Managing Technical Risks
Matrisk

Monetary optimization and quantitative risk acceptance

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An engineering perspective on risk assessment: From theory to practice

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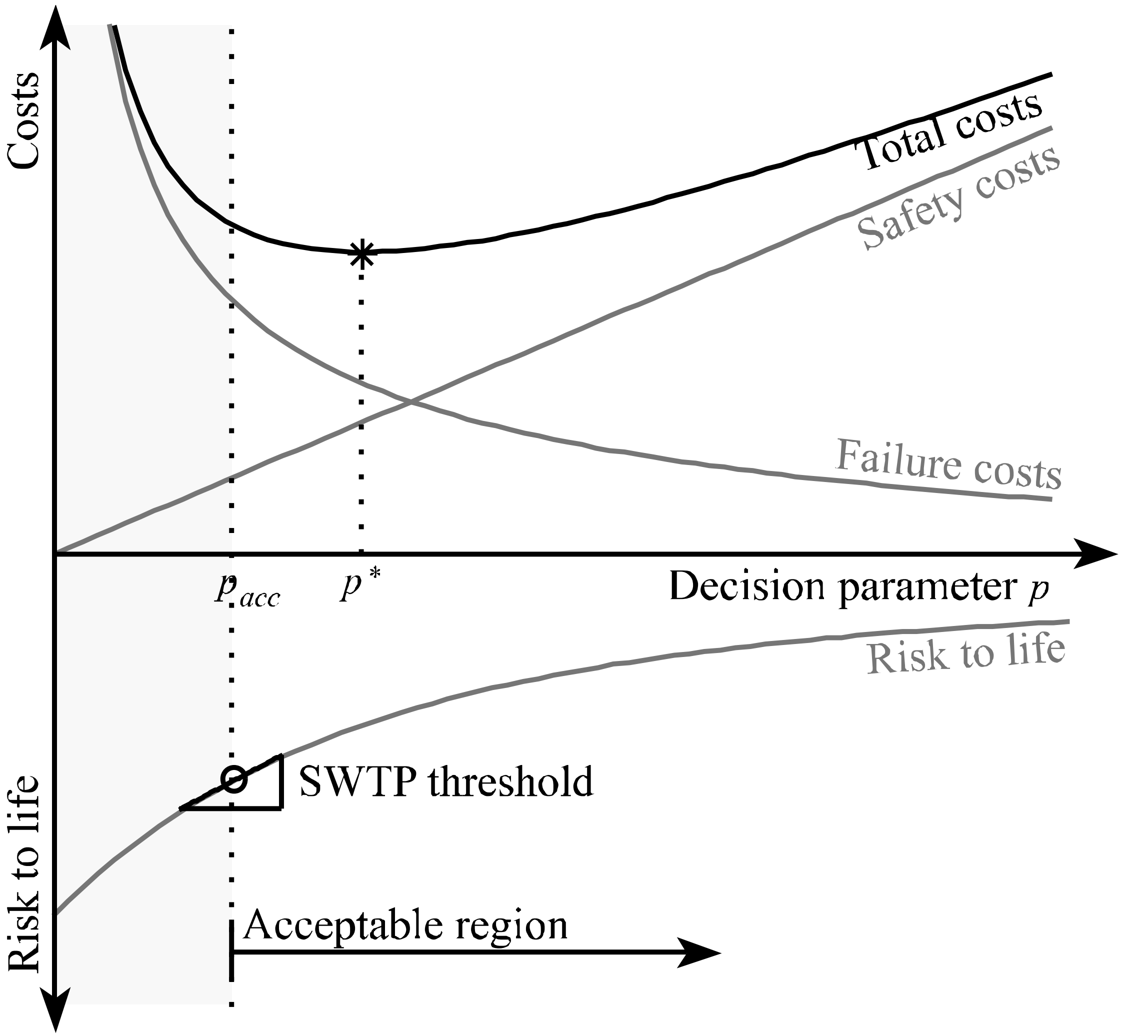
Presentation overview

