

Risk Acceptance Criteria

Engineering methods and practical examples .. and beyond

**JCSS & IABSE Workshop on Risk Acceptance Criteria
in Civil Engineering Decision Making**

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Trondheim 20.06.2023 - 9:15: 9:50

Overview

- Exploring Legal Aspects in Society and Decision Making
- Illustrative Cases from Engineering Practice
 - An examination of risk assessment in tunnels, utilizing the explicit application of the marginal life saving principle.
 - Demonstrates the assessment's effectiveness in determining appropriate safety measures.
 - Highlighting the practical application of the marginal life saving principle to establish the satisfactory safety level of an existing bridge.
 - Emphasizes the principle's ability to provide assurance in maintaining structural integrity.

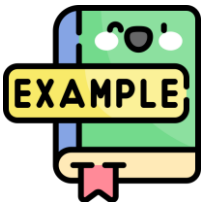
Acceptance criteria and law



When developing acceptance criteria for public administration it is essential to ensure that the acceptance criteria are in accordance with legislation, taking into consideration of:

1. Equality before the law

- Dictates that similar cases should be treated equally
- Distinction can be made only when relevant facts significantly differ



- *A tunnel with 50'000 vehicles may be treated differently from one with 5'000 vehicles per day.*
- *In a hall with 10'000 visitors, other fire protection measures can be ordered than in the same hall if only non-combustible materials are stored.*

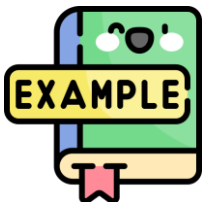
Acceptance criteria and law



When developing acceptance criteria for public administration it is essential to ensure that the acceptance criteria are in accordance with legislation, taking into consideration of:

2. Proportionality

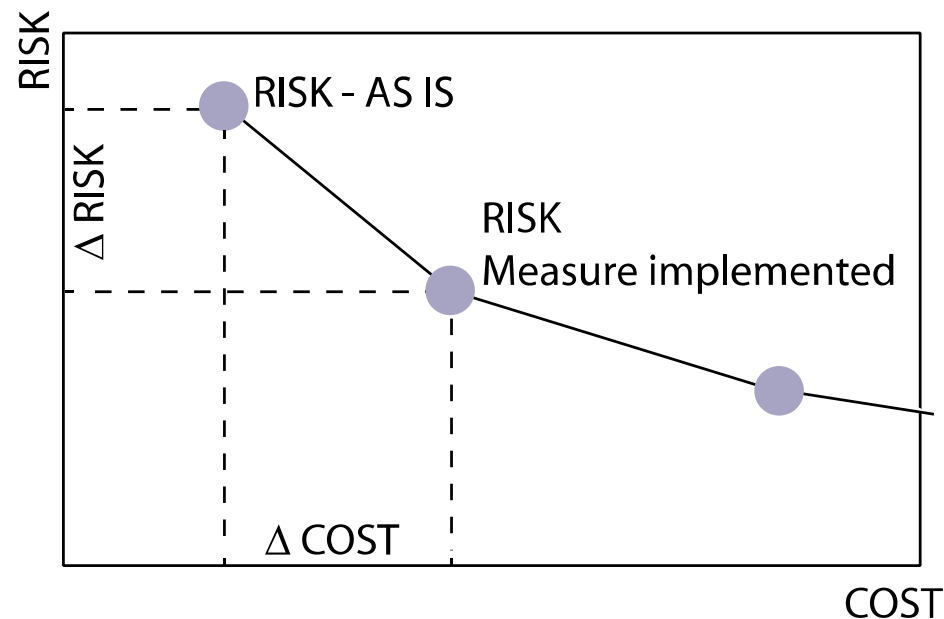
- Means something should be moderate or proportionate in relation to circumstances
- Aims to protect individuals from excessive government regulations
- Contributes to a balanced realization of the common good
- Proportionality prevents excessive demands for safety measures.
- Some constitutions explicitly mention the principle of proportionality (e.g., Article 5, paragraph 2 of the Swiss Constitution)
- In other constitutions, it is considered an unwritten principle



- *Building a new safety tunnel and reducing the distance to emergency exits to 200m may be proportionate in a tunnel with 100,000 vehicles/d but not in a tunnel with 2,000 vehicles/d.*

ALARP

- ALARP principle aligns with proportionality, promoting balanced and reasonable risk reduction.
- ALARP respects “Equality before the Law”, treating similar cases equally.
- Marginal live saving cost principle ensures cost-effectiveness in risk management.
- Consistent risk evaluation and decision-making avoid arbitrary or discriminatory treatment.



