

Robustness of Structures

Discussion and Examples

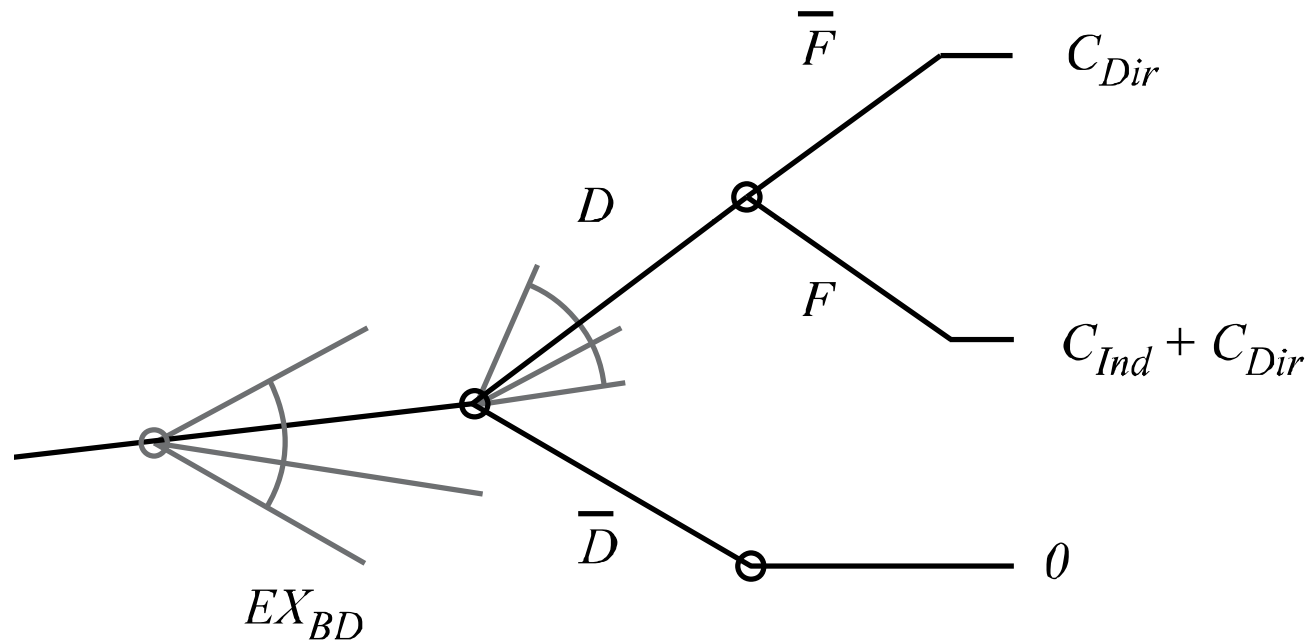
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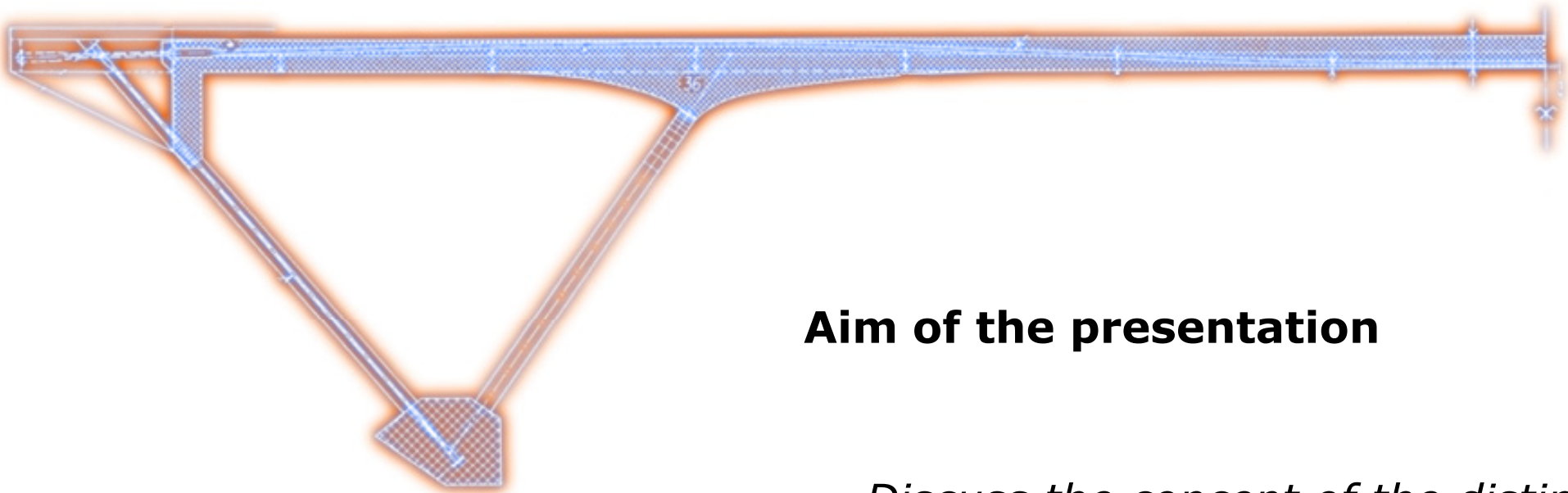
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Concept for the quantification of robustness



