CAPABILITY STATEMENT

Safety Management and Civil Security of Transport Infrastructure
Safety Design

in the Light of the Expectations of Modern Society

The expectations of modern society regarding safety and reliability of technical systems are high. It is thus generally assumed that these systems work failure free and do not pose any hazard to life, health, environment or material assets.
Upon closer scrutiny, this absolute demand for safety proves to be unrealistic. In practice, there is a steady need for sensitive decisions on the acceptability of different risks as well as on the selection of adequate safety measures.

Safety design deals with such risks in a systematic way and develops concepts for preventing and mitigating them, but also for managing the residual risks.

Safety design is increasingly subject to a divergence between high safety demands on one hand and limited funds available for safety on the other hand.

In this challenging context, it is the mission of safety design to actively address safety issues in all their complexity and to provide rational decision support to those in charge. Moreover, it means providing assessment criteria for sensitive, safety-relevant decisions.

Delivering solutions to a great array of challenging safety assignments is an area, where ILF has been able to make its mark as one of the leading European engineering consultancy firms during the last decades, especially with respect to road and rail tunnels as well as underground rapid transit and other traffic infrastructure projects.

ILF’s competence is based on many years of activities, comprehensive international project experience and intensive Europe-wide contacts to experts and authorities as well as to institutions responsible for the continuing development of this specialist field.

Safety is a multidisciplinary and multifaceted matter involving many fields of expertise. In this regard, ILF profits from its interdisciplinary set-up where experts from various disciplines are available under one company roof (e.g. road engineering, rail engineering, tunnelling, tunnel ventilation, tunnel equipment, etc.).
Strategic Safety Design

Safety management tasks can be related to many different applications in an organisation including the definition of procedures, methods and responsibilities as well as control and continuous feedback for safety relevant topics. Typical applications are the development of safety relevant processes or decision-making related to safety topics.
ILF was responsible for the development and application of various risk-based decision models for safety-relevant measures concerning the Austrian railway network.

**Selected references:**

- Safety-based model for the development of a strategy for the upgrading of train control systems in the Austrian rail network (ETCS migration plan).
- Development of a method to prioritise operating strategies for railway stations.
- Development for a risk-based approach for evaluating active protection measures for shunting stations.
- Development of a risk-based approach for the assessment of low-level train control systems.

**Integrated safety and maintenance design of rail infrastructure**

Safety design and maintenance design of rail infrastructure are closely linked. This applies to open railway sections as well as tunnels. Operating permit and hand-over of the infrastructure to the operator require a comprehensive concept addressing safety, maintenance and operation issues and their interactions in an integrated approach. As regards operation, tunnels are often key infrastructure elements, as many tunnels can only be accessed via the tracks and many safety devices require short maintenance intervals. At the same time, rules on rail operation during maintenance work are restrictive. Thus the interval and duration of maintenance activities may severely restrict the availability of a tunnel.
Selected references:

- Maintenance concept for the new Wien/Meidling-St. Pölten high-speed railway line of the Austrian Federal Railways (ÖBB):

As part of a working group consisting of representatives of different organisational units of ÖBB, ILF prepared a maintenance concept for the entire railway (including 7 tunnels) focusing on the operational consequences.

- Compilation of a guideline on “bundling & timing” for the Austrian Federal Railways (ÖBB):

“Bundling & timing” (Bündeln & Takten) refers to the optimisation of inspection and maintenance works in terms of operational consequences. The guideline specifies the transsectoral approach for planning and implementing “bundling & timing” of inspection and maintenance works and provides the necessary basis and tools.

- Koralm Tunnel (33 km) and Semmering Base Tunnel (27 km), both in Austria: development of a maintenance concept for submission to the railway authority including the following tasks: estimation of operational restrictions caused by maintenance works, including considerations on possible maintenance centres, development of operational concepts to be applied during maintenance works.

Safety documentation for road and rail tunnels

The safety documentation contains a description of all preventive and safeguarding measures required to ensure the safety of the users. The requirements to be met by the safety documentation depend on whether a tunnel is in the design phase, the start-up phase or the operating phase. During the design phase, the focus is on the infrastructure and the traffic, while it moves towards aspects of operational procedures, emergency response and operational feedback during the operating phase.