- **Theory**
  - Monetary optimization
  - Marginal life saving costs principle
- **Practice:**
  - Requirements for practical risk control
  - Issues in practical application
- **Solutions:**
  - Local optimization
  - Full optimization
- **Conclusions**

The theory



Monetary optimization for monetary losses

Marginal life saving costs principle as acceptance criterion for loss of lives

(or other intangible goods)

The practice

Some practical requirements for a risk assessment framework as a means for risk control:

- Flexible, applicable in all practical design situations ✓
- Straight-forward and “easy to apply” in practice ✘
- (Quantitative) methods available to do the assessment
- Robust criteria and metrics (w.r.t. modelling choices) ⇦

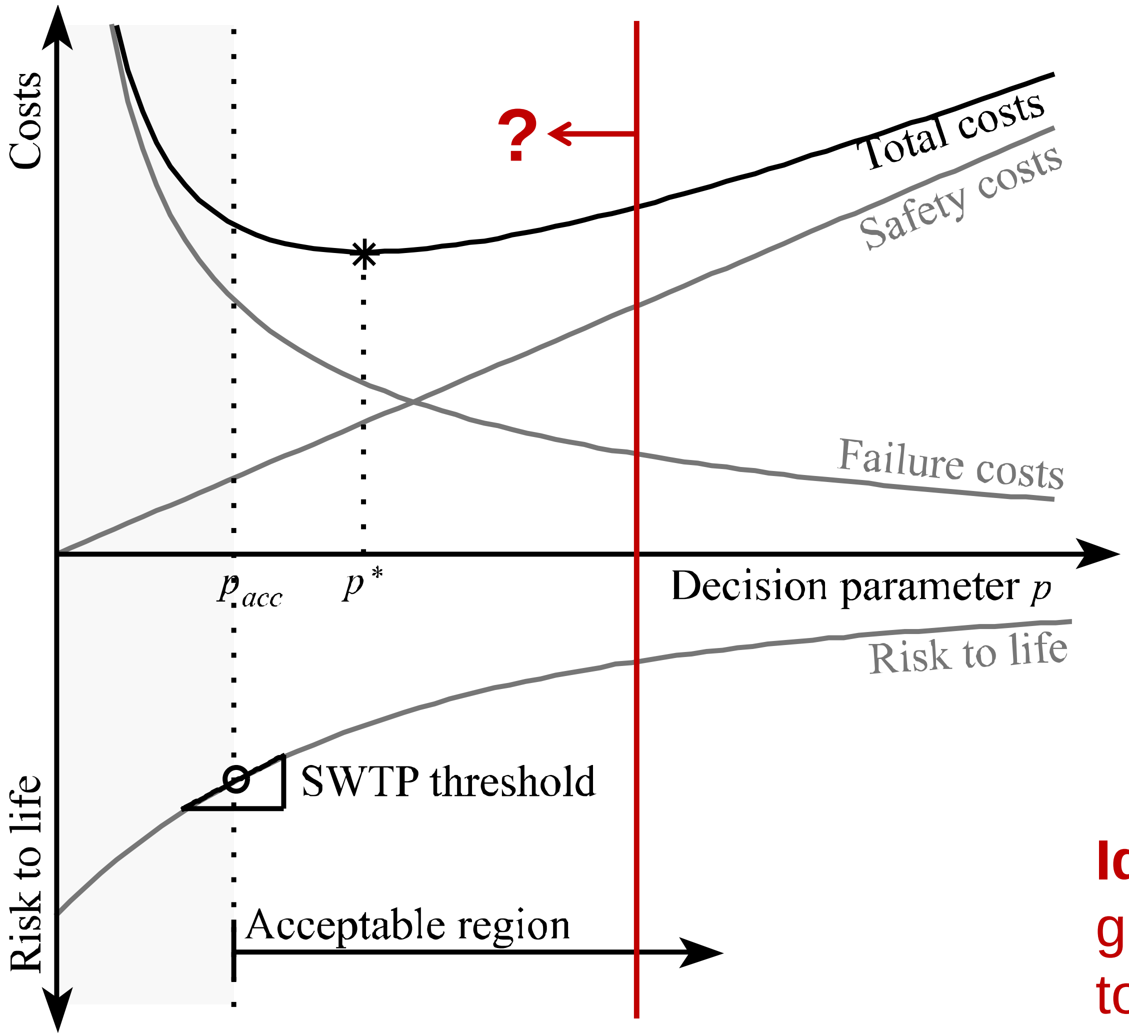
…highlighting the strength and weaknesses of risk based approaches when compared to prescriptive fire safety – the traditional approach to risk control in building fire safety