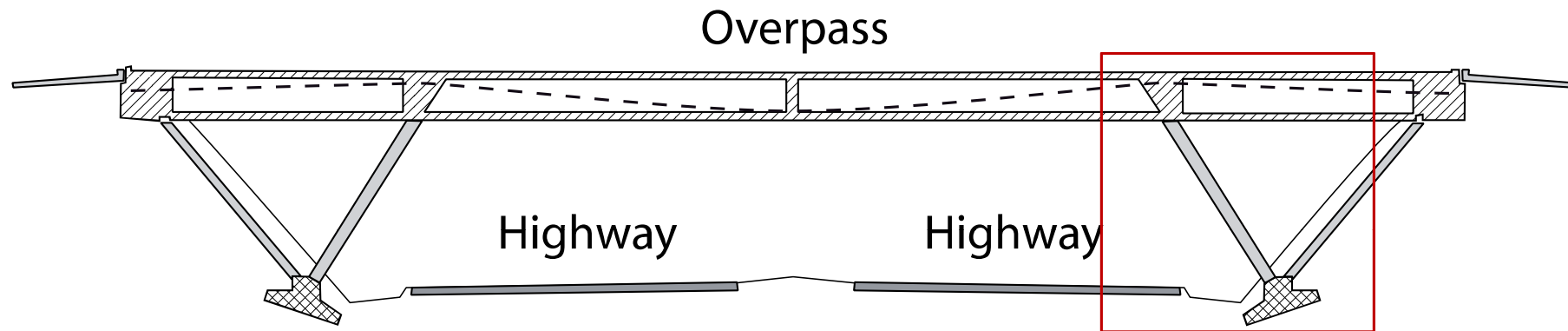
$$I_{Rob} = \frac{\text{Direct Risk}}{\text{Direct Risk} + \text{Indirect Risk}}$$



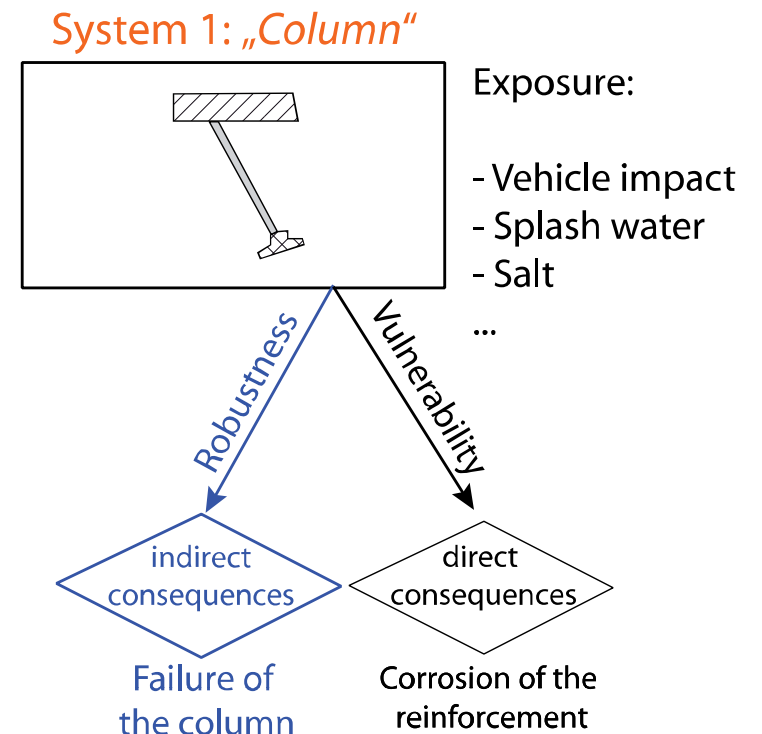
Aim of the presentation

- *Discuss the concept of the distinction between direct and indirect consequences*
- *Discuss system effects on the robustness*

