

IABSE WORKSHOP ON RISK ACCEPTANCE RISK-BASED DECISION-MAKING IN TUNNEL

B. KOHL | 19-20/06/2023





RISK-BASED DECISION-MAKING IN TUNNEL SAFETY

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ROAD TUNNEL SAFETY – GLOBAL VIEW

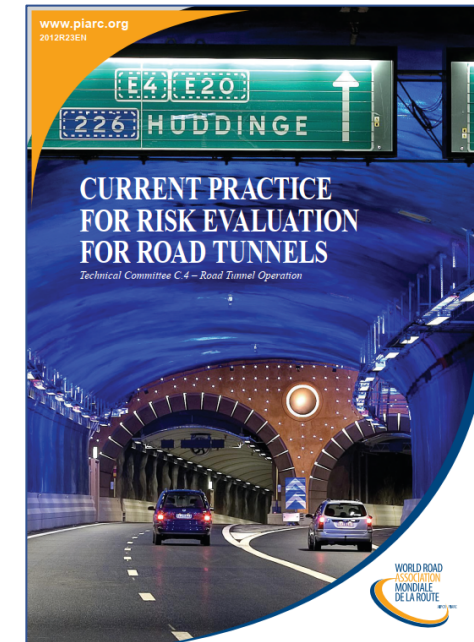
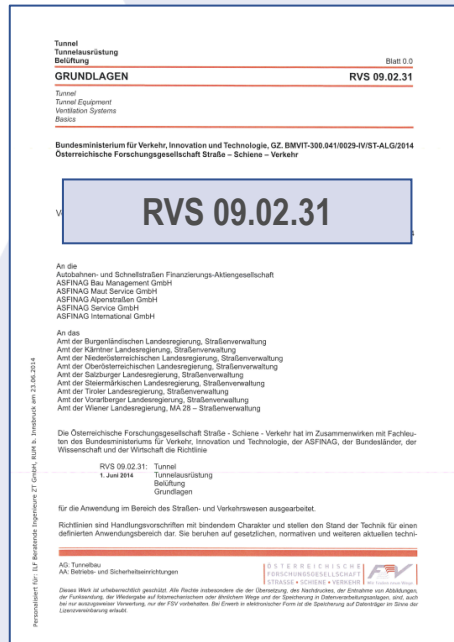
ROAD TUNNEL SAFETY – REGIONAL PERSPECTIVE

» Countries with a long history in tunnels

- ↳ Developed their own national guidelines (several European countries, North America, Japan, ...)

» Countries with little /no experience in tunnels

- ↳ No own guidelines
- ↳ Typically refer to guidelines from other countries or to PIARC documentation
- ↳ often confusing or even contradictory requirements



ROAD TUNNEL SAFETY – GLOBAL VIEW

ROAD TUNNEL SAFETY – HISTORICAL PERSPECTIVE

In the past:

» Tunnel safety implicitly included in prescriptive national guidelines – by defining a certain technical standard for tunnel structure & equipment

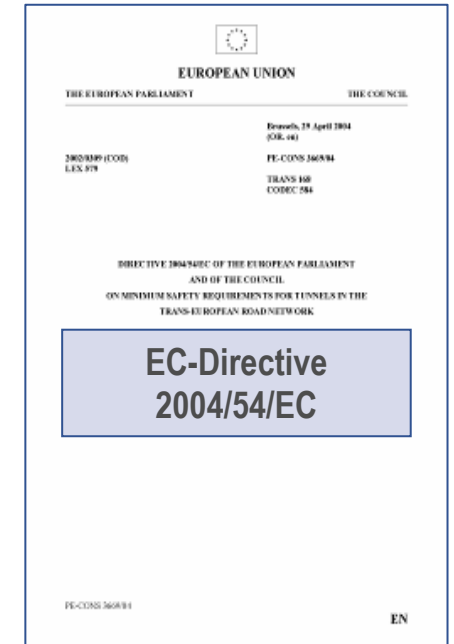
In 2004:

» EC-Directive 2004/54/EC (in Europe)

- ↳ Definition of mandatory minimum safety requirements – initiating a harmonisation of national guidelines; national guidelines typically are stricter than minimum safety requirements
- ↳ Implementation of risk assessment as new tool for road tunnel safety management – at national basis