Selected references:

- Tunnels along the new Vienna-St. Pölten high-speed railway line, Austria: preparation of safety documentation for the start-up of 7 tunnels, including documentation for fire brigade use in case of emergencies.

- Rail tunnel for suburban train lines S60 and S80, Vienna, Austria: preparation of the safety documentation for the start-up including the below-ground stations “Wien Hauptbahnhof” and “Wien Quartier Belvedere”. The assignment also included computing the evacuation duration in the platform areas as well as preparing the documentation for fire brigade use in case of emergencies.

Activities as authorised experts

ILF specialists are engaged in various safety areas as authorised experts in approval procedures, e.g. in traffic safety audits or commissioning procedures of road tunnels. Conducting traffic safety audits requires appropriate training and relevant experience in road safety matters. Several ILF employees are certified traffic safety auditors.

Selected references:

- Norra Länken, Sweden; complex underground tunnel system as part of the northern motorway ring of Stockholm; international expert assignments for fire and life safety and evacuation in the start-up phase.

- A14 Motorway, Conversion of Hörbranz Customs Area, Austria: road safety audit for the permit application design.

- A14 Rheintal/Walgau Motorway, expansion of the unidirectional junction at Klaus-Koblach, Austria: road safety audit for the permit application design and the detailed design. Final check (road safety audit /inspection) of the detailed design

- A14 Motorway, Bludenz-Bürs Access Point, Austria: road safety audit for the preliminary design and permit application design.
Integrated Safety Concepts for Road and Rail Tunnels

The tunnel safety concept is the ID card of a tunnel in terms of safety. It integrates all safety-relevant investigations as well as all construction, equipment, operation and management tasks into an overall concept for a given tunnel. From the beginning of the planning and design process until the operating phase, the tunnel safety concept is developed step by step and focusses on the following issues:
System design of long/complex rail tunnels

System design of long and/or complex rail tunnels requires integrated safety design in an early design phase. Based on the basic safety requirements, it encompasses the conceptual design of the entire system of a complex rail tunnel, such as the number of tubes and the configuration of cross passages, crossovers, emergency stations, emergency exits and set-up of the ventilation system. This design step includes comparing different system alternatives and providing decision support based on multi-criteria assessment methods, taking costs, maintenance, safety and operation into account.

Selected references:
• Wienerwald Tunnel, Austria: comparison of different tunnel systems for a 13 km rail tunnel taking safety, maintenance, operation, construction process and construction cost into account.
• Koralm Tunnel, Austria: tunnel system definition and in-depth system development of a 33 km rail tunnel including emergency station and cross-overs, rescue concept, scenario-based analysis of emergency response.
Risk Analyses

Risk analyses comprise a broad range of services, including simple qualitative analyses as well as detailed and complex quantitative investigations. In the first case, the aim is to identify potential hazards and to assign them to risk categories. In cases requiring a deeper understanding of the extent of the risk and control options, a quantitative risk analysis (QRA) can provide tangible and detailed results.
Road tunnel risk analyses

EC Directive 2004/54/EC demands that each EU country develop and apply quantitative risk analyses. In case of tunnels with special characteristics and/or deviations from the requirements of the Directive, these analyses are applied in order to confirm that the tunnel is sufficiently safe. Furthermore, risk analyses are often used as a decision-support tool during the design phase or during refurbishment of existing tunnels. Risk analyses are often combined with cost-benefit considerations.

ILF uses different risk models, which are applied depending on the assignment and the client’s requirements:

- Austrian Tunnel Risk Model TuRisMo (according to RVS 09.03.11)
- German risk model for road tunnels (according to Research Report FE 03.0378/2004/FR8):
- Slovakian risk model for road tunnels (according to Guideline TP 02/2011).
- Different methods for scenario-based risk analyses, e.g. for detailed smoke propagation studies, self-rescue behaviour or measures for emergency response.

The Austrian Tunnel Risk Model was published for the first time in 2008 and updated in 2014 (TuRisMo 2). TuRisMo 2 exists in two versions, the standard model and the extended model. The latter includes detailed analyses of fire risk, based on the specific smoke propagation characteristics of a tunnel.

