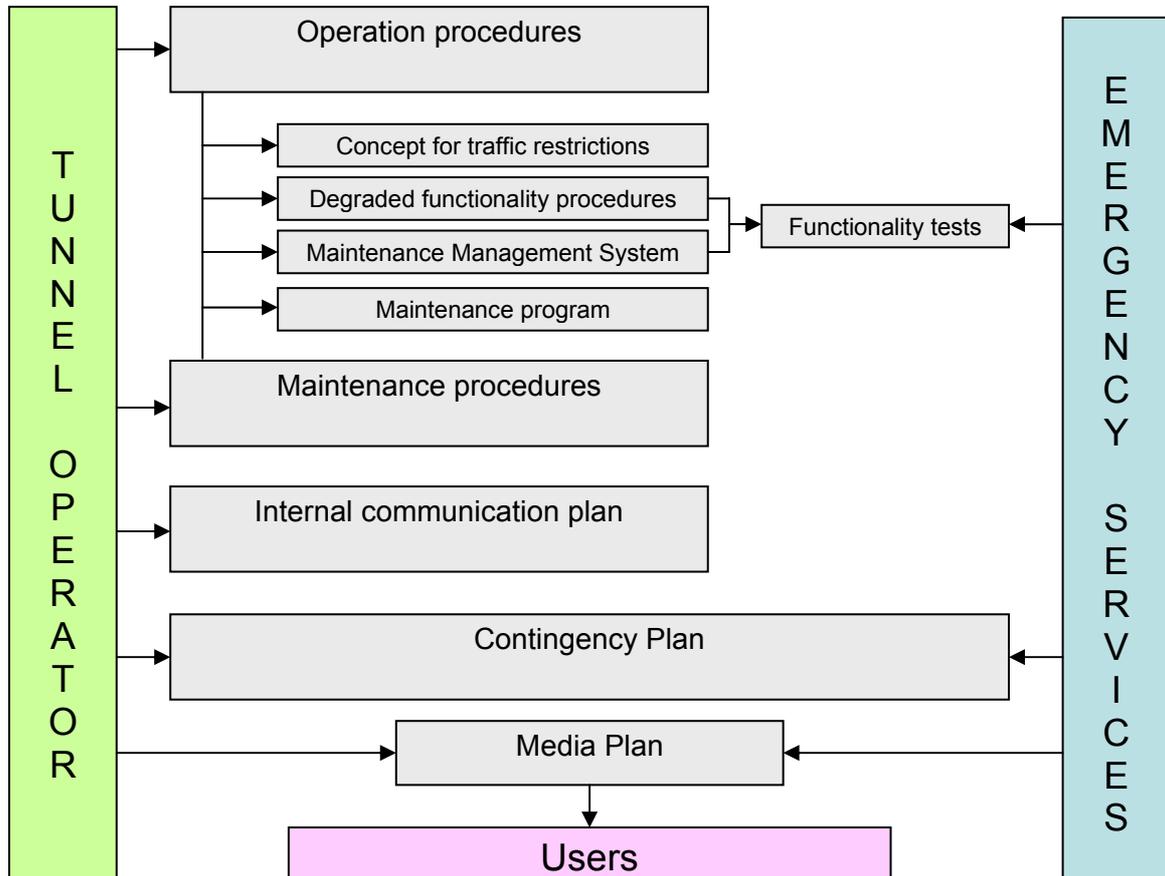


Figure 4 Procedures and plans

Procedures and plans must include:

- Operational procedures for traffic operators concerning traffic and technical systems comprising normal conditions as well as unusual conditions, incidents and accidents.
- Degraded functionality procedures prescribing how to act when a technical defect reduces the functionality and influence the safety.

- Concepts for traffic restrictions to be used when performing maintenance or service work close to traffic. Such standard set ups shall reflect the safety for both tunnel users and maintenance staff.
- Procedures for testing technical systems with safety impact on a regular basis. Such tests minimise the probability for degraded functionality in an accident situation.
- Maintenance procedures regulating how to perform maintenance work from the initial stage to the documentation of the work. All aspects including safety and quality shall be taken into consideration and if necessary risk evaluation shall be performed before initiating critical maintenance.
- Rules for the performance of a maintenance work concerning personal safety devices, rules for using chemical products etc. Another important factor is the education of maintenance staff in how to work and behave in a safe way, how to avoid accidents and how to react in case of an accident. All workers have to receive and pass a course before entering the tunnel and this requirement shall be checked systematically by the control room.
- A Maintenance Management System for creation of an overview of the planned and performed maintenance activities and up-to-date status of all safety related equipment.
- A Maintenance program for planning and co-ordinating maintenance and service activities. Such a programme is extremely useful in order to co-ordinate activities and performs as many activities as possible during e.g. the same traffic restriction thereby minimising the number of restrictions and the probability of an accident to occur.
- An internal communication plan regulating how the tunnel operator organisation communicates in case of incidents/accidents.

In close co-operation with the tunnel operator the emergency services must implement a contingency plan comprising predefined events, resources to alarm, initial responses, special turn-out routes also taking into account the ventilation- and evacuation strategy. Based on the contingency plan specific instructions for each emergency group shall be prepared.

The tunnel operator and the emergency services shall also agree upon a common information- and media plan, comprising information activities with the aim of keeping tunnel users and media focused on safety aspects. The plan shall also define responsibilities for communication during and after an accident.

In addition the tunnel operator shall prepare an information plan in order frequently to inform the users and if possible influence their behaviour when driving under normal conditions and when involved in an incident/accident.