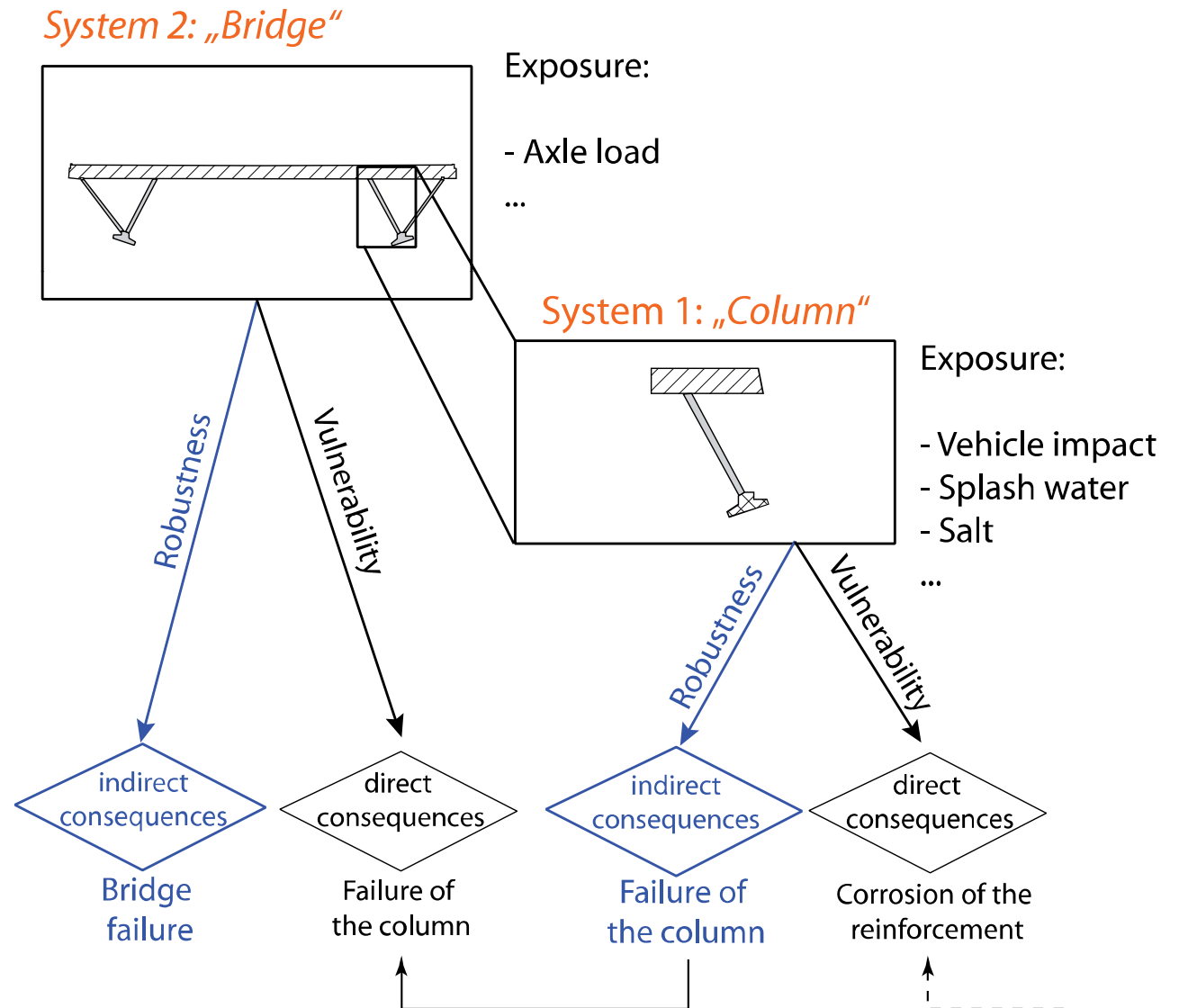
Direct and indirect consequences



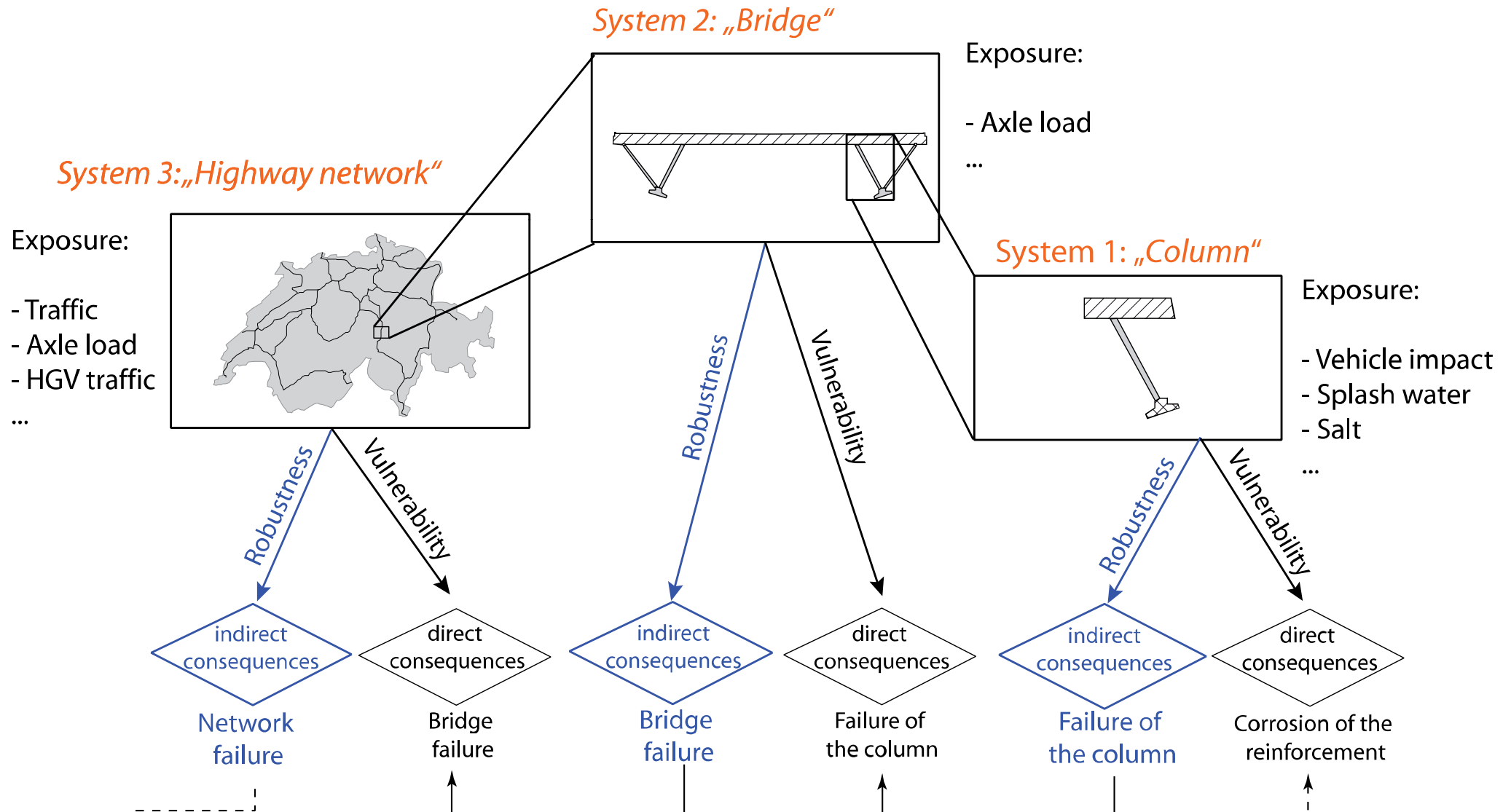
Direct and indirect consequences



Direct and indirect consequences

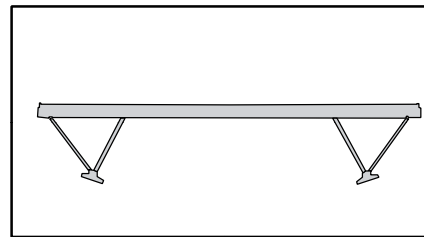


Direct and indirect consequences



Example: Vehicle impact on a V-column bridge

