



3<sup>rd</sup> European Forum of Road Tunnel Safety Officers  
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# Incident Evaluation and Review through Emergency Exercise



LSBG  
Landesbetrieb Straßen,  
Brücken und Gewässer  
Hamburg

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# Incident Evaluation and Review through Emergency Exercise

1. Road Tunnels Operation in Hamburg
2. Basic Information on the Elbe Tunnel
3. HGV Fire in Tunnel Tube 4 in March 2011
4. Evaluation of the HGV Fire
5. Review through Emergency Exercise
6. Conclusions





# 1. Road Tunnels Operation in Hamburg



## Federal Structure in Germany

- Owner of German motorways is the Federal Republic of Germany
- Hamburg is one of 16 Federal States
- Federal States of Germany are responsible for operating the motorways on their territories
- In Hamburg the LSBG is responsible for operating the motorways including their technical infrastructure





## LSBG -> Landesbetrieb Straßen, Brücken und Gewässer -> Hamburg Agency for Roads, Bridges and Waters

- LSBG is a state owned agency and part of Hamburg's administration – with more than 500 employees
- LSBG - fields of activity
  - Design
  - Implementation
  - Operations and Maintenance
- LSBG provides according to German Guideline RABT 2006
  - Administrative Authority
  - Tunnel Manager
  - Inspection Entity
  - Safety Officer



## 2. Basic Information

# Elbe Tunnel



## Elbe Tunnel in the European Context

- Elbe Tunnel is situated on the motorway A7 crossing the river Elbe in Hamburg
- A7 is part of the European Route E45
- E45 connects Northern and Southern Europe (Finland, Sweden, Denmark, Germany, Austria, Italy)
- A7 in Hamburg is part of the Trans European Road Network (TERN)  
-> Directive 2004/54/EG applies



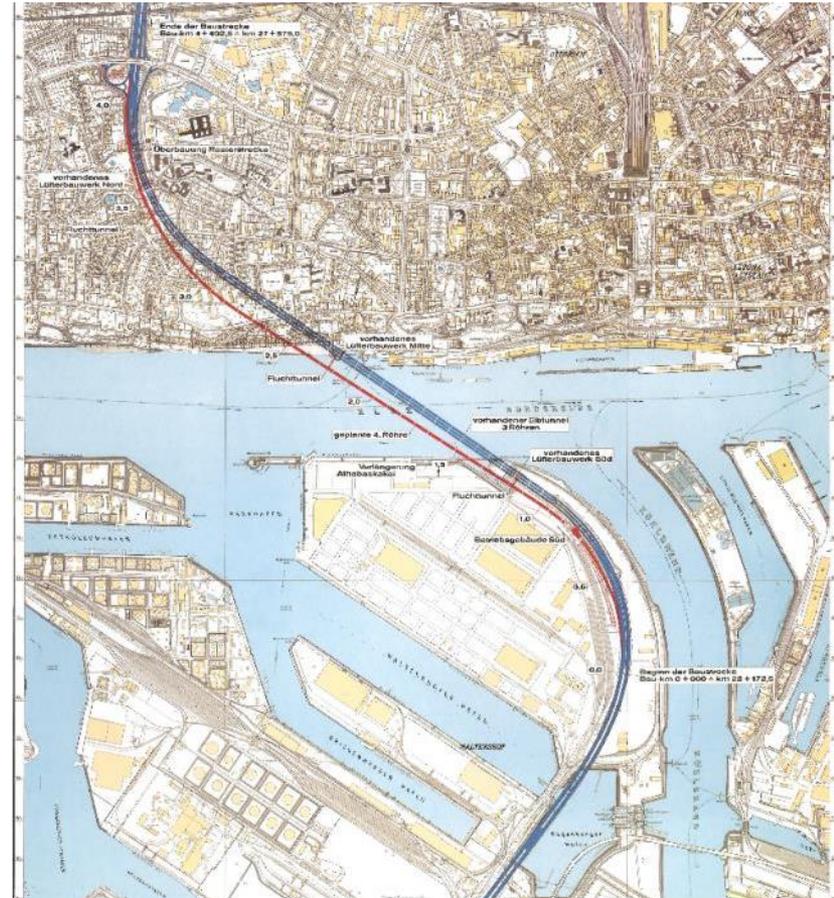
## Bottleneck Elbe Tunnel

- **Metropolitan Area of Hamburg** (population > 5 Mio) has only two major road crossings of the Elbe river:
  - Elbe Tunnel (motorway A7)
  - Elbe Bridges (motorway A1)
- **Traffic at the Elbe Tunnel**
  - ~ 120 000 vehicles per day (average)
  - High traffic load in peak hours (high percentage of commuters)
  - ~ 17% lorries