Now:

» Several different “national” risk assessment methodologies are used in different national regulatory environment, some of them also internationally



ROAD TUNNEL SAFETY – BASICS

PRESCRIPTIVE VERSUS RISK-BASED APPROACH

Prescriptive approach	Risk based approach
<p><i>A tunnel is safe if it is designed in line with valid regulations</i></p>	<p><i>A tunnel is safe if it meets predefined risk criteria</i></p>

- » Technical specification of safety features of a tunnel
- » Standardisation of design, easy to implement, but quite rigid
- » Traffic characteristics, operational issues, user behaviour, residual risk ... many aspects not addressed

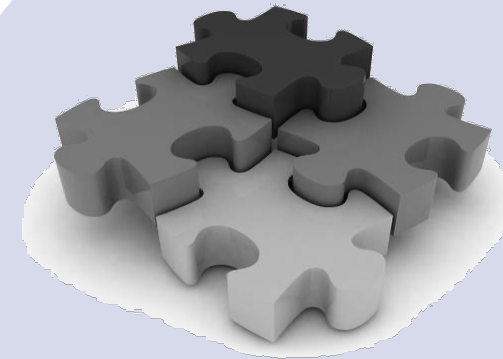
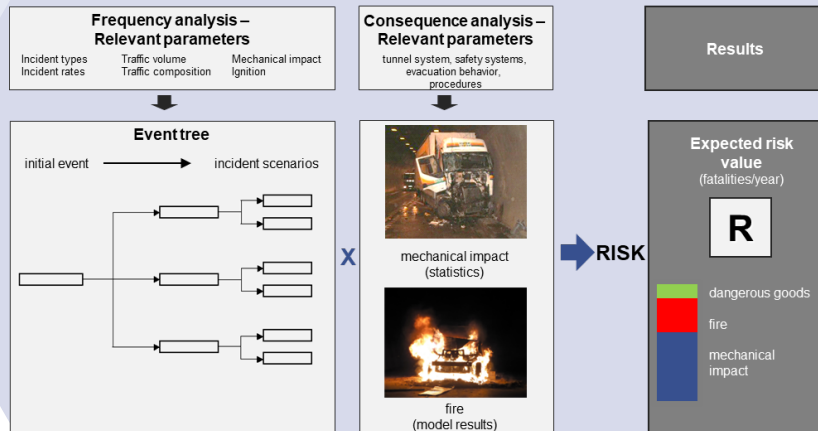
- » Structured, harmonised and holistic safety analysis as basis for decision making
- » Consideration of specific characteristics of a tunnel, much more flexible
- » Quantitative evaluation of residual risk / of effects of safety measures