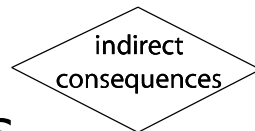
System „V-column bridge“



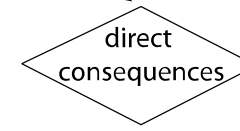
Exposure:

- Vehicle impact on the column

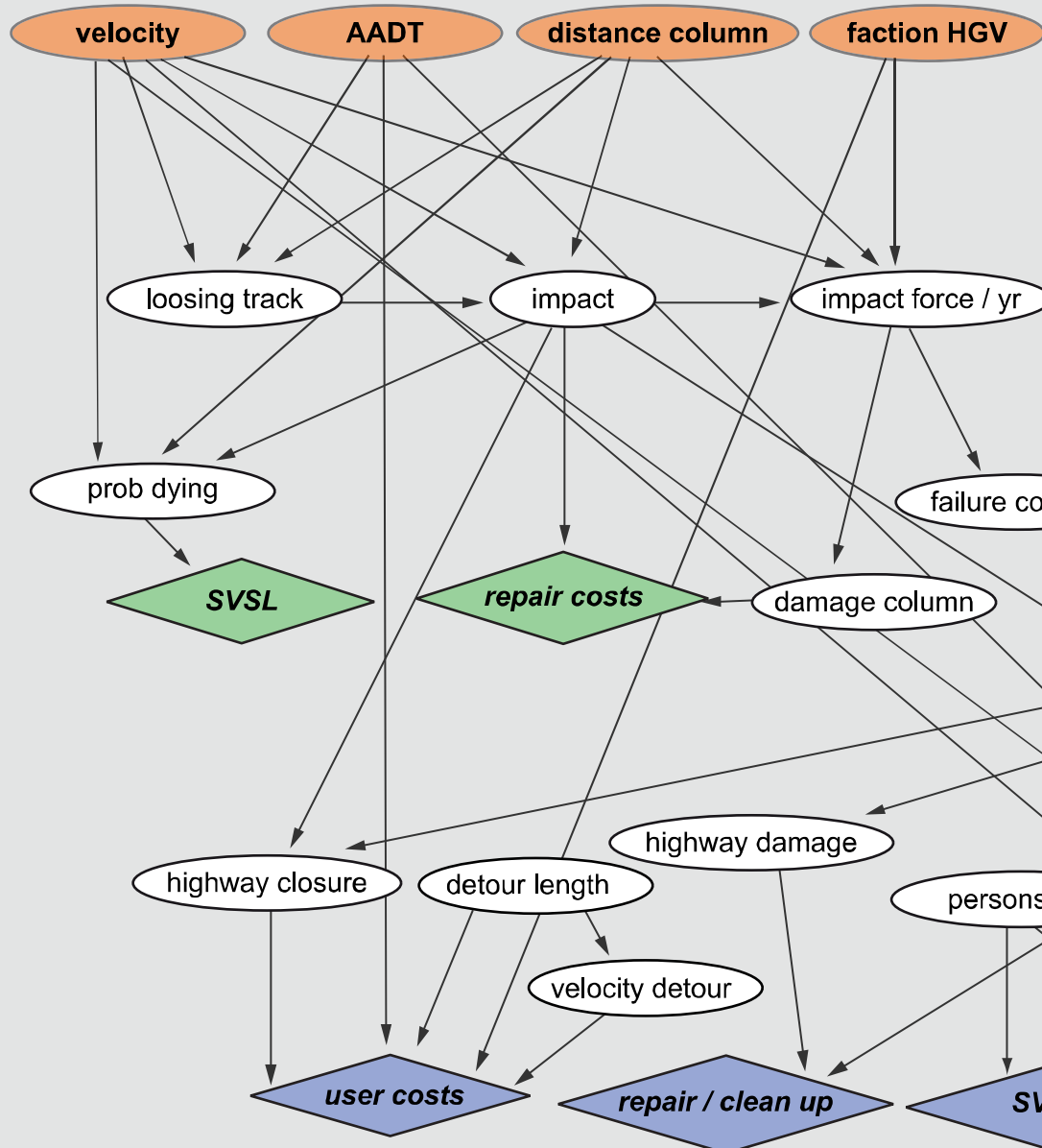
- fatalities / LQI
- clean up costs
- rebuilding costs
- property damage
- user costs