The practice

Some issues that may arise in practice when basing decisions on optimization & marginal life saving costs

- A large number of potential risk reducing measures needs to be considered, including possible combinations & interactions.
- The assessment of safety costs is not straight-forward due to synergies and interaction with other, possibly qualitative, design criteria (not related to fire safety).
- The assessment of fire risk (monetary and human losses) is associated with large model uncertainties.
- All efficient risk reduction measures have been implemented, but the risk is still extraordinary high.
- The overall fatality rate is acceptable, but the risk imposed on a specific group of people is extraordinarily high.

Solution 1 – "Local" risk optimization



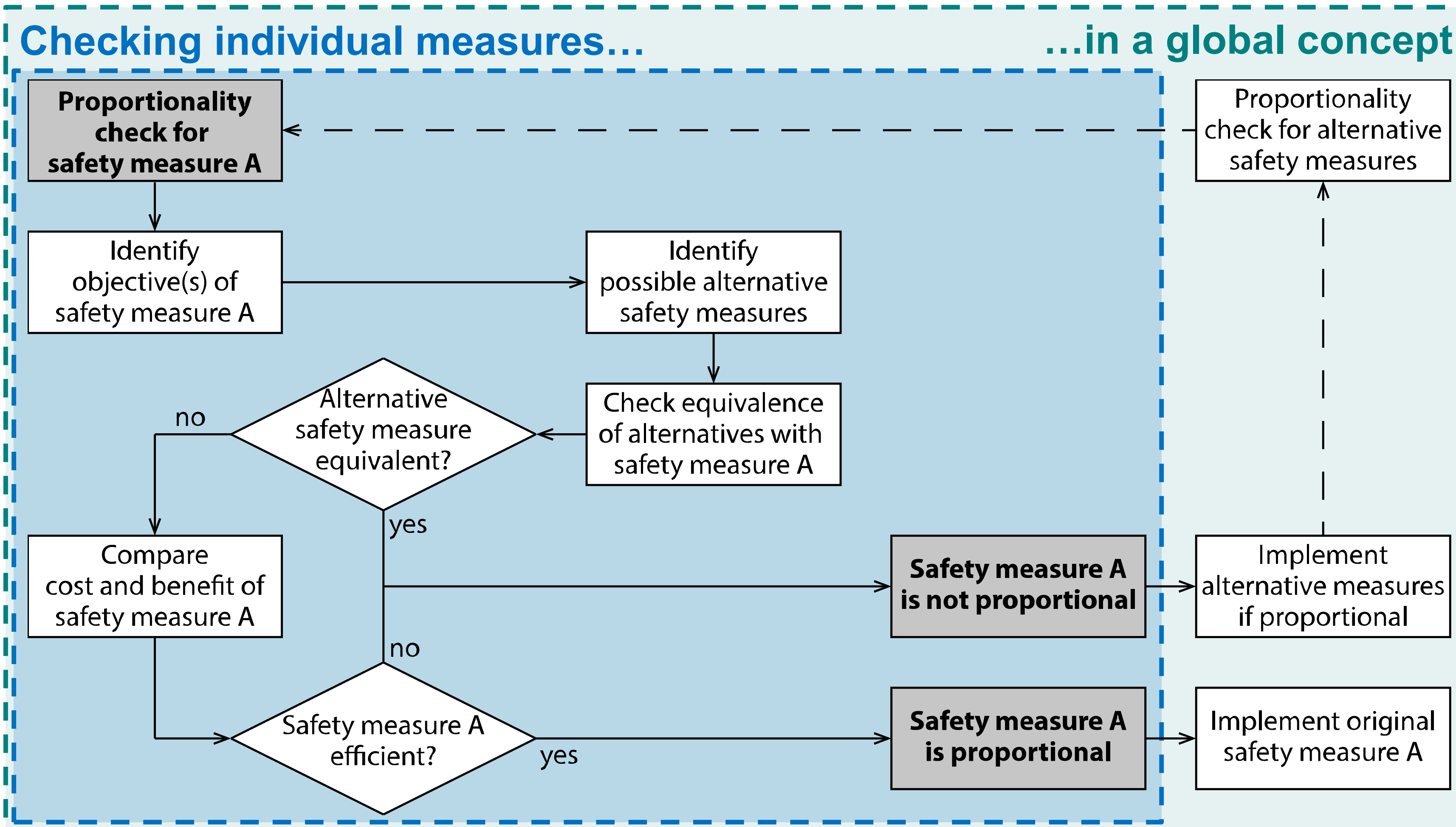
Idea: Start with a given solution and try to improve (locally)