- German risk model for road tunnels (according to Research Report FE 03.0378/2004/FR8):
- Slovakian risk model for road tunnels (according to Guideline TP 02/2011).
- Different methods for scenario-based risk analyses, e.g. for detailed smoke propagation studies, self-rescue behaviour or measures for emergency response.

Selected references:

- Karawanken Tunnel, Austria/Slovenia: investigation of short- and long-term measures for enhancing the safety level during the refurbishment of this 7.9 km cross-border motorway tunnel
- Cholfirst and Fäsenstaub Tunnels, Switzerland: quantitative risk analysis of two urban bidirectional motorway tunnels according to German methodology including cost-benefit analysis. The QRA served as decision basis for selecting one of the safety equipment options (optimisation of the ventilation system and evacuation paths).
- Risk analysis of Slovenian motorway tunnels: specific hazard analysis and QRA according to RVS 09.03.11 including assessment of measures and recommendations for 16 tunnels on the Slovenian motorway network.
- Tunnel Oswaldiberg, Austria: quantitative risk analysis applying TuRisMo 2 for the evaluation of bidirectional traffic during refurbishment (incl. identification and assessment of additional risk mitigation measures).
Risk analyses for the transport of dangerous goods (DG)

The international regulations on dangerous goods transport on roads (ADR) provide for the possibility of limiting the transport of certain substances through tunnels. For this purpose, it is required to categorise tunnels based on a risk analysis. The scope includes the analysis of individual tunnel objects including a cost-benefit assessment as well as the examination of alternative transport routes. For each individual case, the choice of method is closely linked to the applicable benchmark (multi-step assessment approach with absolute and relative assessment criteria).

ILF is currently using the following models:

• Dangerous goods transport model DG-QRAM (OECD/PIARC model) and DG-QRAM Switzerland

• German method for categorising road tunnels and German dangerous goods model (according to research reports FE 03.0437/2007/TRB and FE 86.0050/2008)

Selected references

• Heidkopf Tunnel, Germany: detailed DG risk analysis of a 1.7 km motorway tunnel with high traffic volume for the categorisation according to ADR tunnel regulations based on the German methodology for risk assessment of DG transports in road tunnels.

• Hansastrasse and Sterrenberg noise protection sheds (570 and 630 m), Wupperal, Germany: detailed DG risk analysis for motorway shed structures with high traffic value for the categorisation according to ADR tunnel regulations based on the German methodology for risk assessment of DG transports in road tunnels.

Rail tunnel risk analyses

There are no guidelines specifying risk analysis methods for rail tunnels. However, many methodological components developed for road tunnels can be adapted to the situation in rail tunnels. In addition, qualitative methods are being used, e.g. for comparative assessments of deviations from guidelines.

Selected references:

• Great Belt Tunnel, Denmark: QRA of a 8 km twintube rail tunnel

• Koralm Tunnel (33 km) and Semmering Base Tunnel (27 km), Austria: qualitative risk analysis based on specific safety objectives; detailed analysis of the distance between emergency exits and the design of the emergency stations (evacuation simulation), investigation of operational routines for emergency response.

Risk-based approaches for special tasks

Qualitative and quantitative hazard and risk analyses can be applied to various problems concerning traffic infrastructure, industrial facilities or other technical systems. Individual solutions for special safety-related tasks can be developed by adapting established risk analysis methods. Broad methodological knowledge and the experience of ILF facilitate custom-made solutions for all types of applications.

Selected references:

• Risk-based planning of groundwater protection measures against hazardous releases on transport routes. For this task, ILF developed a risk-based assessment model that is applied to Austrian railway lines on a broad basis.

• Assessment of the risk of a train crash into bridge piers based on UIC Codex 777-2E. The method aims at estimating the risk to humans due to a train crash into bridge piers following derailment near structures built over railway lines and to estimate and assess the effectiveness of safety measures on a quantitative basis.
In order to assess safety during fire events, it is essential to obtain a clear understanding of fire development and smoke propagation. In the case of complex underground structures (e.g. underground stations, tunnel bifurcations) or tunnels with special characteristics (e.g. high longitudinal gradient), simulations based on fire and smoke propagation models are indispensable for any well-founded safety assessment.
Depending on the task, one dimensional (e.g. NumSta) or three dimensional transient CFD simulation models (e.g. FDS) or a combination of both are applied. These simulations allow making precise statements on smoke propagation as a function of time and fluid-dynamic boundary conditions. In the extended Austrian tunnel risk analysis model, these simulations are the key element of determining the fire risk.

