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Visual Inspections and KPIs: Bridging the Gap

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Outline

- Introduction
- KPI for bridges
- Glimpse into the future
- Enhancement to current practice
- Conclusion and future work

Key Performance Indicators

- User related performance indicators
 - “Safe” and “Fast” travel
 - Accident rate
 - Travel time (Expected value and variance)
- Society-related performance indicators
 - Abutter
 - General public
- “Operators KPIs”
 - Maintaining a certain level of KPIs (=performance goals) on the long term at minimum costs
 - Optimum trade-off between the costs and the user related respectively society related KPIs

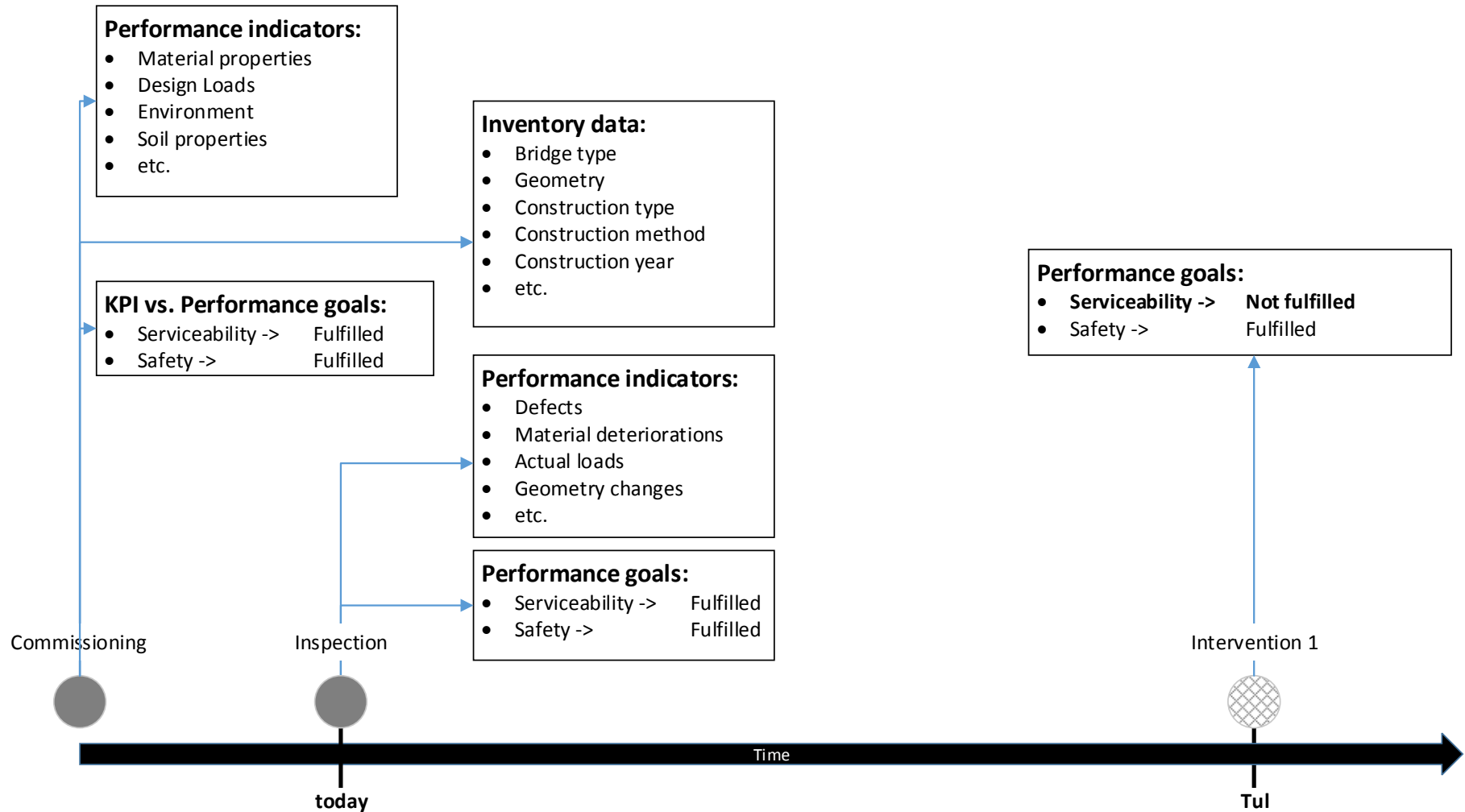
KPIs for bridges

- The primary concerns in bridge design are
 - Safety and
 - Serviceability
- It seems reasonable that this should be the primary concern during the whole service life.
- LTBP -> Performance issues