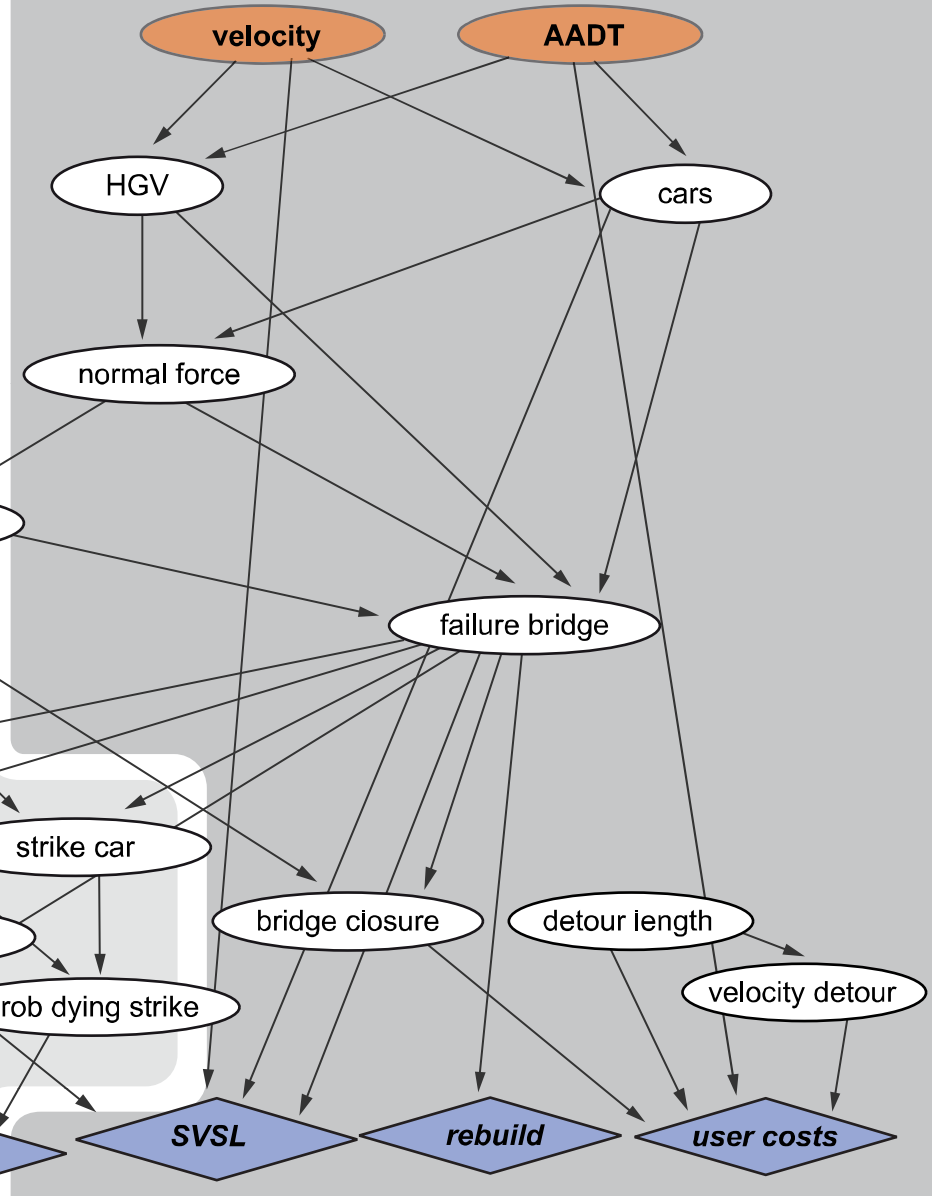
- fatalities / LQI
- repairing costs
- property damage
- clean up costs