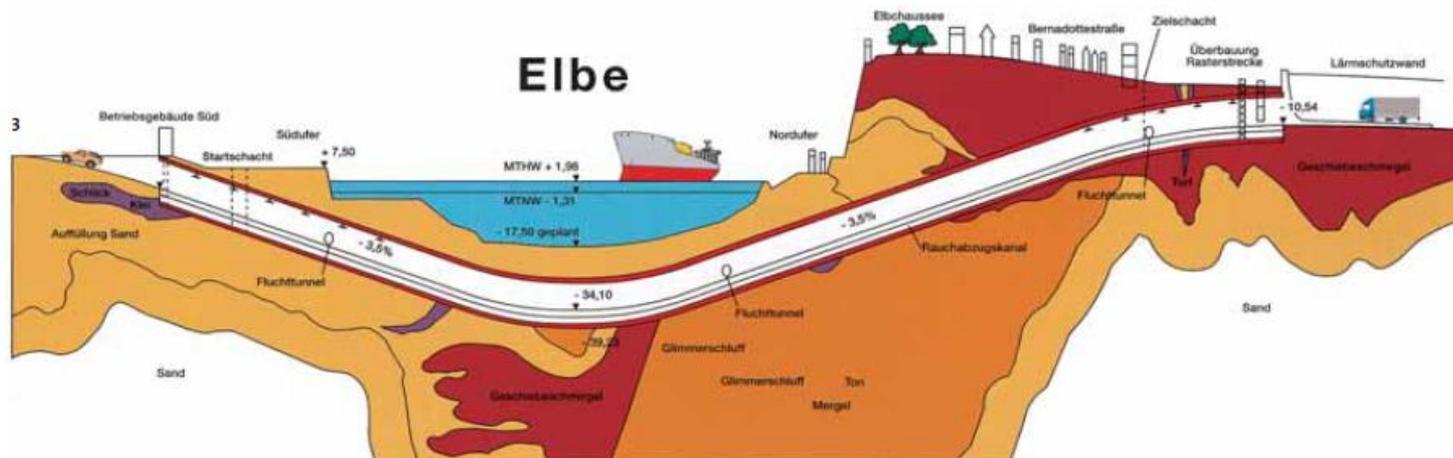
## Layout of the Elbe Tunnel

- ~ 3 km long
- Consists of 4 tubes
- 3 tubes were built from 1968 to 1974
- 4th tube was built from 1995 to 2002
- 2 lanes in each tube