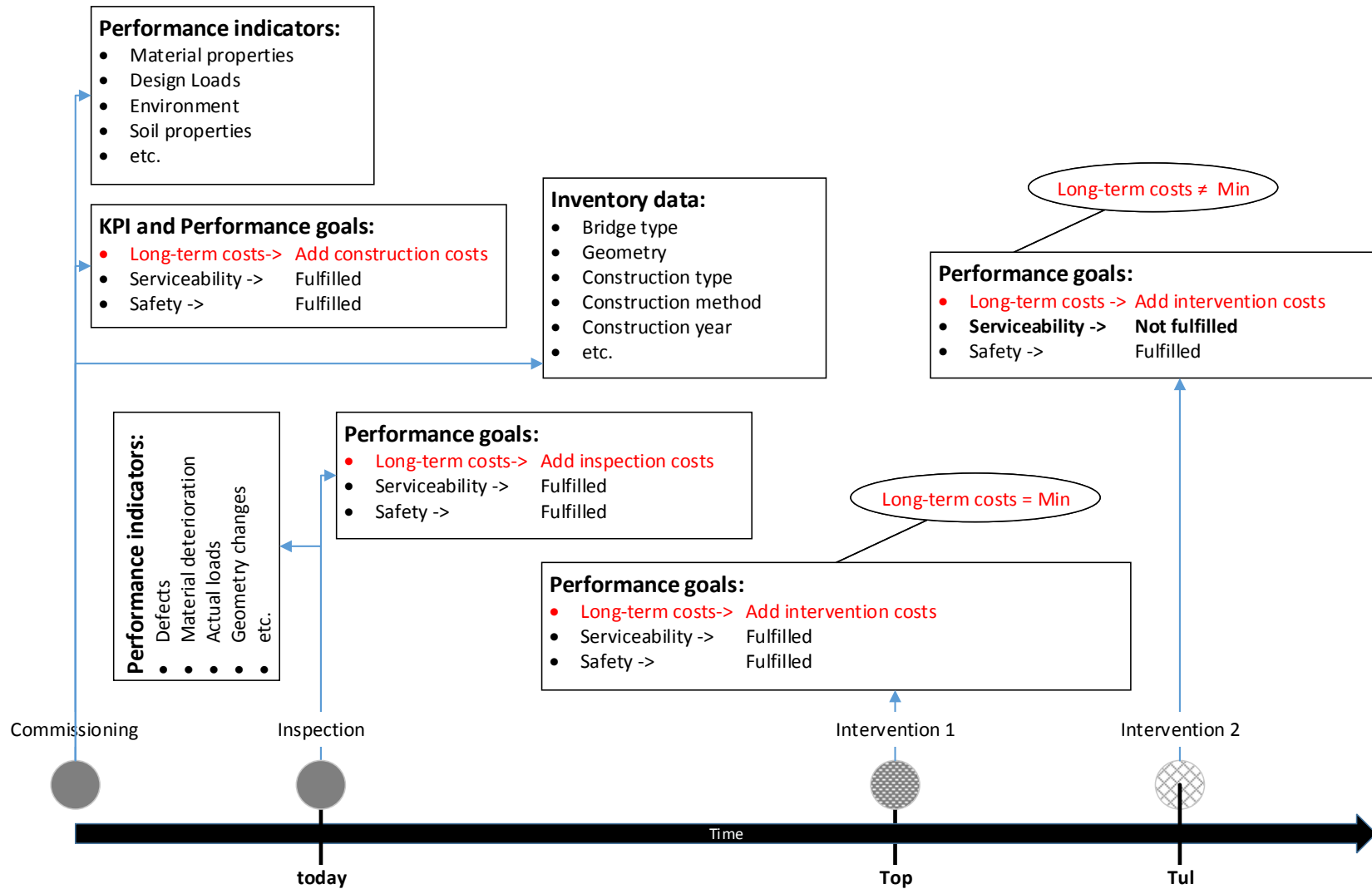


- "Structural integrity" is related only to sudden events
- Observable deterioration processes affect only durability and serviceability.
- The "durability" is a span of time in which neither safety nor serviceability is likely to be compromised.
- The "costs" include also user costs that may also be included in "user safety" and "serviceability".

