

OVERVIEW OF EUROPEAN TUNNEL RESEARCH AND ITA COMMITTEE ON OPERATIONAL SAFETY OF UNDERGROUND FACILITIES

***PROF. DR.-ING. ALFRED HAACK
STUVA e.V., Cologne, Germany; former President of ITA***

ABSTRACT

The tragic tunnel fires of the past years have led to discussions of experts in Europe and around the world. In Germany as well as in other countries they have even caused a complete revision of the national safety guidelines for road and rail tunnels. The European Commission has developed directives concerning the minimum safety equipment of road tunnels as well as of railway tunnels. This action is supplemented by intensive domestic and international research activities.

The paper describes the European projects briefly and gives an idea about the objectives and most important findings. Special focus is given to COSUF – the ITA Committee on Operational Safety of Underground Facilities, joining the 7 research and network projects launched within the 5th Research Programme of the EU. This committee is aiming at a world-wide exchange of views, ideas and experience in the field of safety and security regarding underground facilities.

INTRODUCTION

Fires in transport tunnels can cause catastrophic disasters. The accidents in the Mont Blanc Tunnel (March 24, 1999), in the Tauern Tunnel (May 29, 1999), in the Gotthard Tunnel (October 24, 2001; Fig. 1), in the subway system in Daegu/South Korea (February 18, 2003; Fig. 2), in the Baregg Tunnel (April 14, 2004) and most recently in the Fréjus Tunnel (June 4, 2005; Fig. 3) have made this more than clear. The detailed analysis of the cause and progression of these fires have yielded new insights that had not been expected or calculated to this extent before. The only exception is the fire in the Nihonzaka Tunnel in Japan of 1979, which involved a total of 189 vehicles.

One insight pertains to the extremely rapid development of truck fires with an enormous rise in temperature of up to 1000 degrees Celsius and above. Experience has also shown that large amounts of fire gases are released within a short time, starting in a very early phase of the fire development.

The fire in the Mont Blanc Tunnel also showed that heated gases are capable of setting other vehicles on fire even at distances of 200 meter and more. The third and especially frightening aspect is the behaviour of the tunnel users. Too many of them did not recognize the danger they were in.



Fig 1. Burning lorries in the Gotthard Tunnel (Switzerland) on 24.10.2001



Fig. 2. Arson attack in the subway of Daegu/South Korea on 18.2.2003



Fig. 3. Fire accident in the Fréjus Tunnel (France) on 4.6.2005

When they finally realized what was happening, it was frequently too late for a successful escape. In the context of subway fires, the example of Daegu also showed how crucial the impact of railcar engineering and equipment, operational organization and safety training of train conductors and station managers can be. Severe shortcomings in these criteria were a crucial factor in the tragic outcome with 196 fatalities.

SAFETY RELATED EUROPEAN RESEARCH

In consequence of the devastating fire accidents the European Commission issued directives regarding the minimum fire prevention equipment of road and rail tunnels ^{1,2}. In addition, a number of important research projects were initiated. These are seven multinational projects that have already been awarded and funded in conjunction with the fifth Research Framework Programme of the EU³. They are more or less linked with each other as well as with national projects like a puzzle (Fig. 4).



Fig. 4. European research projects to improve the safety level in traffic tunnels

The following overview briefly discusses the objectives and general structure of these projects:

- **DARTS (Durable And Reliable Tunnel Structures)** was performed in the period 2001-2004 by eight partners from five European countries (coordinators were COWI AS (DK) and CUR (NL)).

The objective of the DARTS-project was to develop operational methods and supporting practical tools for the best pro-active decision-making process for choosing, in each individual case, the cost optimal tunnel type and construction procedures regarding environmental conditions, technical qualities, safety precautions and long service life.

The dominating innovation of DARTS is the integration of reliability based structural design, geotechnical issues, service life design, hazard design including risk assessment, environmental aspects, societal needs, sustainability, and economic aspects. This is merged into a set of practical methods and operational tools for choosing, designing, constructing, operating and upgrading the overall structural, environmental and socio-economic optimal tunnel type for each individual tunnel project. DARTS has been developed for the main current types of tunnel constructions as follows: rock tunnels, bored tunnels, NATM tunnels, immersed tunnels, and cut and cover tunnels. For more information on DARTS, including the reports see: www.dartsproject.net.

- **FIT (Fire In Tunnels)** was established in March 2001 and limited to four years. This “thematic network” included 33 partners from twelve European countries and was

coordinated by the Belgian Building Research Institute (BBRI) in Belgium. The project was to gather information from all over Europe and around the world about existing research results and general experiences with fire prevention and mitigation in transport tunnel facilities.