Solution 1 – “Local” risk optimization

Focus on specific safety measures in a given concept

- Focus on measures or aspects of fire safety design for which risk based approaches can make a real difference
- Assumes the overall fire safety concept to be given (e.g. based on prescriptive design, or status quo for existing buildings)
- Straight-forward and relatively simple application of cost-benefit analysis and marginal life saving costs principle
- A safety measure is “proportionate” if:
  - no “equivalent” alternative measure exists achieving the same goal at a lower cost – incl. nonmonetary aspects
  - and the safety measure is “efficient”, i.e. its benefit outweighs the costs
- The approach does not necessarily require a full quantitative analysis, and uncertainties may play a less important role.

Example: Proportionality assessment



Developed for armasuisse Immobilien: Fire safety in existing buildings (with Risk&Safety AG)

Example: Proportionality assessment

Safety measure: New external staircase in existing building to reduce egress distance on each floor from 40m to 35m – focus safe egress

First step: Check equivalence of alternative safety measures

- e.g. installation of automatic fire alarm system
- 5m egress route reduction leads to around 5s regress time reduction – early alarm likely to achieve more than this
- Possible to stop the assessment here and install alarm system

Second step: Semi-quantitative efficiency assessment

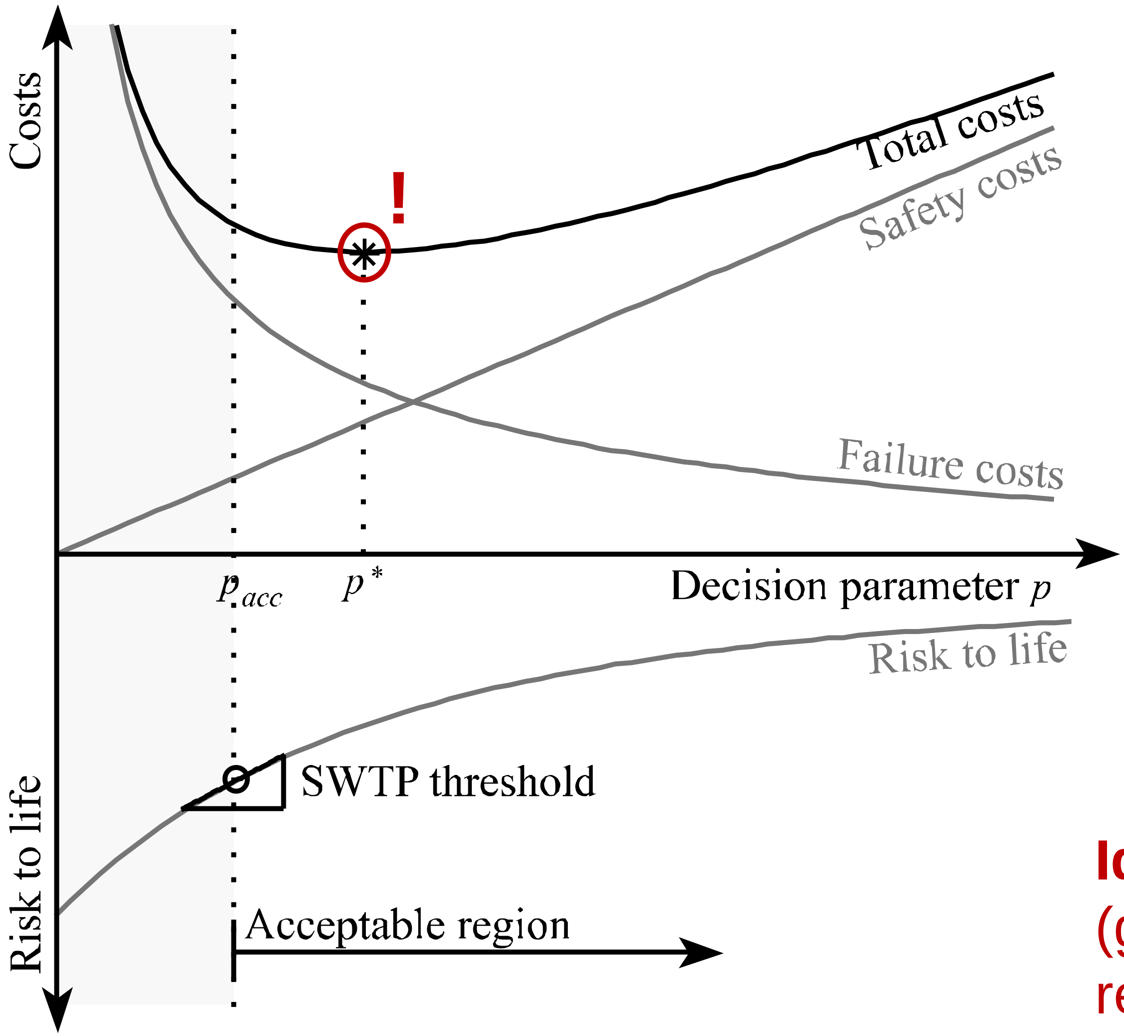
- Cost estimation: 80’000CHF, service life 100a, discount rate 2% → Discounted annual cost of safety measure: 1’850CHF/year
- Assumed fire occurrence rate: 1 / 300Jahre (incl. small fires) → «Required» loss reduction in case of fire: 555’000 CHF
- SWTP for marginal life saving costs application: 6.5 Mio. CHF → «Required» No. of people saved per fire event: 0.09

Solution 1 – “Local” risk optimization

Some concluding remarks on local optimization

- The local approach is straightforward and relatively easy to apply, especially in the following situations:
  - Assessment of safety measures to improve fire safety in existing buildings
  - New buildings and fire safety concepts that are generally within the scope of other (e.g. prescriptive) approaches
- Results will not be consistent with alternative approaches unless these have been calibrated with risk-based methods
- “Local” optimization focussing on specific measures may not be sufficient for the design of special buildings or facilities, especially those outside the scope of code-based design