6. TRAINING AND EDUCATION

The tunnel operator shall implement an education plan, covering all staff dealing with safety. The plan shall include external maintenance staff and comprise both education of new employees and repeated education. As a part of the plan the traffic operators shall on a regular basis carry out exercises with focus on prevention and handling of incidents/accidents and seldom used procedures.

Also the emergency services need an education plan for all rescue staff involved. The education shall not only reflect the actions to be taken by different categories of rescue forces, but also secure updated knowledge of the tunnel structure, the technical systems' functionality and limitations in e.g. communication.

Small scale exercises can be used to obtain the optimum knowledge of specific systems like fire hydrants, fire central units and special turn-out routes.

As a follow up on the education common exercises involving the emergency services and the tunnel operator staff is essential. The exercises can be either theoretical or practical full-scale. It is important that users of the tunnel are familiar with signage, technical equipment and how to behave in various situations. This can be obtained by distributing information leaflets to the users.

7. TECHNICAL EQUIPMENT / SYSTEMS

To optimise the training of the tunnel operator's staff a simulation Supervisory Control And Data Acquisition system (SCADA) shall be available. From a safety point of view the simulation system is also a valuable tool for testing of modifications/changes in the SCADA system before implementation in the operative system.

In order to facilitate the traffic operator's correct responses to an incident/accident a special designed programme with a minimum number of commands shall be integrated in the SCADA system.

A Traffic Management System makes it possible for the traffic operator to regulate the traffic, detect an incident, judge the situation and activate necessary traffic restrictions.

A possibility of communication with all involved parties and of creation of an acceptable environment by removing pollution such as smoke is essential.

From the emergency services' point of view the handling of a tunnel accident implies a number of environmental conditions compared to efforts on open land. The need for specific tunnel rescue facilities/equipment shall therefore be analysed and if found favourable from an efficient and safe rescue point of view incorporated in the emergency services normal rescue facilities.

The options for making an efficient and clear alarm for resources to all parties involved in case of an accident should be investigated. If emergency services from different organisations or countries are responding to an alarm, special attention shall be paid to the advantages of introducing a computer based alarm system securing that all involved parties get the same and correct information at the same time no matter which of the centrals has initiated the alarm, see an example in figure 5.

Reliable, efficient and fast communication possibilities for the rescue staff internally in the tunnel and externally with the rescue centres are essential and shall be tested regularly.

The users shall have easy access to call for help from e.g. emergency telephones or/and help buttons and to reach help tools like fire extinguishers or -hoses.

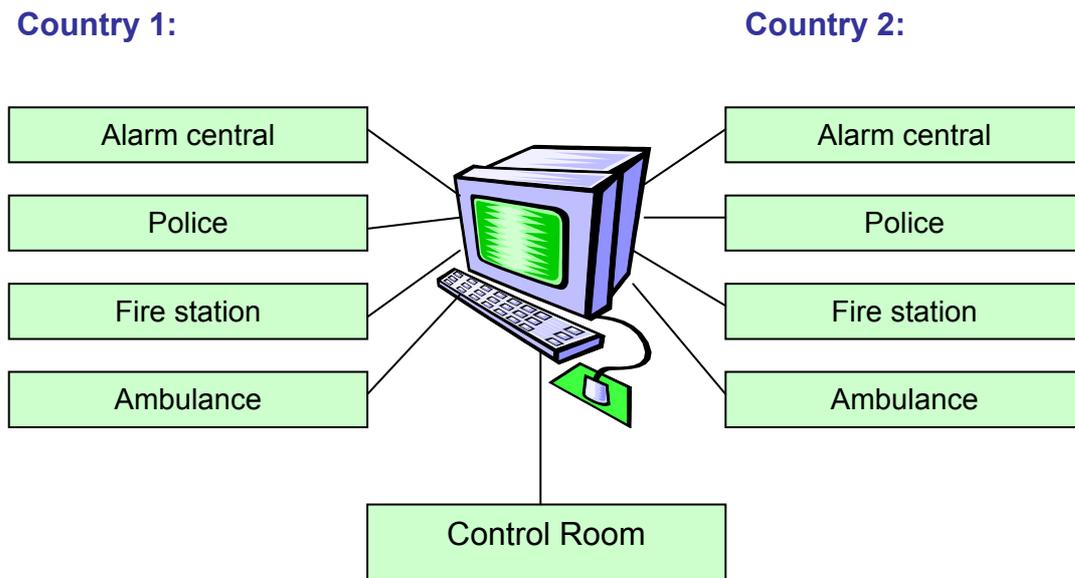


Figure 5 Computer based alarm system

8. QUALITY ASSURANCE

Prerequisites of the risk analysis shall regularly be checked in order to verify whether they correspond to reality.

Safety related events and defects in technical systems shall be evaluated by the tunnel operator in an organised way in order to identify safety improvements in organisation, procedures, technique etc. Evaluation of safety-related events and risk trends shall be performed in co-operation with the emergency services.

The quality of performed education shall be verified by e.g. theoretical or practical test-exercises. When part of an education or exercise is finished either for the tunnel operator's staff, the emergency services or both, an evaluation of the quality of education/exercises shall be performed. Necessary improvements shall be identified and implemented.

The entire tunnel operation shall be examined and evaluated from a safety point of view. A yearly examination shall include technique, procedures, organisation, education and driver's behaviour in order to detect safety risks and identify appropriate actions.

Together with the emergency services the tunnel operator shall follow-up and take necessary corrective actions to safety related incidents caused by user's attitude and behaviour.