## Layout of the Elbe Tunnel

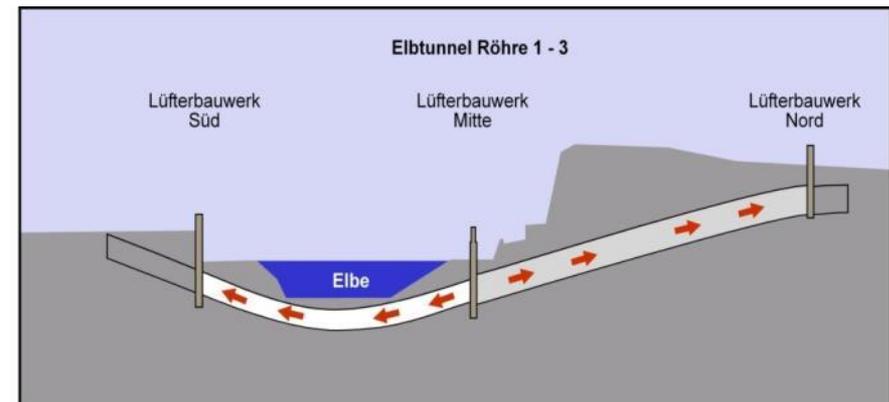
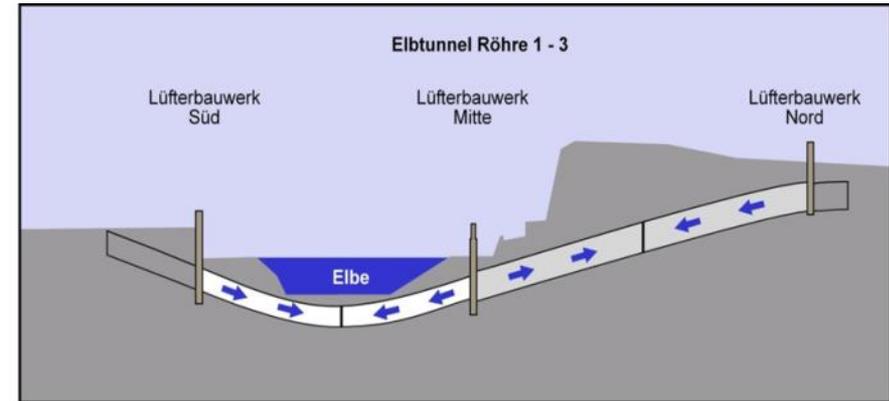
- Emergency crossings between tunnel tubes
- Maximum slope ~ 3,5 %



## Ventilation System Elbe Tunnel

### Tube 1 - 3

- Transverse ventilation
- Supply ducts for fresh air and exhaust ducts along the tunnel tubes with openings towards the tubes
- In case of fire:  
-> damper groups open at the location of the fire



## Ventilation System Elbe Tunnel

### Tube 4

- Longitudinal ventilation (jet fans) with smoke extraction
- 48 groups à 4 dampers at the tunnel crown (every 60 m)
- In case of fire:  
-> damper groups open at the location of the fire



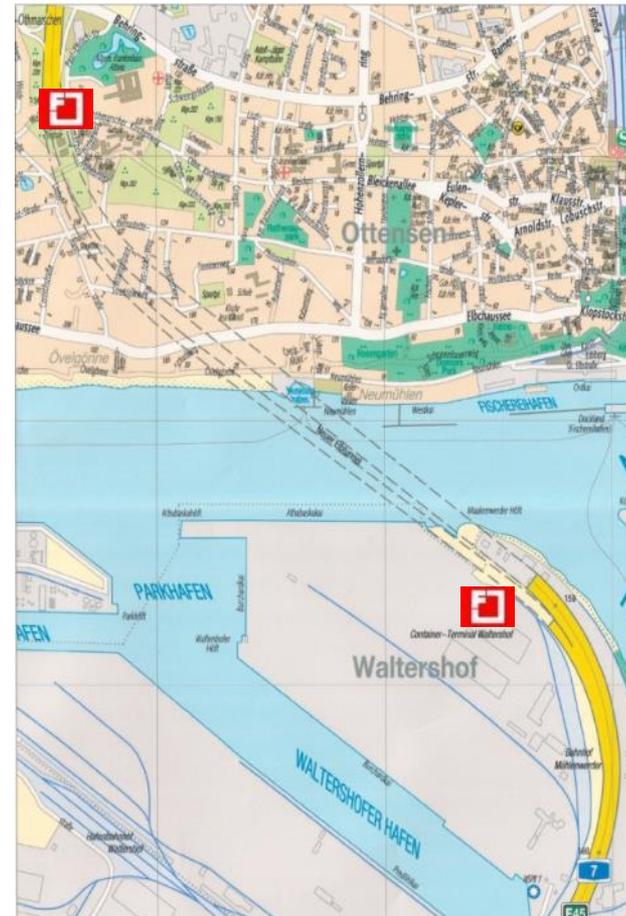


## Tunnel Control Centre (TCC)

- 3 authorities 24/7 at TCC
  - **LSBG**
    - Operation of the tunnel structure and technical equipment
  - **Fire Services**
    - Fire fighting
    - Technical Assistance (after accident, vehicle breakdown, ...)
    - Co-ordination of ambulance
  - **Police**
    - Traffic Monitoring and Control