Solution 2 – Full optimization



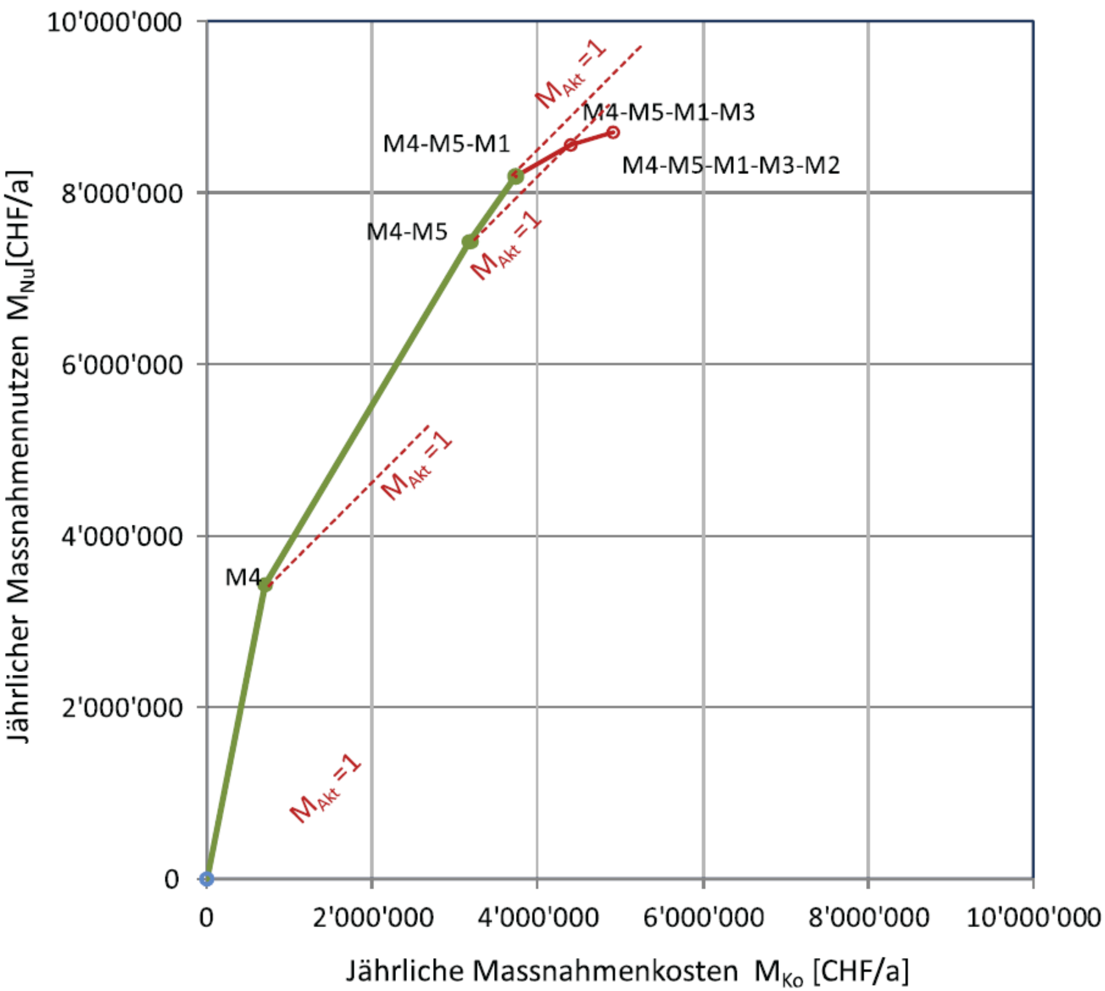
Idea: Aim at the (globally) optimal resource allocation

Solution 2 – Full optimization

Combine risk based optimization with fixed thresholds

- More flexible than local optimization, applicable also to special facilities not covered by other design approaches
- Requires consideration of all possible risk reduction measures and combinations, which can be very demanding in practice
- The assessment becomes more robust when adding absolute risk thresholds as “bounds” to the optimization
  - Approach corresponding to the well-known ALARP assessment, which is already best practice in many fields
  - To get full benefit, risk acceptance must be independent of alternative approaches (no comparative risk assessment)
  - Metrics used to define fixed thresholds must be consistent with optimization approach and should be comparable with other domains – e.g. fatality rates for building occupants