Highway



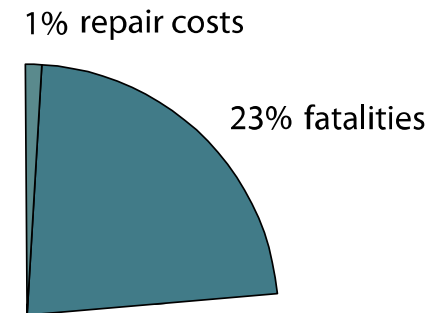
Overpass



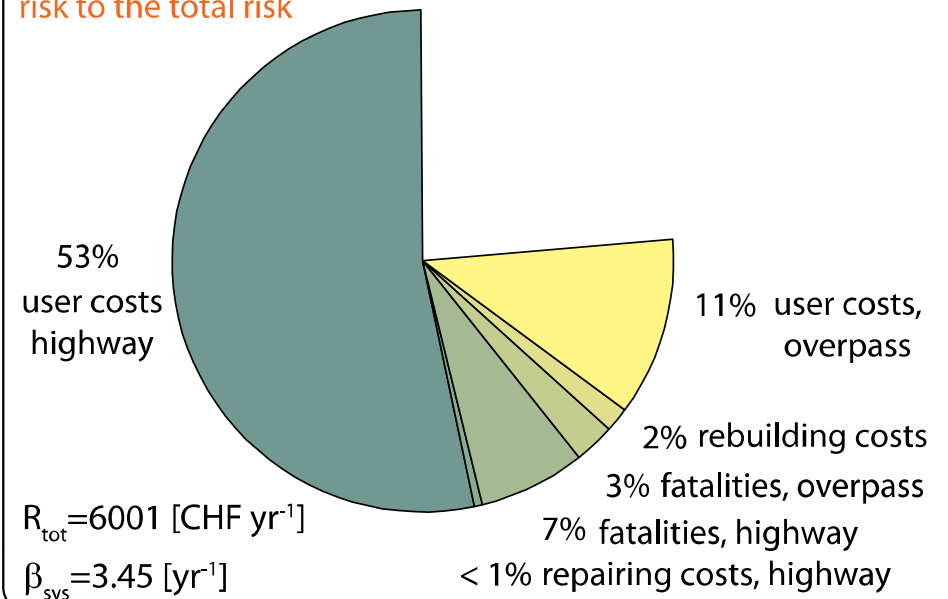
Contributions to the total risk

- Disproportionality between the two types of the risk.
- Indirect risk dominates the total risk.
- User costs play major role.
- Can the index of robustness be increased by increasing the reliability?