## Fire Stations at the Elbe Tunnel

- At each portal a fire station with 3 fire fighters
- Exclusively for incidents at the Elbe Tunnel
- in case of major incidents:  
-> additional fire fighters throughout Hamburg will be alerted



# 3. HGV Fire in Tunnel Tube 4

## March 31<sup>st</sup> 2011



## Course of the Event

- HGV caught fire in the middle of tunnel tube 4
- Cause of fire: self-ignition in the engine compartment
- Operator noticed smoke on cameras
- While the operator tried to assess the situation, the heat detector sensors triggered the fire programme on the SCADA System
- Instant response of the Elbe Tunnel fire fighters (they were present in the tunnel tube 3 minutes after alert)
- The fire could be controlled and extinguished within 30 minutes



Tractor unit of HGV after the fire

- Fortunately no casualties
- Only two persons suspected of injuries



Smoke extraction via axial fans in operation



Emergency services and evacuees at the tunnel entrance



Final fire fighting operations

## Damage to Tunnel Wall



- Concrete walls more or less intact
- Refurbishment of the joint necessary
- Escape route lighting in direct vicinity to the fire was fully intact

## Damage to Cabling at the Tunnel Ceiling



- ~ 50m of electrical installation at the tunnel ceiling has been damaged



## Reconstruction of Asphalt and Fire Protection Cladding



- ~ 50 m<sup>2</sup> of asphalt and fire protection cladding had to be replaced
- After 10 days of refurbishment and testing the tunnel tube was re-opened

# 4. Evaluation of the HGV Fire



## TSO's Evaluation based on Incident Report by Tunnel Manager

### Directive 2004/54/EC, Article 5 (3)

„Any significant incident or accident occurring in a tunnel shall be subject of an incident report prepared by the Tunnel Manager. This report shall be forwarded to the Safety Officer [...].“

30.4.2004 EN Official Journal of the European Union L 167/ 39

DIRECTIVE 2004/54/EC OF THE EUROPEAN PARLIAMENT  
AND OF THE COUNCIL  
of 29 April 2004

on minimum safety requirements for tunnels in the  
Trans-European Road Network

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 71(1) thereof,

Having regard to the proposal from the Commission,

Having regard to the Opinion of the European Economic and Social Committee<sup>1</sup>,

Having regard to the Opinion of the Committee of the Regions<sup>2</sup>,

Acting in accordance with the procedure laid down in Article 251 of the Treaty<sup>3</sup>,

<sup>1</sup> OJ C 220, 16.9.2003, p. 26.

<sup>2</sup> OJ C 256, 24.10.2003, p. 64.

<sup>3</sup> Opinion of the European Parliament of 9 October 2003 (not yet published in the Official Journal), Council Common Position of 26 February 2004 (OJ C 95 E, 20.4.2004, p. 31) and Position of the European Parliament of 20 April 2004 (not yet published in the Official Journal).

## Content of an Incident Report

### Recommendations for TSO:

- Agree with your Tunnel Manager on a general template for incident reports to ensure that you get all information you need

- Check PIARC report

-> „**Tools for Tunnel Safety Management**“

for a comprehensive compilation of information which should be included in an incident report



## Other Sources than the Tunnel Manager's Incident Report

### Recommendations for TSO:

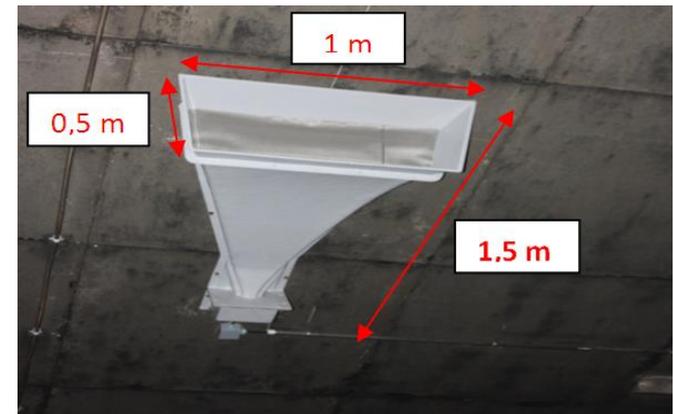
- To get first-hand information (and information off the record) for a better picture:
  - > talk with persons who were involved in the incident response
  - > make sure that this happens in a trustful atmosphere
- Check media for additional information, e.g. interviews with evacuees (may not be 100% reliable information, but worth to take into account)