$RISK < \max RISK$
&
 $\Delta RISK > \Delta COST$

ALARP

In Switzerland, the ALARP (As Low As Reasonably Practicable) principle has been widely implemented in various areas, including:

- *SIA 269 - Assessment of existing structures*
- *ASTRA 19004 - Tunnel risk assessment*
- *Swiss fire protection regulations 2026 (under development)*
- *Natural hazard management*

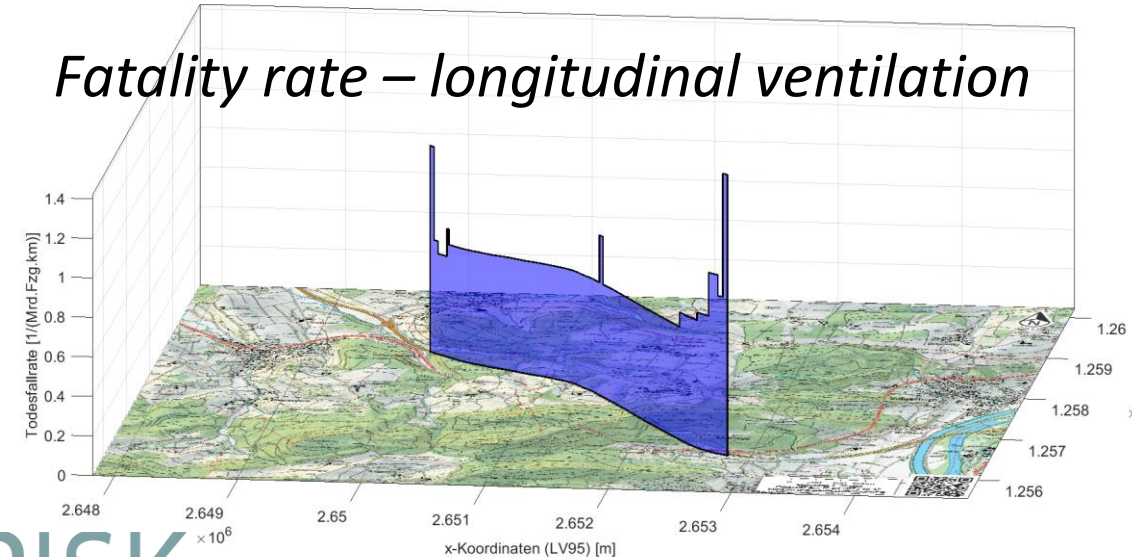
- Over the past 15 years, the ALARP principle has demonstrated its practicality and usefulness in various projects.
- It provides a solid basis for decision-making processes.
- Allows for a comprehensive assessment of risks while considering practical constraints.

Tunnel Risk assessment: ASTRA 19004

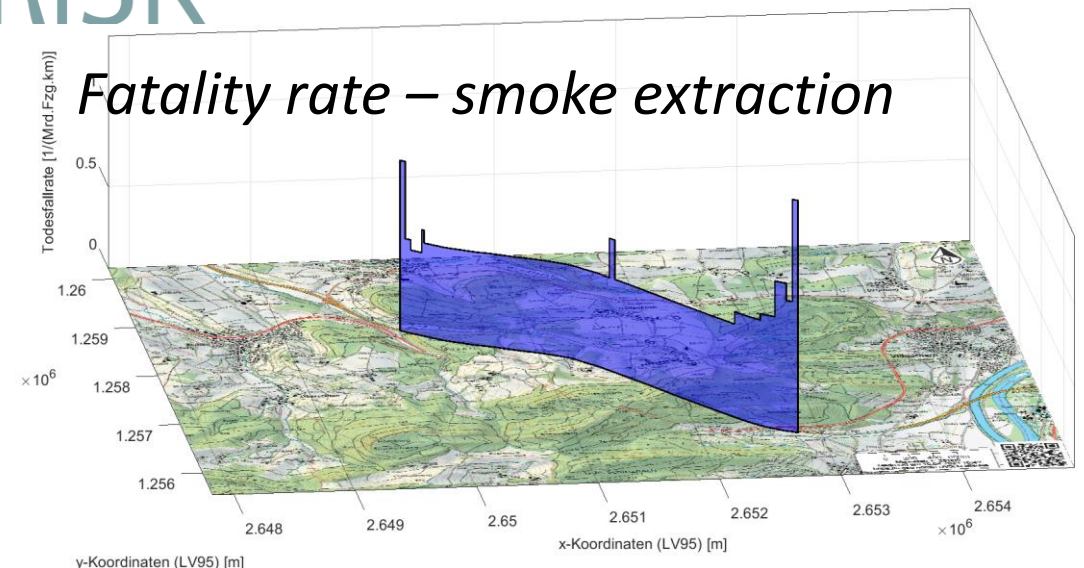
- Risk (human safety) is calculated in the tunnel using methodology ASTRA 19004.
- The marginal life saving costs in CH are presently set to 6.9 Mio. CHF
- Calculating different scenarios allows for calculating the risk reduction (also combination of measures) such as ventilation system, distance emergency exits.