Contribution of the direct risk to the total risk

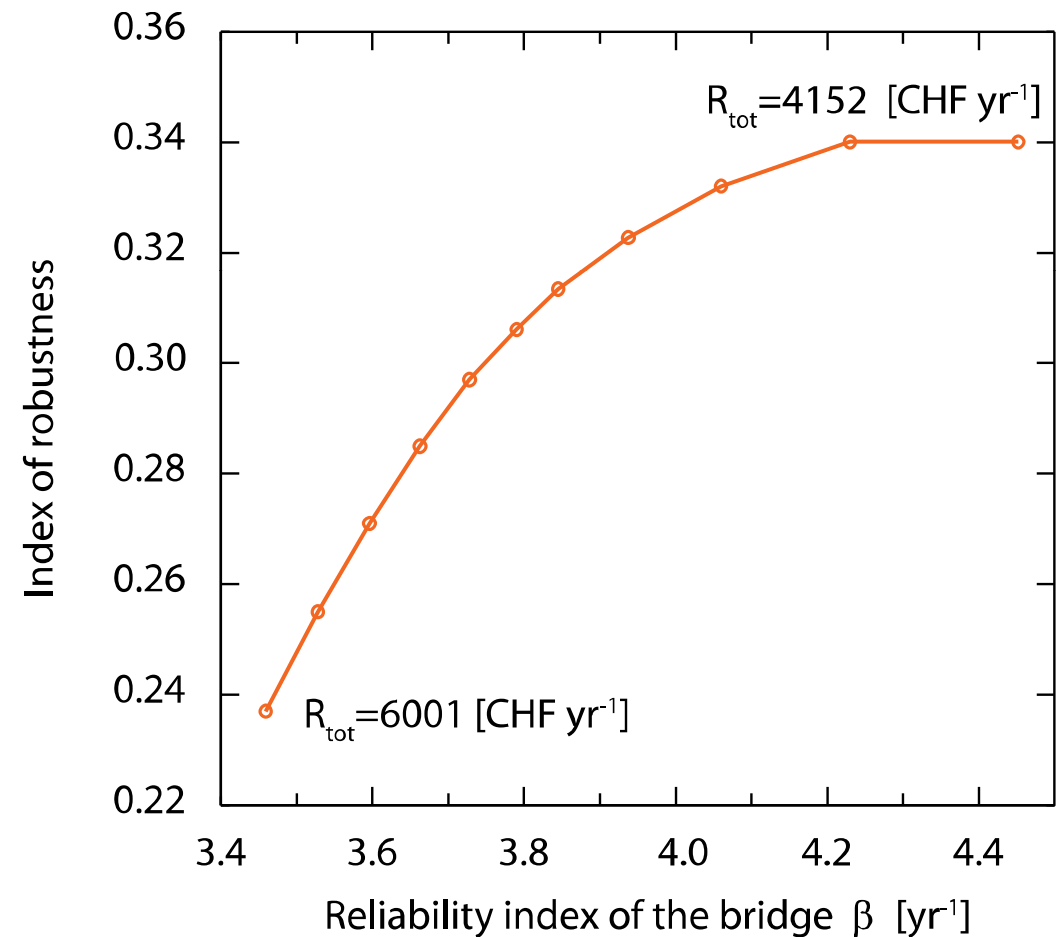


Contribution of the indirect risk to the total risk



Influence of the reliability on the robustness

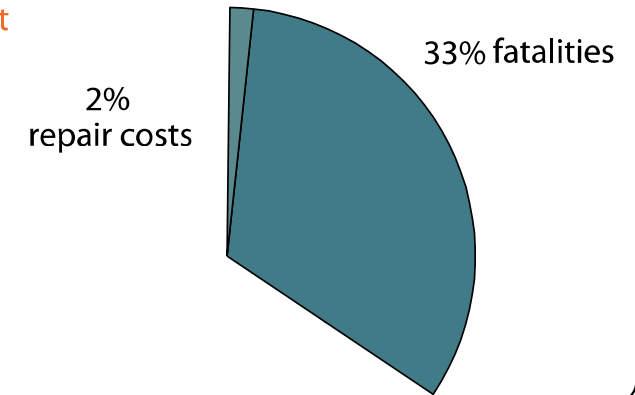
- Increasing the reliability lead to increase of the robustness.
- The total risk can be reduced.
- Index (and the total risk) converge to an upper limit.
- Reliability is not the only characteristic which leads to robustness.



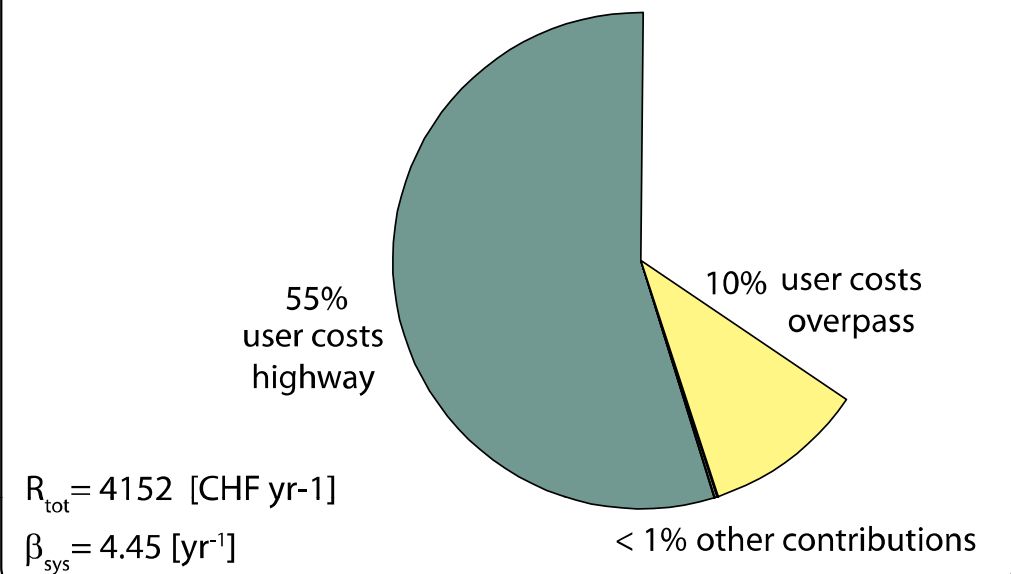
Contributions to the total risk

- High reliability – indirect risk still dominate the total risk.
- User costs contribute significantly to the total risk.
- Robustness is influenced by the location in the system - Redundancy