## Evaluation - Major Findings Evacuation Process

- Evacuation of the tunnel tube took ~ 30 min  
(according to German guidelines it should be ~ 15 min)
- Tunnel users felt safe in the tunnel although they saw a „wall of smoke“ ahead („the fire brigade is present – so nothing will happen to me...“)
- Tunnel users did not understand the instructions to leave tunnel given through the PA System
- “Conventional” PA System is not sufficient in tunnel environment because of massive sound reflection

## Improvement Measure PA System

- Speed up the process to install a new loudspeaker system (SLASS)
- Tailored for tunnels (SLASS – Synchronised Longitudinal Announcement Speaker System)
- Review performance of the new system in an emergency exercise



New loudspeaker system

## Evaluation – Major Findings Evacuation Process

- Tunnel users had difficulties to open the emergency exit doors
- The inspection after the incident showed that the force to open the doors was in compliance with German Regulations (less than 100 N)
- Assumption: people do not expect to need so much force to open the door and get confused if they should push or pull the door open



## Improvement Measure – Emergency Doors

- Application of additional signs on the door indicating how to open the door (direction of opening and how to use the door handle)
- Review the effect of additional signs on the door in an emergency exercise



## Evaluation - Major Findings Operation Control during the Incident

- the contingency plan states that the fire services have operation control in case of fire, but police and tunnel operator did not act accordingly, e.g.:
  - a police patrol happen to be in the 4<sup>th</sup> tube during the fire and took the lorry driver out of the tunnel in their car - the police did not notify the fire services, so the fire fighters spend time to search for the lorry driver in the tunnel tube although he was already safe outside the tunnel
  - in the neighbouring safe tunnel tube police and fire brigade gave contradictive instructions to evacuees on the direction to leave the tunnel (north or south portal)
  - the tunnel operator activated an additional ventilation programme without asking / notifying the fire fighter in command
- Improvement measure: Briefing of all parties to respect the chain of command and chain of reporting – review in an emergency exercise

## Evaluation – Major Findings Fire Fighters

- Difficulties to communicate in noisy tunnel environment
  - > Optimisation of radio communications  
(new bone conduction headsets, implementation of digital radio)
- Integration of remote fire stations regarding
  - Thermographic cameras
  - Long-term breathing equipment
  - Training on rescuing under long-term breathing equipment
- Improvement measures:
  - > Provision of more and more suitable equipment
  - > Consideration to integrate rescuing under long-term breathing equipment into the fire academy's performance tests

# 5. Review through Emergency Exercise





## **DIRECTIVE 2004/54/EC**

### **ANNEX II, 5. Periodic exercises**

“The Tunnel Manager and the emergency services shall, in cooperation with the Safety Officer, organise joint periodic exercises for tunnel staff and the emergency services.

[...]