Fatality rate – longitudinal ventilation



Fatality rate – smoke extraction



Tunnel Risk assessment: ASTRA 19004

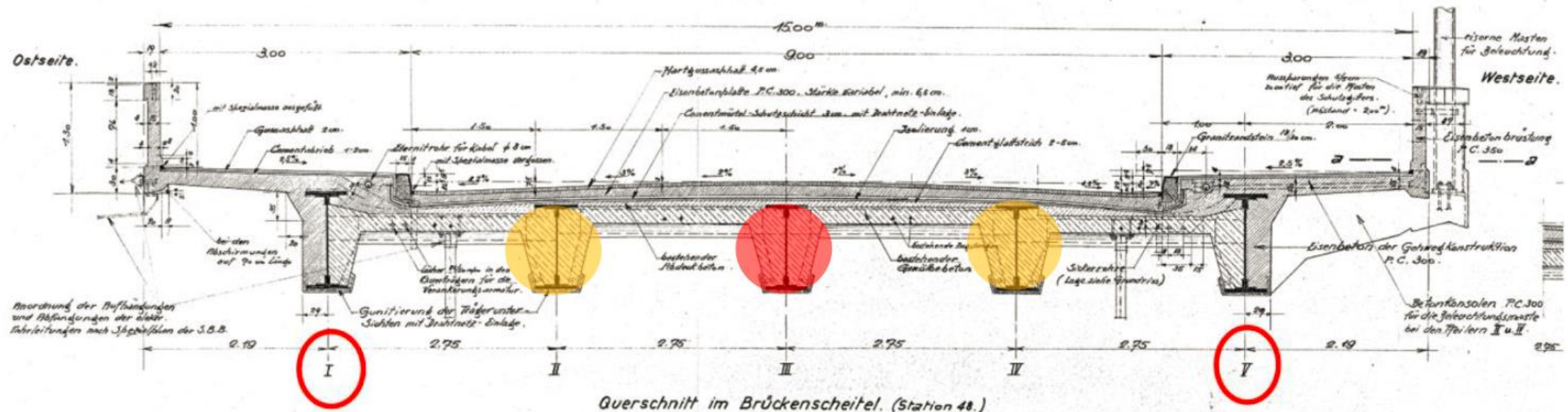
Using the marginal live saving cost principle in ASTRA 19004 we can provide answer to questions like



- What is the proportional financial cost to halve the distance between emergency exits?
- What is the proportional financial cost to replace the existing ventilation system with a smoke extraction?
- What is the proportional financial cost to implement a smoke extraction system for a tunnel operated in two-way traffic during a 2-year renovation period?
- What is the proportional financial cost to implement a smoke extraction system for a tunnel operating at night (e.g. 8:00 p.m. to 5:00 a.m.) in two-way traffic during a 4-year renovation period?

Length: 96.3 m (6-span continuous beam)