ROAD TUNNEL SAFETY – BASICS

PRESCRIPTIVE VERSUS RISK-BASED APPROACH

§ Legal / regulatory environment

Risk Assessment Approach

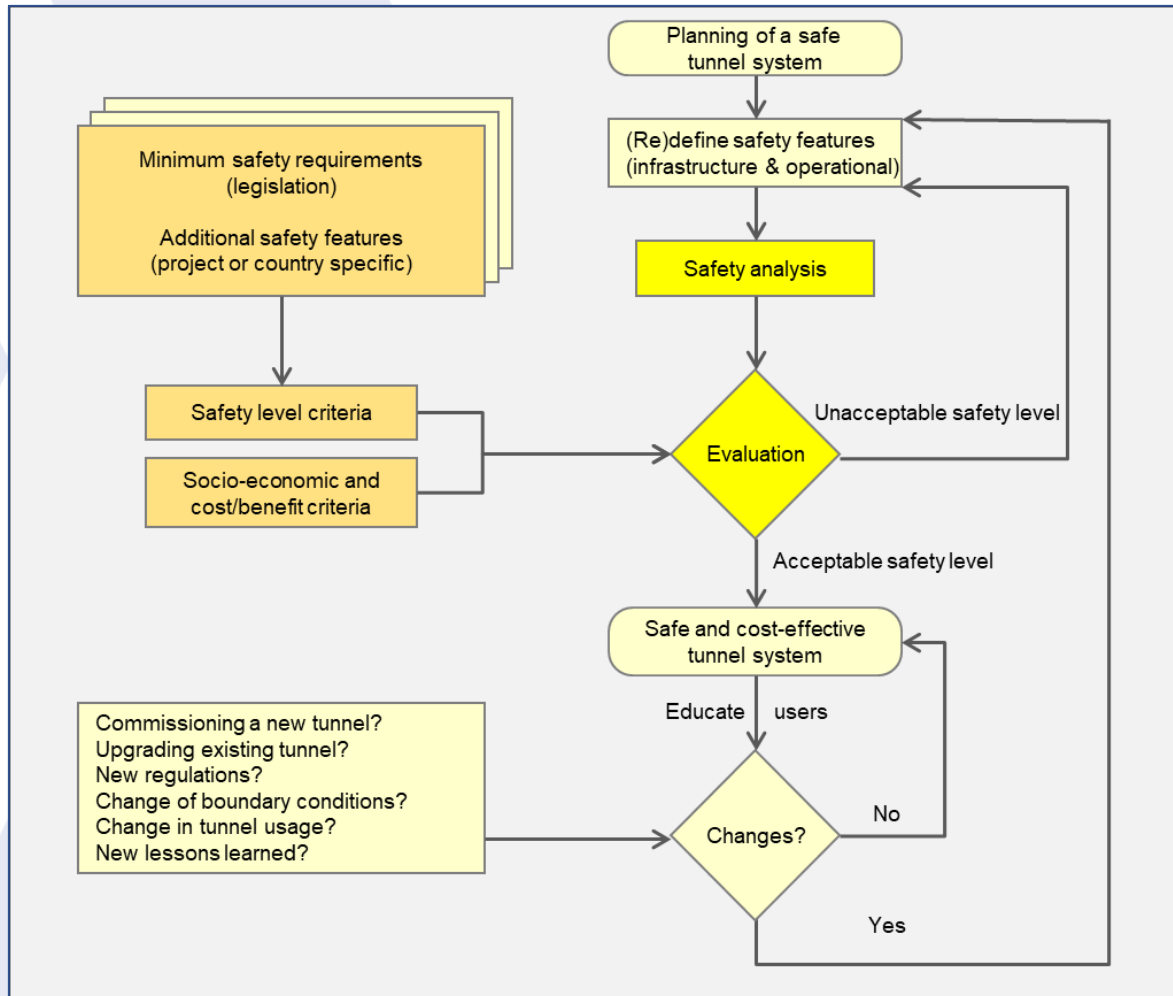


“Prescriptive approach and risk based approach have to be used as complementary elements of the safety assessment process.”

(PIARC Report 2012R23,
Current Practice for Risk Evaluation for Road Tunnels)

