Upgrading of the Austrian Tunnel Risk Model TuRisMo
The Austrian Tunnel Risk Model TuRisMo (RVS 09.03.11)

- TuRisMo is a quantitative, system-based method focussing on mechanical accidents and fires (realistic scenarios)
- It fulfils the requirements of article 13 of the EU-Directive
- It allows the quantification and comparison of tunnel risks as well as the evaluation of effects of risk mitigation measures
- TuRisMo was developed on behalf of the Austrian Ministry of Traffic, Innovation and Technology, accompanied by a working group of experts
- It has been published in 2008 in the Austrian guidelines RVS 09.03.11
Introduction

Experience in application of TuRisMo (1)

application of model in general:

• It can be used in the published version for many Austrian road tunnels
• It was also applied for risk analysis studies in other countries (e.g. Slovenia, Slovakia, Croatia, Greece, Portugal); in particular in countries, which also apply the Austrian guidelines RVS for tunnel design
• Its application is easy (compared to other risk models)
• However, for some applications additional simulations are required (complex tunnels, complex ventilation)
• Due to the structure of the method there are limitations in its application, which became more and more relevant with the increasing use of the tool
Experience in application of TuRisMo (2)

Investigation of safety measures:

- Not all measures can be evaluated quantitatively
- In some cases specific information for quantitatively modelling the effects of a specific measure is lacking
- In some cases the effects of a specific measure cannot be modelled with the existing method
Main features of TuRisMo

**Probability calculation**

- Event tree approach for probability calculation, including a representative set of accident scenarios
- Scenarios differ in type of accident, vehicle involvement, involvement of DG and influence of fire

**Consequence estimation**

- Statistical approach for mechanical accidents (based on specific Austrian tunnel accident data)
- Combination of smoke propagation model (1D model) and evacuation simulation model for fires

**Results**

- Personal risk of tunnel users – expressed as expected value of the societal risk
- Shows shares of risk due to mechanical effects, fires and hazardous goods separately
Main features of TuRisMo

Structure of TuRisMo

Probability calculation – Input parameters
- Accident type
- Accident rates
- Traffic composition
- Traffic volume
- Scenario evolution
- Vehicle involvements

Damage values – Input parameters
- Tunnel type, ventilation system, emergency exits

Logical tree
- Initial event
- Accident scenarios

Results

Expected risk value (fatalities/year)
- Mechanical accidents (statistics)
- Fires (model results)
- Dangerous goods
- Mechanical accidents
Main features of TuRisMo

Limitations in the application of TuRisMo

- TuRisMo is a standardized method
- It provides characteristic damage values for tunnel accidents and tunnel fires for a set of model tunnels (in tables)
- These damage values were elaborated during the development of the method.

⇒ Hence the application of these standardized values requires that the investigated tunnel fulfills specific requirements (which were taken as a basis for their calculation)

- This is limiting the use of the model to tunnels which fulfill crucial requirements (e.g. for ventilation) which are defined in the guideline
- The limitations are in particular relevant for non-standard tunnels and for the investigation of specific ventilation problems
Particular problems in applying TuRisMo

**High longitudinal gradients**
- The model calculations for fire damage values were performed with low gradients (appr. 1 %)
- Tunnels with higher gradients: assumption that specification of the ventilation system covers influence of gradient (target values of ventilation design guideline are met)
  - Ventilation systems not fulfilling these requirements and specific (3D) effects of steep gradients cannot be investigated

**External influence on air-flow conditions in fires**
- The model calculations were based on standardized assumptions for the first phase of event (experience, expert judgement)
  - Traffic movements still taking place (bidirectional traffic) or specific meteorological effects (e.g. strong winds) are not covered
**Influence of tunnel cross section**

- The model calculations were performed with a 2-lane vaulted tunnel cross section.
- Recent research results show that there is a relevant influence of height, width, and shape of tunnel cross section on (fire) risk.