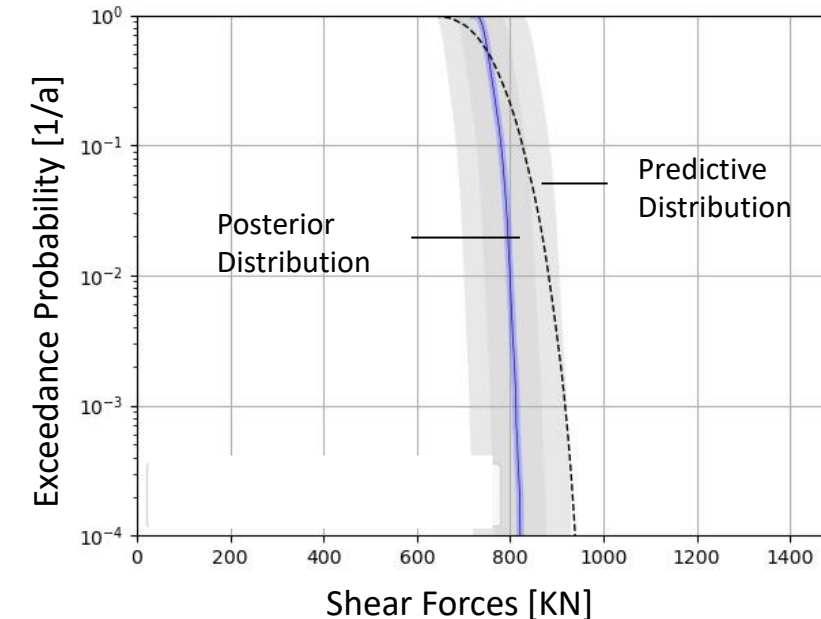
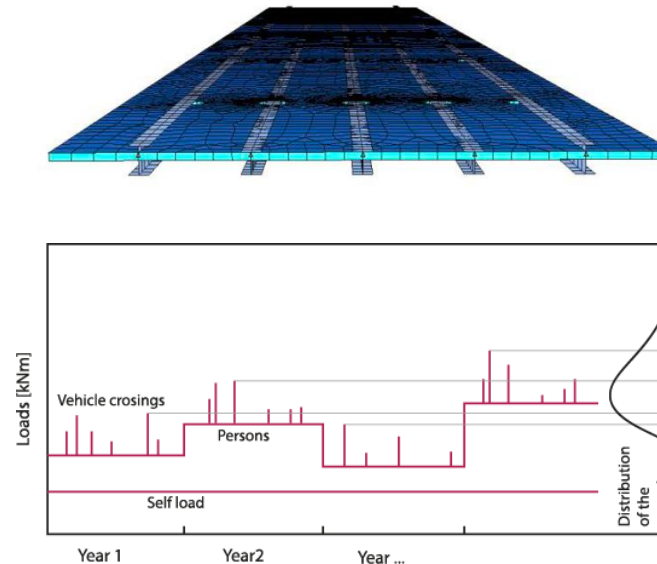
During an inspection, the shear force verification for supports not be satisfied (according to the new codes).



Calculation of the failure probability



Type	Geometry
11	
12	
22	
23	
111	
111r	
112r	
1211r	
122	
1112r	
112a	
113a	
123a	



Assessment of consequences and target reliabilities

Efficiency of safety measure $E = \Delta R / C_S$	Failure consequences $\rho = C_F / C_B$		
	Minor $\rho < 2$	Moderate $2 < \rho < 5$	Large $5 < \rho < 10$
Small $E < 0.5$	$\beta_t = 3.1$ $P_f \approx 10^{-3}$	$\beta_t = 3.3$ $P_f \approx 5 \cdot 10^{-4}$	$\beta_t = 3.7$ $P_f \approx 10^{-4}$
Normal $0.5 \leq E \leq 2.0$	$\beta_t = 3.7$ $P_f \approx 10^{-4}$	$\beta_t = 4.2$ $P_f \approx 10^{-5}$	$\beta_t = 4.4$ $P_f \approx 5 \cdot 10^{-6}$
Large $E > 2.0$	$\beta_t = 4.2$ $P_f \approx 10^{-5}$	$\beta_t = 4.4$ $P_f \approx 5 \cdot 10^{-6}$	$\beta_t = 4.7$ $P_f \approx 10^{-6}$

⇒ Annual target reliabilities based on optimisation

Human fatalities
(Re-)construction costs
business interruption SBB
damage on railway infrastructure