ROAD TUNNEL SAFETY – BASICS

INTEGRATION OF RISK-BASED APPROACH INTO TUNNEL LIFE CYCLE

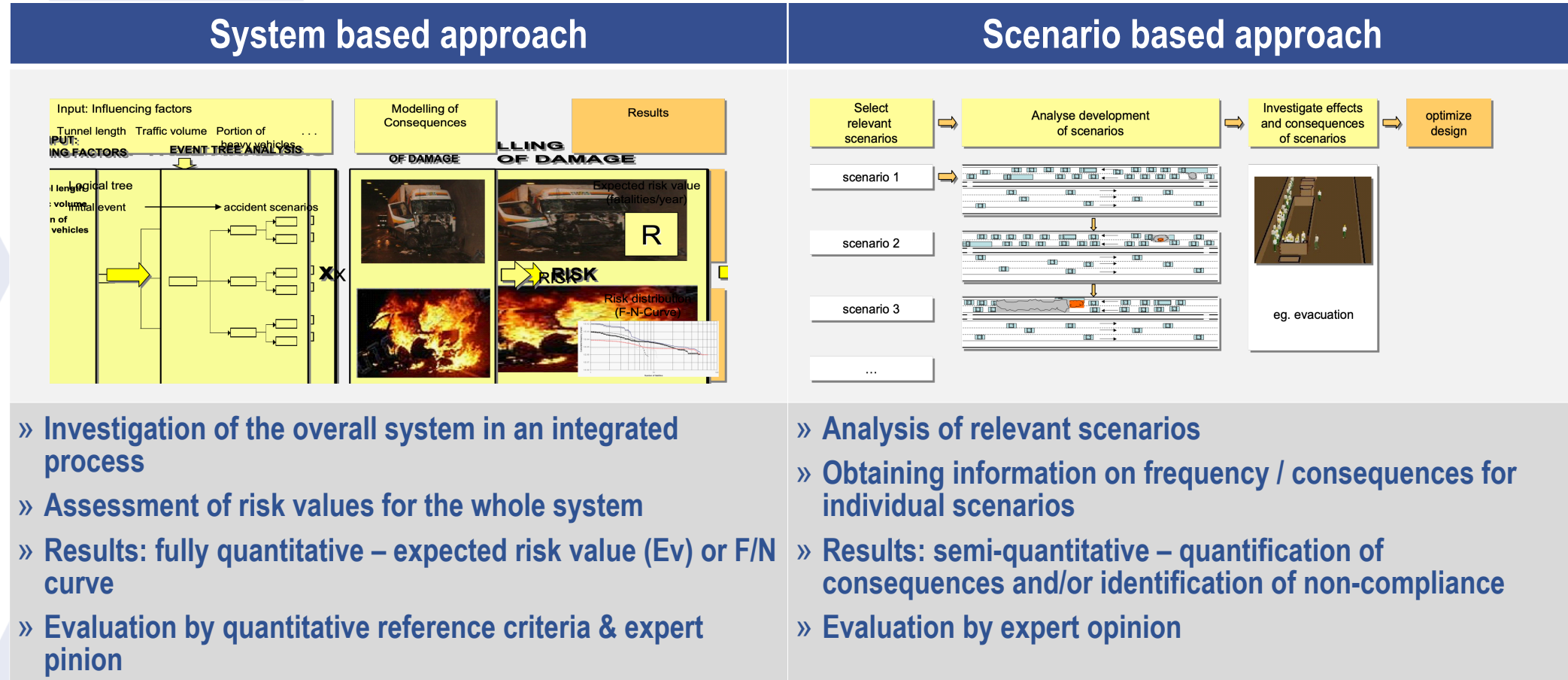


Implementation of safety criteria & socio economic criteria into safety evaluation throughout the life cycle of a tunnel

(PIARC report 2007R07, Integrated Approach to Road Tunnel Safety)

RISK ASSESSMENT – METHODS

SYSTEM BASED / SCENARIO BASED APPROACH



RISK EVALUATION - PRINCIPLES

» Relative risk evaluation approach

- ↳ Quantitative risk profile of existing state of a tunnel is compared to a reference state which is representing a sufficient level of safety
- ↳ Typical approach for system-based risk assessment methodologies (e.g. in Austria, Germany) and for alternative route comparisons in DG-transport

» Absolute risk acceptance criteria

- ↳ Quantitative risk profile of a tunnel is compared to absolute threshold values
- ↳ Applied in countries with legally defined risk thresholds (e.g. in the Netherlands) and for DG-transport through tunnels (first stage in multistage assessment process)

» Expert opinion

- ↳ Independent expert, nominated by the administrative authority, evaluates the semi-quantitative risk assessment results
- ↳ Typical approach for a scenario-based risk study (e.g. in France)