Influence of tunnel geometry (bidirectional tunnel)

- **Model tunnel:** 1.2 km bidirectional; 20,000 veh/d; longitudinal ventilation
- **Tunnel 1:** vaulted cross section
- **Tunnel 4:** rectangular cross section

*Influence of tunnel cross section on fire risk in a bidirectional tunnel with longitudinal ventilation* (research project “Sicherheitsbewertung RABT-konformer Tunnel” – Heimbecher, Kohl 2011)
Particular problems in applying TuRisMo

- **Complex tunnels / tunnel systems**
  - The model calculations were performed for tunnels with a continuous cross section and one ventilation system (longitudinal or smoke extraction)
  - Tunnels with changing cross sections, ramps or specific / combined ventilation systems cannot be handled with standardized methods – however, such tunnels often require a risk-based approach

- **Fire scenarios bigger than ventilation design fire**
  - The model calculations were performed for 5 MW and 30 MW fire scenarios
  - Real tunnel fires and fire tests show, that much bigger fires are possible
  - The specific effects of a fire scenario bigger than the ventilation design fire cannot be investigated
Particular problems in applying TuRisMo

- **Influence of specific safety measures**
  - The model calculations were based on standardized assumptions for the first phase of event
  - More detailed risk analysis showed that safety measures influencing this first phase of a fire can be very effective (e.g. by reducing the damage potential in the danger zone)
  - These effects cannot be handled with a standardized model
The Austrian Research Association Road-Rail-Traffic started a new research activity to improve the existing risk model.

**Fire risk:**

- The model shall be expanded to cover more relevant parameters in a more specific way
- The improved model and the conditions for its application shall be defined in a way that it can be applied directly for individual tunnels
- The new model shall be used to improve the standardized “old” model to enlarge its range of application as well
- The study shall also cover a systematic parameter study of relevant influence factors as well as an actualisation of the data base of the risk model (for mechanical accidents)
Scope and objectives of new research project

- **Implementation of a combined 1D / 3D smoke propagation model**
  - To cover all relevant (global and local) factors influencing smoke propagation in the tunnel

![Diagram showing influencing factors and implementation of a combined 1D / 3D smoke propagation model]
Implementation of an integrated evacuation simulation tool in the smoke propagation model

- The smoke propagation model calculates obscuration and concentration of toxic gases in dependence of time at 1.6 m height, transferring it directly into the evacuation model.
Features of integrated evacuation simulation tool:

- Reduction of evacuation grid to 1 dimension. This allows to reduce model complexity and computational demands while the loss of precision is minimal.
- Direct data transfer for higher precision and optimisation of work flow.
- Accumulation model by D. A. Purser to calculate the accumulated doses of toxic gases and their effect on human physiology.
- Definition of representative populations with different types of agents.
- Shift of fire location vs. configuration of emergency exits (big influence on the calculated number of victims).
- Increase the total number of scenarios – covered the risk analysis (fire locations in the tunnel, traffic scenarios) better and more representative results.
Scope and objectives of new research project

Enhanced use of statistical traffic data:

- So far the fire risk damage values were calculated on the basis of the AADT, hence for an average situation
- It is envisaged to take at least 3 different traffic scenarios into account (for low, average and high traffic situations)
- These values shall be defined on the basis of statistical traffic data of one complete year
- This approach allows to take effects into account which directly depend on the traffic situation
Outlook

• The development of the new risk model is almost completed
• The combined smoke propagation model and integrated evacuation simulation have been successfully tested (in test calculations as well as in specific applications for individual tunnels for specific tunnels)
• The new model works and delivers comparable results to the existing model.
• As a next step, systematic parameter studies will be performed to investigate the influence factors addressed more in detail
• The final step will be the modification and completion of the standard damage values of RVS 09.03.11 and the documentation of the new model in the updated guideline
• The project shall be finished by end of 2012
RVS 09.03.11 –
Upgrading of the Austrian Tunnel Risk Model TuRisMo

Thank you for your attention!

contact:
rudolf.hoerhan@bmvit.gv.at

DI Rudolf Hörhan
BMVIT, Radetzkystraße 2, 1030 Vienna, Austria