$$\rho = \frac{C_F}{C_W} = \frac{136}{14} = 9.7$$

(Re-)construction costs

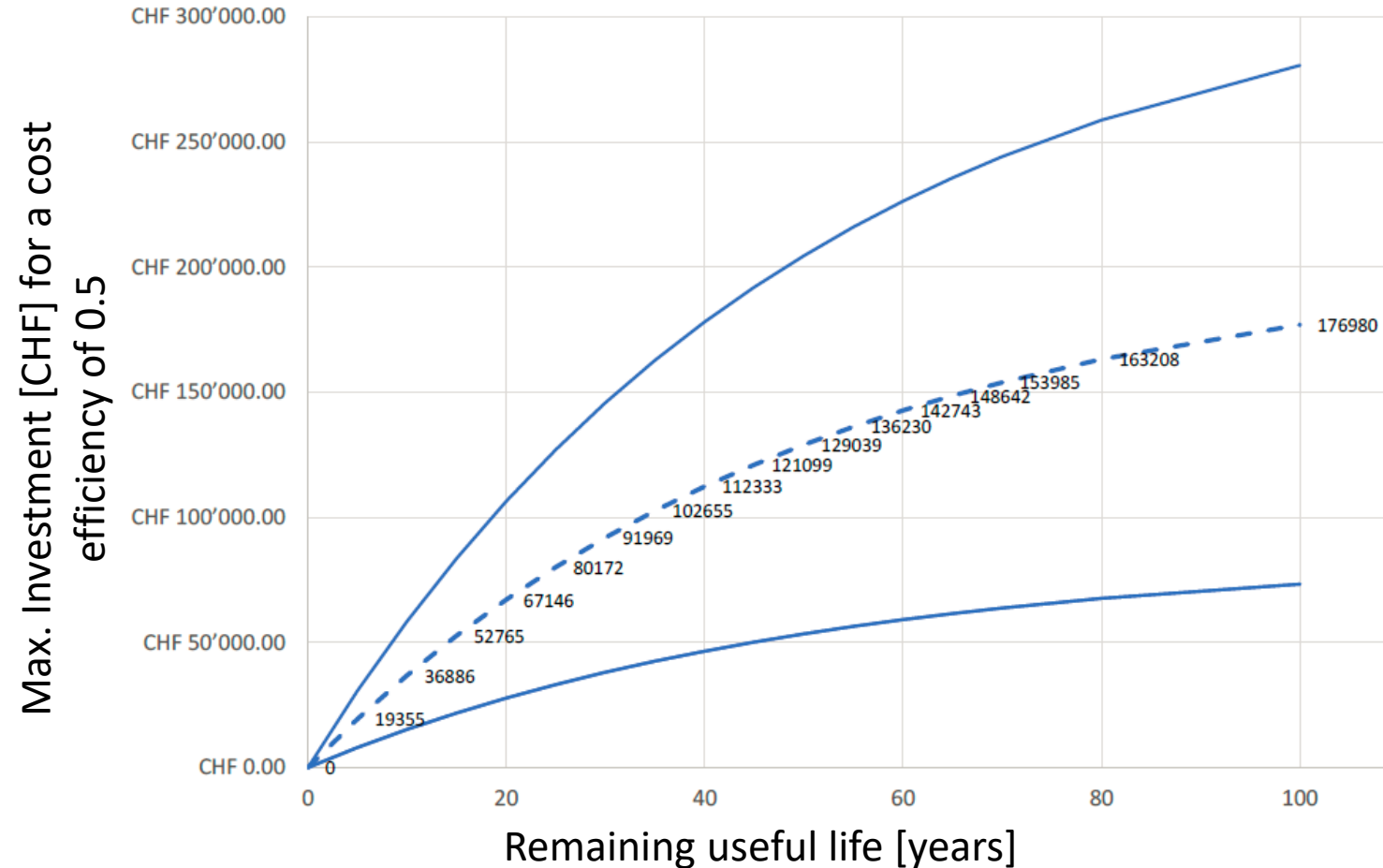
ΔR from As-Is to b=4.7
taking into account MRS

$$EF_M = \frac{\Delta R_M}{SC_M}$$

Assuming EF=0.5

Acceptance criteria

- If investments are above the calculated limits we can assume an efficiency smaller than 0.5
- In this case, the target reliability is 3.7
- The calculated reliabilities using the updated traffic model are between 4.1 and 4.7.
- The structure fulfils the target reliabilities in the As-Is status.



Conclusions

- By adhering to principles such as equality before the law and proportionality, we can strike a balance between safety and practicality.
- Understanding and implementing the ALARP principle in risk assessment processes can help ensure the well-being of individuals while maintaining a sustainable approach.
- In many projects in the last 15 years we applied these acceptance criteria and demonstrated practical applicability.
- The approach can provide very good decision support in many practical questions and help to save societal resources.

Risk Acceptance Criteria

**Thank you for your attention
questions – remarks - discussion**

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