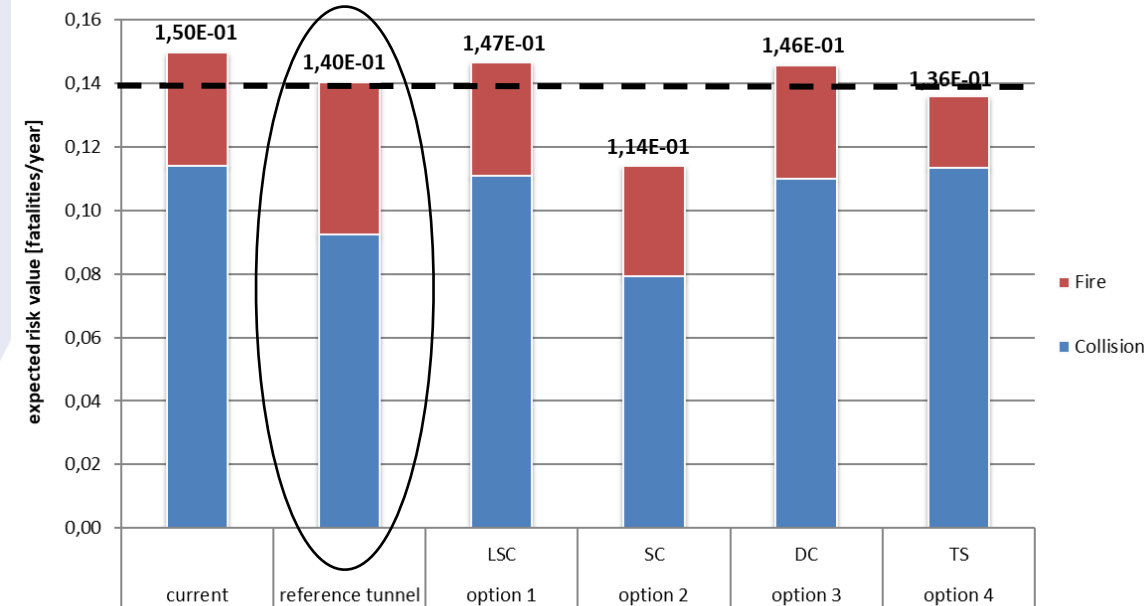
» ALARP principle

- ↳ It needs to be demonstrated that all “reasonable” safety measures have been implemented;
- ↳ what is reasonable? Can be combined with willingness to pay approach

RISK EVALUATION - PRINCIPLES

RELATIVE RISK EVALUATION APPROACH – EXAMPLE: AUSTRIA

- » Regulated in Austrian Guideline for Tunnel Risk Analysis RVS 09.03.12
- » Reference tunnel must fulfil minimum safety requirements according to Road Tunnel Safety Law (corresponds to EC-Directive) - requirements less strict than in the Austrian design guidelines -> certain flexibility
- » For some critical parameters of this reference tunnel standardised specifications are provided, e.g.



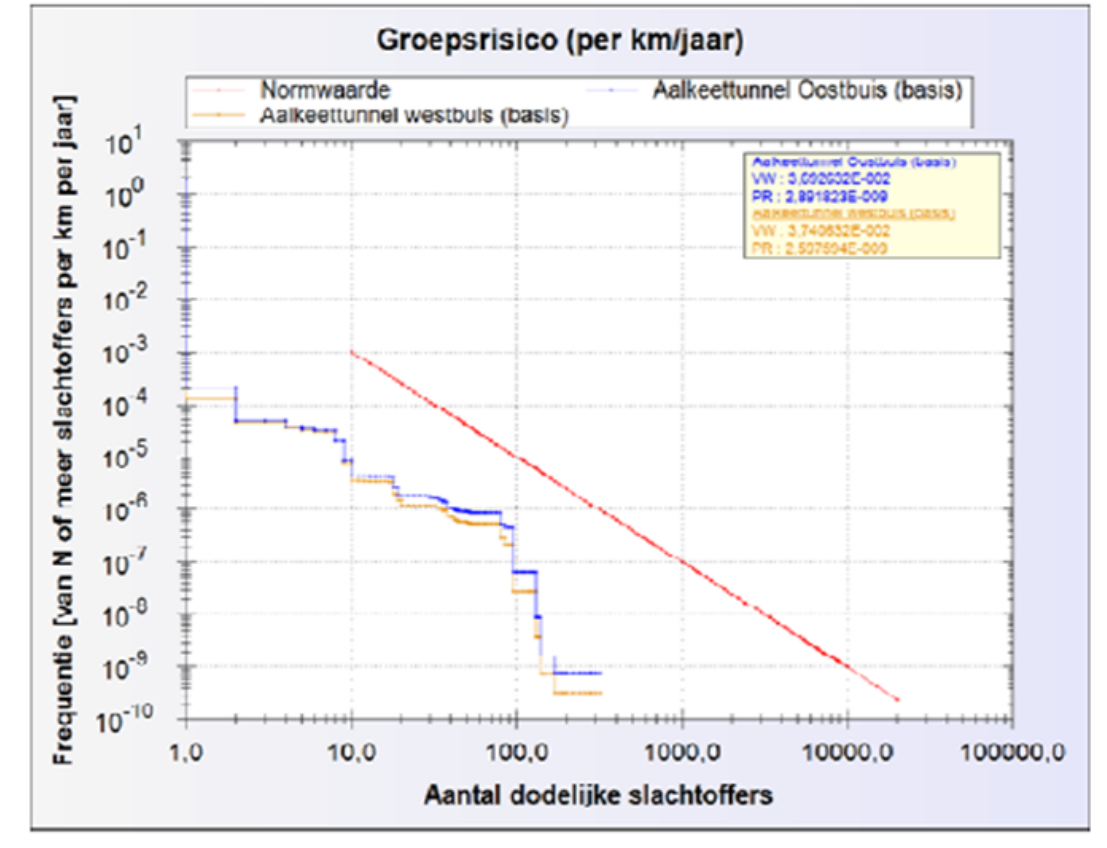
- ↳ No congestion
- ↳ Reference values for traffic composition & some other parameters on the basis of definitions in the EC-Directive (e.g. 15% HGV)
- ↳ Ventilation system: according to principles defined in the EC-Directive, but technical standard (layout, performance, operation etc.) according to Austrian design guidelines
- ↳ Speed: 100 km/h for unidirectional tunnels, 80 km/h for bidirectional tunnels