Six dedicated databases focus on research projects, tunnel test site facilities, numerical models for course of fires and smoke propagation, safety equipment, reports on fire accidents and case studies for upgrading tunnels. Three work packages within the FIT project were focused on a number of fundamental questions. This includes the determination of fire ratings, compilation of guidelines and recommendations for optimised principles of design that are suitable for fire prevention as well as advocating optimised measures for escape routes, assisted rescue and fire fighting. The corresponding partial reports have been completed in their draft versions. For further details visit: www.etnfit.net.

- **UPTUN** (Cost-effective, sustainable and innovative **UP**grading methods for fire safety in existing **TUN**nels) is a RTD project, running from 2002 – 2006. UPTUN is being performed by 42 partners from 18 European countries and coordinated by TNO and CUR (NL) and ENEA (I). UPTUN comprises research work of approx. 950 man months.

The UPTUN project's main objectives are twofold:

- Development of innovative technologies where appropriate and where relevant comparing to and the assessment of existing technologies for tunnel application (Fig. 5). Focus is on technologies in the areas of detection and monitoring, mitigating measures, influencing human response, and protection against structural damage. The main output is a set of innovative cost-effective technologies.
- Development, demonstration and promotion of procedures for rational safety level evaluation, including decision support models; and knowledge transfer. The main output is a risk based evaluating and upgrading model.

The results of UPTUN will provide designers, builders, operators and owners, but also emergency and rescue teams, a better basis for measuring and increasing safety standards with regard to people, goods and the tunnel structure itself. Detailed information on UPTUN and its partners can be found at www.uptun.net.



Fig. 5. Upgrading of tunnels: Well marked emergency exit in the re-opened Mont Blanc Tunnel (France/Italy)

- **Safe Tunnel (Safety in Road Tunnels)** begun in September 2001 and was designed for a project term of three years. The Centro Ricerche FIAT, Italy, was in charge of coordinating the nine members. The main focus was to reduce the extent and number of fire accidents in road tunnels.

The basic idea was to filter out and stop vehicles with irregularities such as overheated engines, blocked brakes or existing smoldering fires before entering the tunnel, using suitable measurement equipment. At the same time, devices (Fig. 6) need to be in place to monitor vehicle speed in order to reliably determine and prosecute speed violations. The web address of this project is: www.crfproject-eu.org.



Fig. 6. For testing purposes with an onboard equipped truck of the Safe Tunnel-project

- **SIRTAKI (Safety Improvement in Road& Rail Tunnels using Advanced Information Technologies and Knowledge Intensive Decision Support Models)** was initiated in September 2001 for a term of three years. The initiative was shared by twelve European partners under the project management of the Spanish ETRA Group. The main focus of the project was to reform operative concepts with regard to safety and emergency management. Once the concept has been developed, it will be tested in a variety of road and rail tunnels. The project outcome includes better prevention of critical situations, decision-making aids for tunnel operation, the introduction of a European operating network as well as the improvement of sensor-based vehicle and facility monitoring. Further details are available at: www.sirtakiproject.com.
- **Virtual Fires (Virtual Real Time Emergency Simulator)** was started for a duration of three years with eight partners from five European countries. The Institute for Structural Analysis of TU Graz, Austria served as the project coordinator. The objective was to develop a suitable and practical simulator to train firefighters in confining and fighting fires in tunnels. A computer model is used to create virtual simulations of fires in tunnel situations.

Such a device is more cost-efficient and environmentally friendly than the usually applied method of training firefighters by setting real vehicles and liquids on fire in tunnels that are no longer in use. The simulator may also be used for studying and assessing tunnel facilities and their equipment with regard to their fire safety. Tunnel operators, planners and government safety agencies could be among the possible users of this simulation device. For more information visit: www.virtualfires.org.

- **Safe-T (Safety in Tunnels)** represents another thematic network with a three-year term that was started in the fall of 2003 and is coordinated by TNO in the Netherlands. The

primary objective is to harmonize the European requirements regarding tunnel safety. Experiences gathered at the national level are to be compiled and assessed in such regulations. Given the background of the negative experiences with the former operative concept of the Mont Blanc Tunnel, special emphasis will be on cross-border operative concepts. The experience of regional authorities, firefighters and emergency rescue services are of special importance for this project. Further details are available from the website at: www.safetunnel.net.

CURRENT RESEARCH OF EU

The European Union is continuing its efforts to improve the safety level in tunnels and other underground facilities. Especially worth mentioning are the following two projects launched within the 6th European research frame programme.

L-SURF (Design study for a **L**arge **S**cale **U**nderground **R**esearch **F**acility on Safety and Security) as a research project on safety and security in enclosed underground spaces is of outstanding importance as most recent incidents (tunnel fires, terror attacks in metros etc) have shown. However currently the competence related to safety and security in Europe is largely unstructured, fragmented and mostly national oriented. Especially missing is a large scale research facility.

By L-SURF all relevant aspects for such a facility will be elaborated to such a level that the facility could be established at least as a legal entity with the necessary structures and activities and that preliminary concepts and plans for the physical construction are laid out.