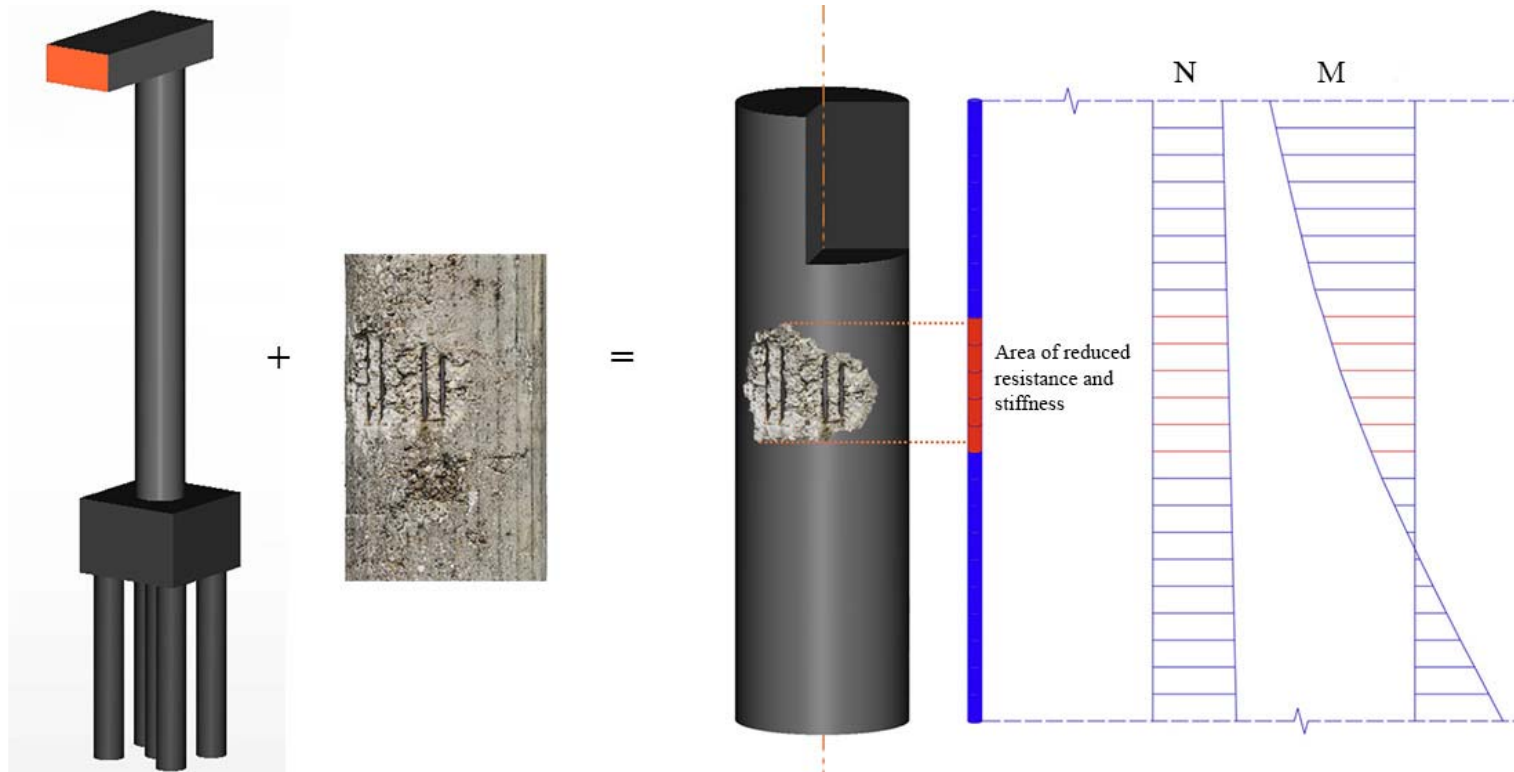
Bridge KPIs over time



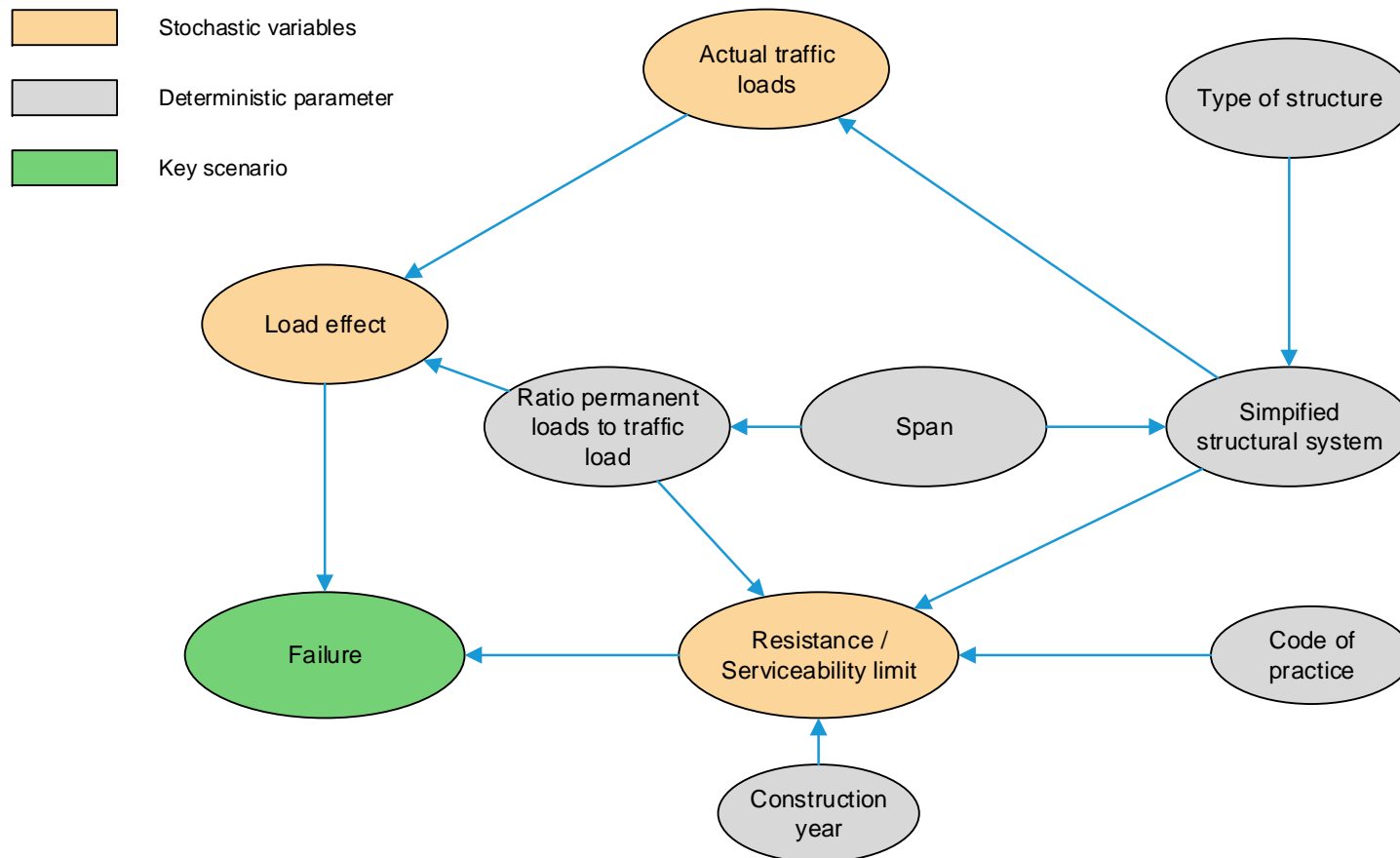
Optimum time



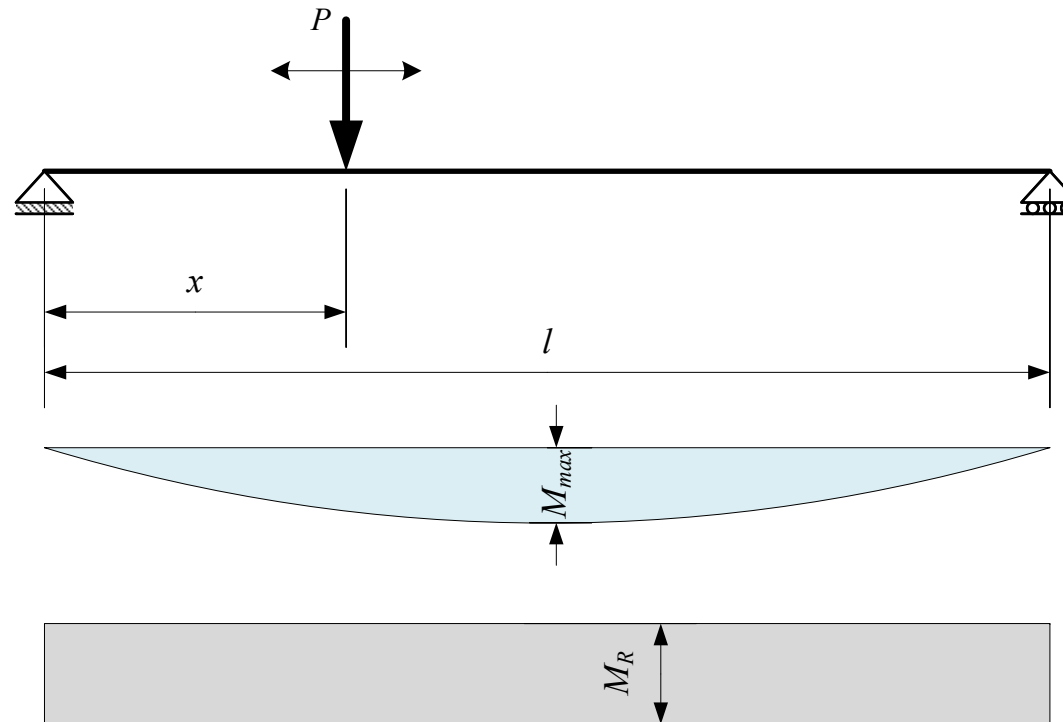
Deployment of B(r)IM



À priori assessment

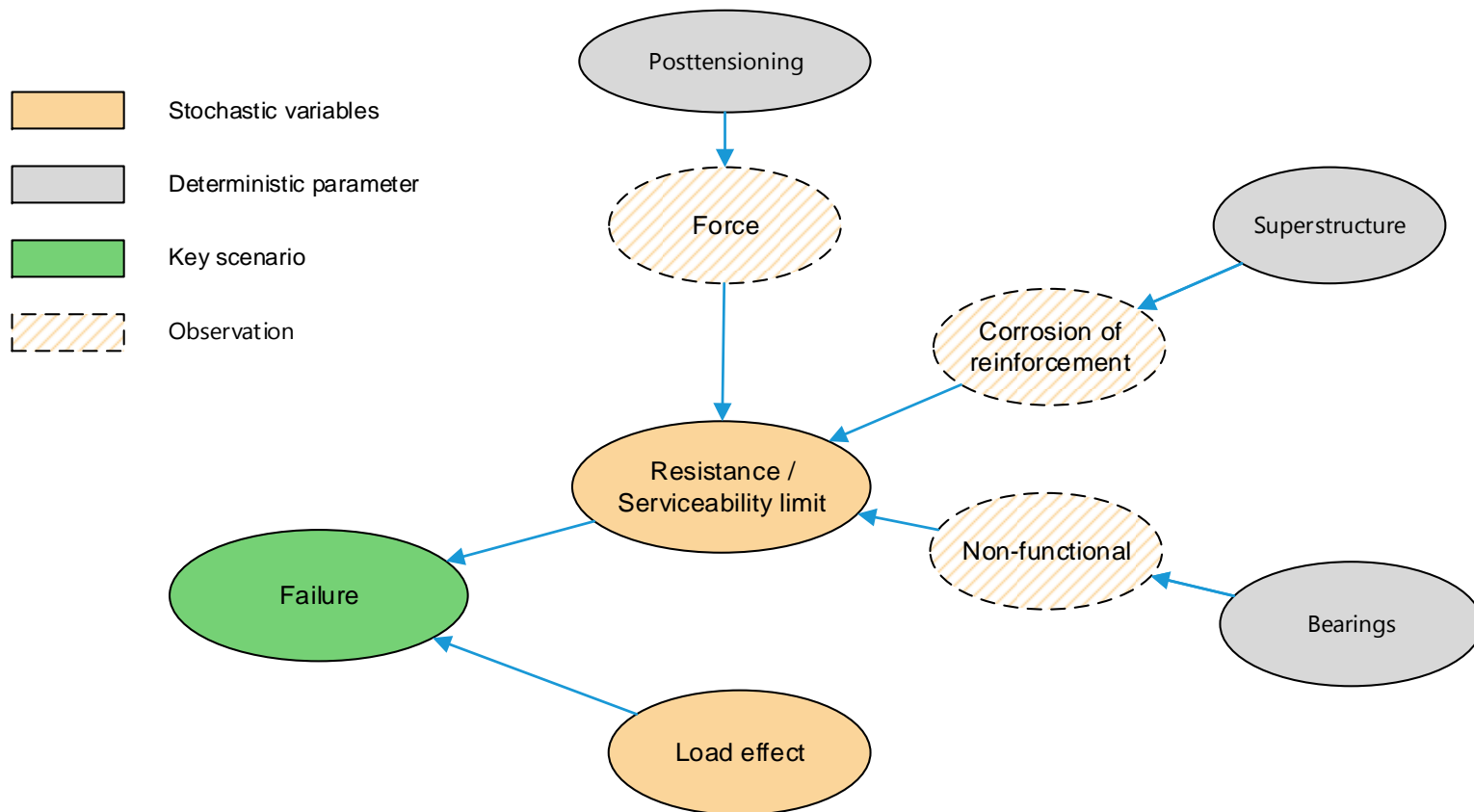


Example: à priori assessment

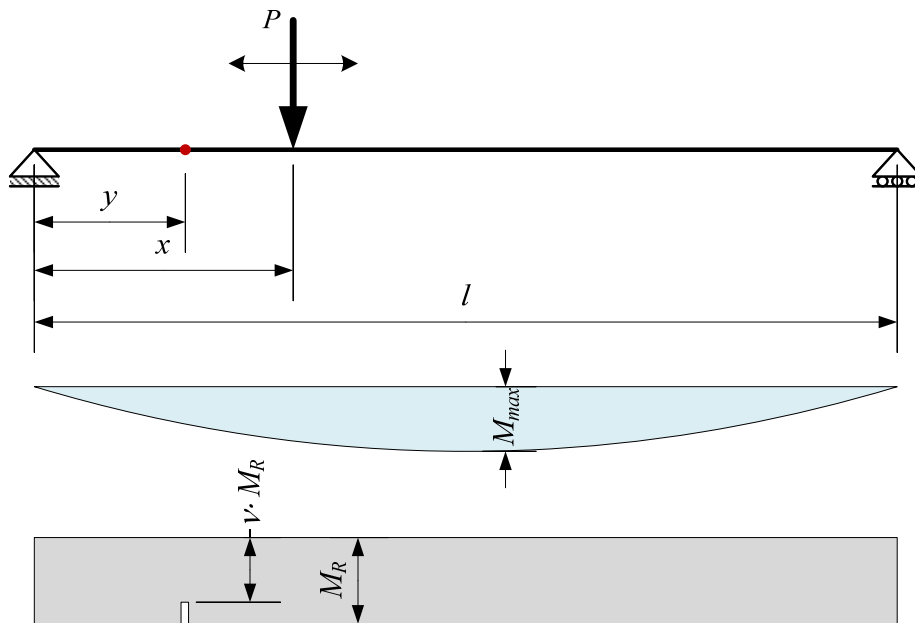