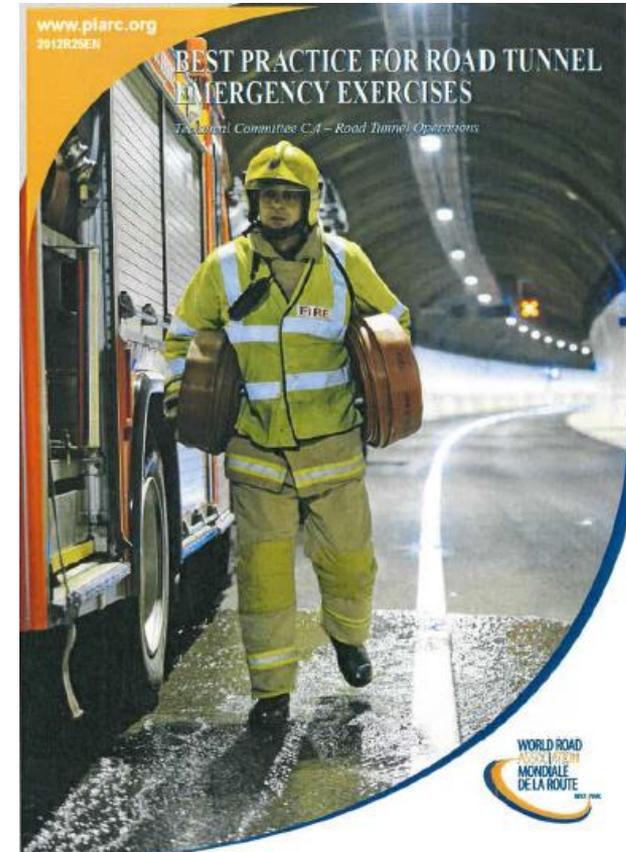
**(b) The Safety Officer and the emergency services shall evaluate jointly these exercises, draw up a report and make appropriate proposals.”**

## Organisation of a Full Scale Exercise

- Helpful source for the organisation of an emergency exercise:

PIARC Report

**„Best Practice for Road Tunnel  
Emergency Exercises“**



## Incident Scenario „Fire in Tunnel Tube 3“

- After a traffic accident and a small explosion a car catches fire
- Several persons trapped in cars
- When the fire brigade arrives at incident scene a second car catches fire
- Delayed activation of smoke extraction to exercise in smoky surrounding
- 20 volunteers acting as tunnel users (some of them injured)
- ~ 150 participants in emergency exercise from different authorities



## Evaluation of Emergency Exercise based on

- Observers on site and in tunnel control room
- Movie shots from camera crew
- SCADA system logs
- Debriefing
- Analysis of questionnaires



(Quelle 4: Internet: Explosion im A7 Eibttunnel, © Copyright 2011-11-10 alle Fotos: Harald Haack, Newsbattery.eu)



## Questionnaire for Fire Fighters

- To be filled in after the exercise (anonymous)
- Questions concerning
  - Access Routes
  - Orientation in the tunnel
  - Signing
  - Emergency telephones
  - Hydrants
  - General remarks / suggestions on improvement

### FRAGEBOGEN EINSATZKRÄFTE

ÜBUNG ELBTUNNEL 10. November 2011



Der Landesbetrieb Straßen, Brücken und Gewässer (LSBG) ist u.a. zuständig für den Betrieb des Elbtunnels. Im Ereignisfall ist ein reibungsloses Zusammenwirken zwischen Einsatzdiensten, Tunnelbetrieb und technischen Einrichtungen von großer Wichtigkeit. Aus einer Übung können sich wertvolle Erkenntnisse im Hinblick auf mögliche Verbesserungen ergeben. Deshalb sind wir an Ihrem Feedback interessiert.

Bitte füllen Sie den folgenden Fragebogen aus und schicken ihn bis spätestens 01.12.2011 über F40V und/oder F40 an LSBG, B236. Vielen Dank für ihre Mitarbeit!

Zu welcher Wache bzw. Abteilung gehören Sie? \_\_\_\_\_

Waren Sie mit dem Anfahrtsweg zum Elbtunnel vertraut?

ja  verbesserungswürdig  nicht relevant für meine Aufgabe

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

War es für Sie einfach, den Weg in die richtige Tunnelröhre zu finden?

ja  verbesserungswürdig  nicht relevant für meine Aufgabe

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

War es für Sie einfach, sich innerhalb der Tunnelröhre(n) zu orientieren?

ja  verbesserungswürdig

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

Welche Hilfsmittel nutzten Sie, um sich in der (den) Tunnelröhre(n) zu orientieren?