The main objectives of the design study are fourfold:

- to conduct a feasibility study into the establishment of a pan-European facility
- to perform scientific and technological research into the technical specifications for a corresponding versatile scheme and innovative measurement sensors
- to work out a detailed business-plan (including users, customers and finance options)
- to finally establish a legal entity named L-SURF

Since leading European institutes and companies with relevant expertise are working closely together, L-SURF provides a vehicle on the path to further **internationalisation** of research on safety and security. For more details see www.L-Surf.org.

Another additional and important research project is dealing with existing road tunnels in Europe:

EuroTAP (**E**uropean **T**unnel **A**ssessment **P**rogramme) aims at an improved safety level of Europe`s road tunnels. In January 2005 the programme was started in Munich at the occasion of a symposium organized by ADAC (German Automobile Club) and ÖAMTC (Austrian Automobile and Touring Club). In a giant test programme all in all 150 tunnels Europewide will be investigated concerning their safety conditions during the coming three years. By this action it is last but not least to ensure that the European Directive for Road Tunnels will be followed and exploited. The results gained in the frame of EuroTAP concerning the first 50 tunnels investigated were published end of April 2005. Massive support this action receives by the European Commission in Brüssel, which funds the project with 1.5 Million Euro. In addition the partnership of eleven other automobile clubs coming from ten European countries gives the project significant strength.

Since 1999 **EuroTest**, the joint test organisation of the European automobile clubs, investigates the safety level in road tunnels throughout Europe. Nearly one third of the tunnels investigated so far offered a too low safety level and failed in the tests. In the meantime many of those criticized tunnels have been improved concerning their safety conditions. The most recent examples are given with the Felbertauern Tunnel in Austria and the tunnel San Juan in Spain which both were upgraded after harsh criticism and significantly improved concerning the safety concepts taking investments of more than four million Euro for each.

Besides the comprehensive tunnel tests EuroTAP will continue the public campaign „Safe in a Tunnel“ which was already started in 2004. This campaign aims directly to the tunnel users by preparing brief descriptions of definitive tunnels and publishing those on the internet pages of the Automobile clubs involved. It is complemented by a PC-Educational game as well as information sheets concerning the best behaviour of the users in a tunnel. On the bases of all the test results and protocols of the investigations a catalogue shall be worked out as fundamental tool for the design and layout of the safety concept for road tunnels in future. For more details the ADAC-webpage should be visited: www.adac.de.

FUTURE ACTIVITIES

Especially worth of mentioning is the establishment of the ITA Committee on Operational Safety of Underground Facilities (COSUF; Fig. 7). This committee was installed in May 2005 and involves all the 7 research and network projects issued by the European Union within the 5th European research frame programme in consequence of the devastating fire accidents in various European road tunnels during the last couple of years. In addition, also the L-Surf project launched within the 6th European research frame programme joint COSUF. Although starting from these 7+1 European projects described above COSUF is open for all institutions, companies, consultancies, governmental organisations etc. world-wide which are active and interested in the field of safety and security regarding underground facilities. COSUF is preparing its inaugural meeting combined with a technical seminar for 30th and 31st May 2006 in Lausanne, Switzerland, the headquarter of ITA. The seminar will mainly focus on the results of the two projects Safe-T and UPTUN and give some information also about the findings of the other projects.

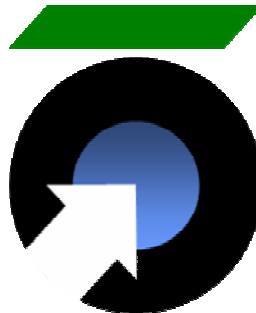


Fig. 7. Logo of COSUF

OUTLOOK

The research efforts of the European Commission described here to improve the safety in traffic tunnels are an essential prerequisite for an all-European harmonization in this field. Here COSUF forms a platform to continue the activities even after finalising the research projects and in the same time presents a forum for a world-wide exchange of views, ideas and experience in the field of safety and security regarding underground facilities. Tunnels are an indispensable part of the trans-European traffic network. Given this background, the research activities are delivering a crucial contribution to guarantee the mobility of persons and goods, which represents a high political priority.

REFERENCES

- [1] Directive 2004/54/EC of the European Parliament and of the Council, 29. April 2004 on minimum safety requirements for tunnels in the trans-European road network. In: Official Journal of the European Union L 201/56 pp; published 7.6.2004
- [2] Directive 2004/49/EC of the European Parliament and of the Council, 29. April 2004 on safety on the Community's railways and amending Council Directive 95/18/EC on the licensing of railway undertakings and Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification (Railway Safety Directive). In: Official Journal of the European Union L 164/44 pp; published 30.4.2004
- [3] Haack, A. (Mai 2005): European Research and Development on Safety in Road Tunnels; 3rd International Congress – Traffic and Safety in Road Tunnels – HBV-Verkehrsconsult, Hamburg, 18.-20. May 2005 in Hamburg