$$\beta = \frac{\mu_{M_R} - \frac{\mu_P \cdot l}{4}}{\sqrt{\sigma_{M_R}^2 + \left(\frac{\sigma_P \cdot l}{4}\right)^2}} = \frac{500 - 250}{\sqrt{50^2 + \left(\frac{150}{4}\right)^2}} = \frac{250}{50 \cdot \sqrt{\frac{25}{16}}} = \frac{1000}{250} = 4.0 \quad P_f = 3.17 \cdot 10^{-5}$$

À posteriori assessment

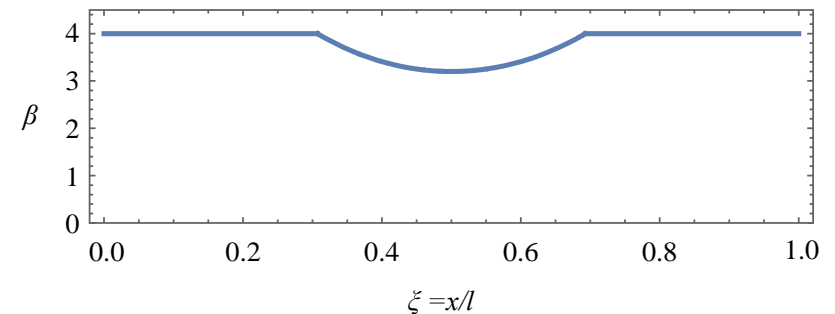