Nischennummerierung  Fluchtwegnummerierung  Objektplan  keine

Waren die Kennzeichnungen der Nischen und Fluchtwege

optimal  verbesserungswürdig  zur Orientierung nicht benutzt

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

Falls Sie ein Notruftelefon benutzt haben, war die Kommunikation mit der Zentrale

optimal  verbesserungswürdig  Notruftelefon nicht benutzt

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

Falls Sie einen Hydranten genutzt haben, war dieser leicht zu finden?

ja  verbesserungswürdig  Hydranten nicht benutzt

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

Falls Sie einen Hydranten genutzt haben, war dieser einfach benutzen?

ja  verbesserungswürdig  Hydranten nicht benutzt

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

Haben Sie weitere Verbesserungsvorschläge oder Kritikpunkte?

(Falls Platz nicht ausreichend, bitte auch Rückseite benutzen!)



## Questionnaire for Volunteers

- To be filled in after the exercise (anonymous)
- Questions concerning
  - Audibility of PA System
  - Comprehensibility of announcements
  - Emergency exits easy to find?
  - Usability of emergency telephones
  - General remarks / suggestions on improvement

### FRAGEBOGEN MIMEN ÜBUNG ELBTUNNEL 10. November 2011



Landesbetrieb  
Straßen, Brücken  
und Gewässer  
Bz - Tunnelbetrieb

Der Landesbetrieb Straßen, Brücken und Gewässer (LSBG) ist u.a. zuständig für den Betrieb des Elbtunnels. Im Ereignisfall ist eine reibungslose Evakuierung des Tunnels von großer Wichtigkeit. Aus einer Übung können sich wertvolle Erkenntnisse im Hinblick auf mögliche Verbesserungen ergeben. Deshalb sind wir an Ihrem Feedback interessiert.

Vielen Dank für ihre Mitarbeit!

Nutzen Sie den Elbtunnel auch privat?

regelmäßig  gelegentlich  sehr selten oder nie

Haben Sie die Lautsprecherdurchsagen akustisch gut verstanden?

ja  verbesserungswürdig

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

Waren die Anweisungen über Lautsprecher für Sie nachvollziehbar?

ja  verbesserungswürdig

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

Falls Sie einen Notausgang benutzt haben, war dieser leicht zu finden?

ja  verbesserungswürdig  Notausgang nicht benutzt

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

War die Fluchtwegkennzeichnung und Brandnotbeleuchtung an den Tunnelwänden

hilfreich  verbesserungswürdig  zur Orientierung nicht benutzt

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

Falls Sie eine Notausgangstür geöffnet haben, war diese leicht zu öffnen?

ja  verbesserungswürdig  Notausgangstür nicht geöffnet

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

Falls Sie ein Notruftelefon benutzt haben, war die Kommunikation mit der Zentrale

optimal  verbesserungswürdig  Notruftelefon nicht benutzt

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

Falls Sie ein Notruftelefon benutzt haben, waren die Anweisungen der Zentrale

hilfreich  verbesserungswürdig  Notruftelefon nicht benutzt

Wenn verbesserungswürdig, was wäre zu verbessern? \_\_\_\_\_

Haben Sie weitere Verbesserungsvorschläge oder Kritikpunkte?

(Falls Platz nicht ausreichend, bitte auch Rückseite benutzen!)

## General Evaluation of the Exercise at the Elbe Tunnel

- In principle the defined incident plan proved to be effective
- Very good collaboration and communication between fire brigade, police and tunnel operator
- The safety facilities in the tunnel have been judged as „good“ by fire fighters and volunteers





## Potential for Improvement deducted from Exercise

- Use and train on a unified “tunnel language” - precise wording is important in communications
- Enhance training for emergency services from remote stations regarding orientation and provide more signing on access routes outside the tunnel
- Speed up replacement process from analogue to digital radio communication in the tunnel

# 6. Conclusions



## Conclusions Incident Evaluation and Review through Exercise

- Use all available sources for your evaluation of a major incident (not only the tunnel manager's report, if possible)
- Establish a trustful atmosphere with all involved parties (the aim is not to blame, but to get as much information as possible to find out how to do better next time)
- Keep record on potential improvement measures deducted from incidents and exercises
- Check the status of implementation of improvement measures with tunnel manager and emergency services on a regular basis



# Many Thanks for your Attention!

**Christina Kluge**

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Landesbetrieb Straßen, Brücken und Gewässer

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