Contribution of the direct risk to the total risk

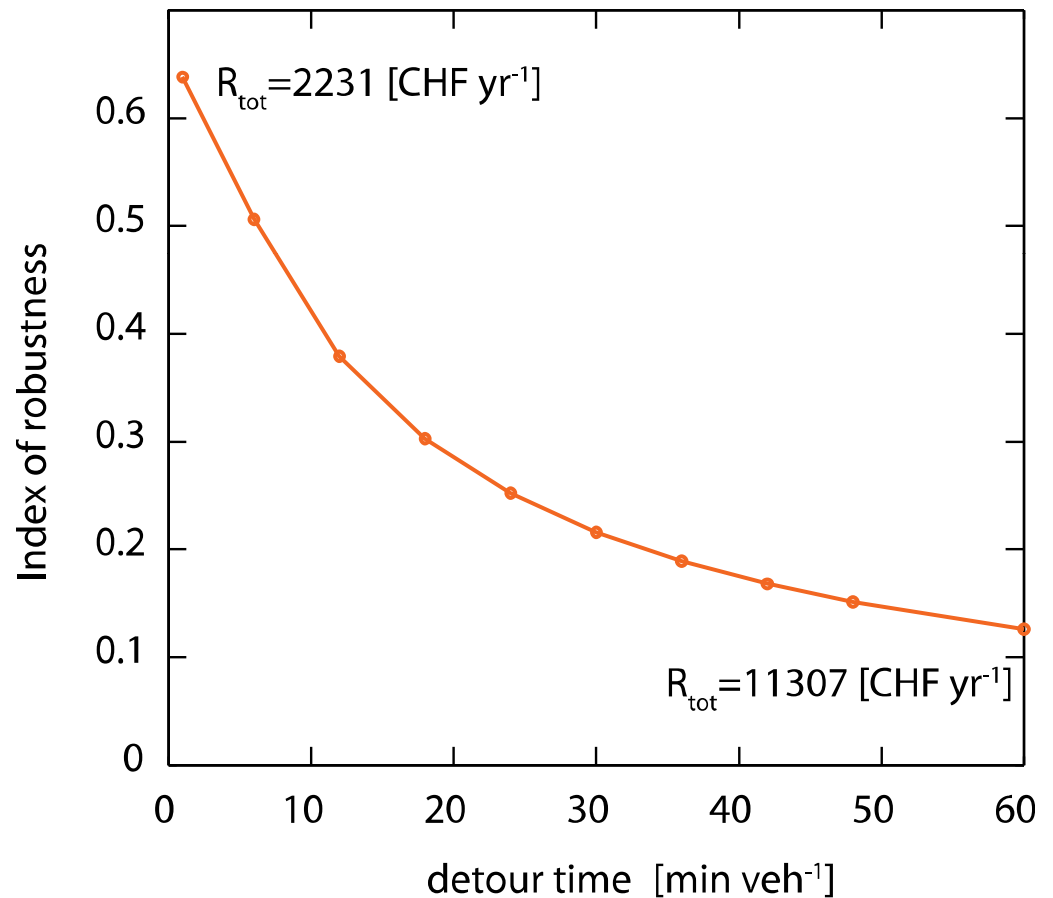


Contribution of the indirect risk to the total risk



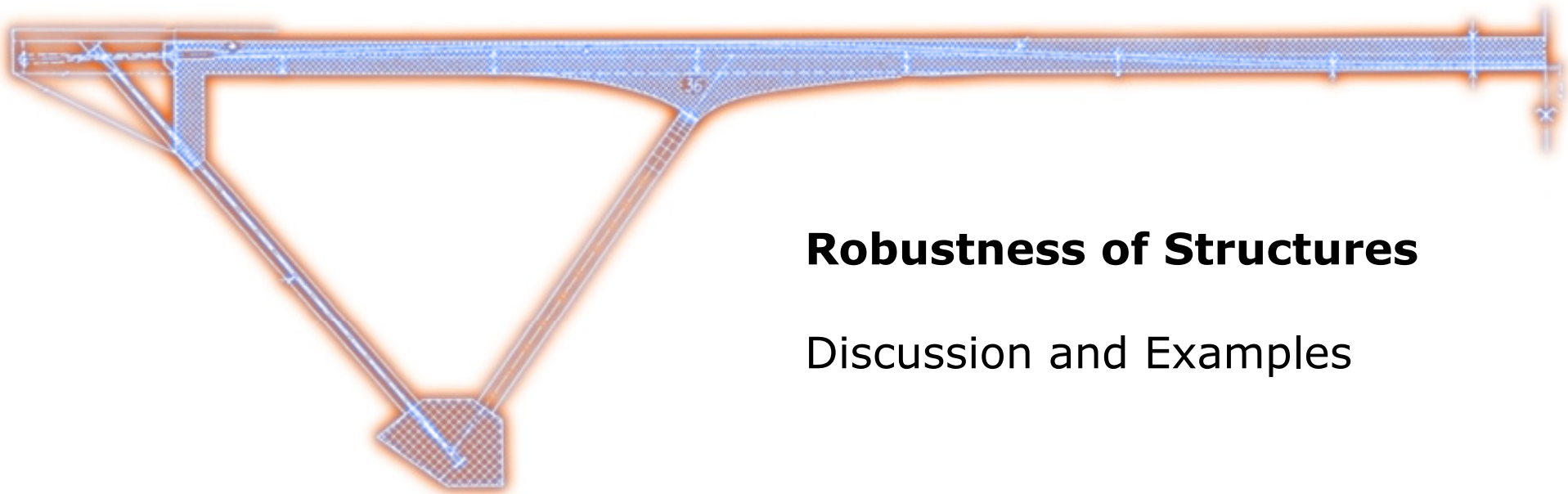
Influence of the redundancy on the system

- Redundancy leads to a reduction of the indirect consequences.
- Robustness can be increased by introducing redundancy into the system.
- Bridge (structure) change its characteristics (reliability, redundancy, etc.) with its location and significance in the network (system).



Conclusions

- Distinction between direct and indirect consequences is related to the problem settings, the decision maker and the definition of the considered system.
- The proposed index of robustness is applicable to complex and realistic systems.
- It accounts consistently for different robustness related aspects such as reliability and redundancy.
- Robustness (and reliability) are not just characteristics of the static system.



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Discussion and Examples

Thank you for your attention