RISK EVALUATION - PRINCIPLES

ABSOLUTE RISK ACCEPTANCE CRITERIA – EXAMPLE: NETHERLANDS

- » Risk acceptance curve defined in Dutch Tunnel Safety Law
- » Applicable to DG risks and risks of major fires (≥ 10 casualties) – hence limited to low probability / high consequence incidents
- » Risk acceptance criteria defined per km (tunnel length) and year; with a negative square coefficient for risk aversion
- » Rijkswaterstaat Tunnel Risk Model QRA 2.0 must be used (software is annex to corresponding tunnel regulations)
- » Many parameters in Dutch tunnels are standardised, hence most of the tunnels are very similar (unidirectional traffic, longitudinal ventilation, high traffic load, similar technical equipment)

Afbeelding 3.1. Berekende groepsrisicocurve Aalkeettunnel



DISCUSSION & PERSONAL VIEWS

- » I see two different ways of how to apply QRA for road tunnels
 - ↳ For a clearly defined purpose, with a strictly national regulatory background: method, application rules & risk evaluation approach are regulated, many parameters are standardised
 - ↳ In a wider context - for risk-based decision making in general (e.g. in countries without own guidelines, or for specific tasks, like decision on additional mitigation measures, combined with cost-benefit considerations): selection of method + risk evaluation approach according to subject
- » QRA method and risk evaluation approach are not independent – e.g. an absolute evaluation approach is linked to a specific method (e.g. DG-QRAM) and requires the standardisation of relevant parameters (see e.g. the Dutch example)
- » A relative risk evaluation approach is much more flexible: for many use cases a plausible reference case can easily be found – everywhere, also in countries without own tunnel regulations
- » A relative approach establishes a link between prescriptive requirements and the risk-based approach, by “translating” the not tangible safety level of a “safe” tunnel (= in line with regulatory requirements) into a quantitative risk profile
- » A prerequisite for an absolute approach is the existence of broadly accepted quantitative acceptance criteria; if these are not existing yet (e.g. in the legal environment) it is a big challenge to establish them (e.g. when updating the German methodology this approach was eliminated, because it was never put into practice)

DISCUSSION & PERSONAL VIEWS

- » A relative approach is less sensitive to the fuzziness which is inherent in all risk assessment methodologies
- » Quantification of risk is always helpful, because it gives a feeling for the influence of certain parameters and the effects of certain measures; however, sometimes quantitative results are misinterpreted as precise figures, even by experts
- » Quantitative risk evaluation should be seen as a tool and an expert opinion is always needed additionally, to interpret results in a proper manner
- » However, a mere expert opinion approach opens room for biased and arbitrary decisions
- » A well-thought combination of relative & absolute elements can be quite useful (see e.g. the Austrian one, where a relative approach is used for decision making, on the absolute risk of a tunnel is used to define the level of tunnel equipment in the technical design guidelines)

Table 1: Risk classes

Expected risk value		Risk classes
Under limit	Upper limit	
	0.02	<i>I</i>
0.02	0.1	<i>II</i>
0.1	0.5	<i>III</i>
0.5		<i>IV</i>