Example: Swiss Tunnel risk analysis

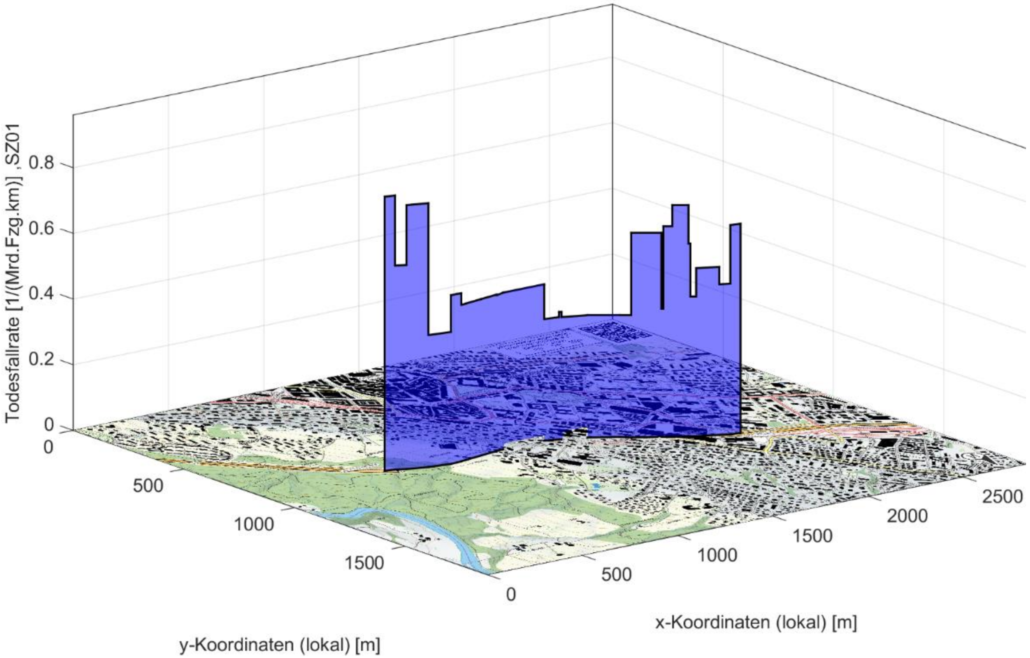


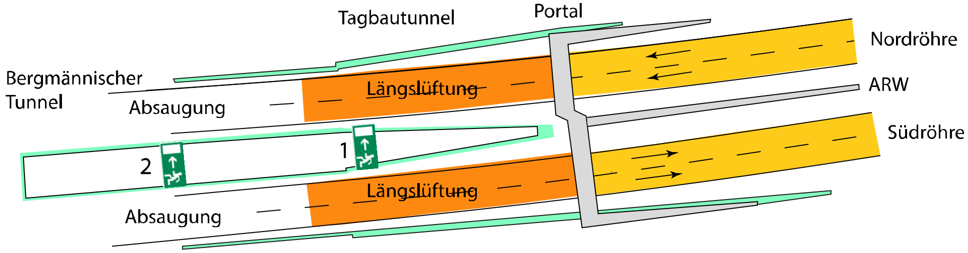
ASTRA 89005, policy and risk concept for tunnels of federal roads

- optimization and marginal life saving costs principle with upper and lower bound for the fatality rate
- Considers single safety measures and combinations of measures
- Published 2014, successfully applied in practice

Example taken from ASTRA 89005

Example: Swiss Tunnel risk analysis





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Application & extension to consider smoke recirculation at tunnel portal

Conclusions

- **Theory:**
  Optimization & Marginal life saving costs principle – consistent, well-founded, fully applicable to fire safety
- **Practice:**
  Issues w.r.t. risk control, partly arising from challenges associated with the practical implementation
- **Solutions:**
  - **Local optimization:** Ideal for existing buildings, and for "standard" when combined with alternative approaches
  - **Full optimization:** Ideal for special buildings or facilities outside the scope of alternative approaches

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