**Selected references**

- Branisko Tunnel, Slovakia: analysis of the effects of a reduced smoke extraction capacity at the near-portal tunnel sections on smoke propagation for different traffic scenarios for a 4.9 km bidirectional tunnel.
- Kaisermühlen Tunnel, Vienna, Austria: 2.1 km high-traffic urban motorway tunnel with several access points to the Viennese road network; investigation of the safety-relevant effects of a refurbishment and adaptation of the ventilation system as part of a risk analysis.

### Evacuation simulations

An evacuation simulation allows to investigate the possibilities and the flow of evacuating a large number of persons from buildings or underground traffic facilities based on the case-specific boundary conditions. Depending on the task, one- or three-dimensional evacuation models are applied (e.g. buildingEXODUS, FDS-Evac). This makes it possible to carry out the following types of analyses:

- Computation of evacuation times taking the behaviour and properties of a group of persons and the environmental conditions (e.g. smoke) into account.
- Analysis of critical spots (e.g. doors or stairs)
- Investigation of the possibility to optimise the design of the structure and/or organisational measures
- Analysis of different escape routes or emergency exit distances in buildings and underground traffic facilities
- Quantification of fire risk in combination with smoke propagation simulations

**Selected references:**

- Linz Central Station, Austria (multiple-level transport hub with trains, tramways and busses): evacuation simulations of the below-ground facilities (software: buildingEXODUS). Sensitivity analyses of non-availability of escape routes, definition of requirements to be met by the design of stairs and exits
- Underground metro station “Altes Landgut” on the metro line U1, Vienna, Austria: evacuation calculation by means of an analytical approach and evacuation simulation by means of FDS-Evac.
Emergency plans

Emergency plans define the necessary measures for emergency response. The plans are coordinated with the relevant organisation units of the operator and the affected emergency response organisations (police, fire brigade, rescue services) as they are being developed.

ILF provides the following services:

- Definition of the operational measures for emergency response
- Establishment of an organisational plan for emergency response in cooperation with emergency response organisations (alarm and response plan)
- Compilation of plan documents to be used in case of an incident (plans for fire brigade use, tunnel system plans, etc.)

Emergency exercises

Emergency exercises serve to test and train the smooth interaction of the measures defined in the emergency plans; knowledge gained during the exercises is incorporated into the emergency plans.

ILF provides the following services:

- Development of exercise assumptions (emergency scenarios)
- Participation, analysis and documentation of emergency exercises
- Debriefing together with the involved emergency response units and joint definition of possible improvement measures.

Selected references:

- Transalpine Oil Pipeline, Austria/Italy: organisation of emergency exercises for the interaction of external and company response units in case of incidents/emergencies.
- Local Traffic Hub in Graz, Austria (underground tram and bus station at Graz Central Station): preparation of emergency plans for the construction and operating phases, conduct of a large-scale exercise with several emergency response organisations.
Development of Methods and Research

Apart from providing classical consulting services, ILF is actively involved in developing methods and guidelines for tunnel safety and security. In addition, ILF has participated in a number of international research projects on tunnel safety and other risk-related areas.

Selected references:

- Development of the Austrian road tunnel risk model (RVS 09.03.11 “TuRisMo”)
- EU research project AllTrain (funded by a CIPS Action Grant): preparation of an all-hazard guide for transport infrastructure.
- EU research project SECMAN (funded by a CIPS Action Grant): preparation of a security risk manual for road bridges and tunnels with respect to sabotage and terrorist activities.
- Research project on the assessment of the technical and cost effectiveness of fixed fire-fighting systems in road tunnels for BASt (Federal Highway Research Institute), Germany; the research project takes the interaction with tunnel user behaviour into account and includes an assessment of possible compensation effects.
- Member of the Technical Committee C 3.3 “Road Tunnels Operation” of the World Road Association (PIARC) and chair of Working Group 2 “Feedback from Experience on Tunnel Safety.”
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