Example: à posteriori assessment



$$\beta = \text{Min} \left(\frac{v \cdot \mu_{M_R} - \mu_P \cdot \xi \cdot (1 - \xi) \cdot l}{\sqrt{\sigma_{M_R}^2 + (\sigma_P \cdot \xi \cdot (1 - \xi) \cdot l)^2}}, 4 \right)$$

$$P_f = \Phi(-\beta)$$



$$P_f = \int_0^1 \Phi \left(-\text{Min} \left(\frac{v \cdot \mu_{M_R} - \mu_P \cdot \xi \cdot (1 - \xi) \cdot l}{\sqrt{\sigma_{M_R}^2 + (\sigma_P \cdot \xi \cdot (1 - \xi) \cdot l)^2}}, 4 \right) \right) \cdot d\xi = \int_0^1 \Phi \left(-\text{Min} \left(\frac{0.9 \cdot \mu_{M_R} - 100 \cdot \xi \cdot (1 - \xi) \cdot 10}{\sqrt{20^2 + (15 \cdot \xi \cdot (1 - \xi) \cdot 10)^2}}, 4 \right) \right) \cdot d\xi = 15.69 \cdot 10^{-5}$$

$$\beta = -\Phi^{-1}(P_f) = 3.6$$

Conclusions

- Safety and serviceability are adequate bridge KPIs
- Why not condition state:
 - Condition is not proxy for safety and serviceability
 - The condition state is actually a vague measure for the deviation of an inspected bridge from the “as new” condition.
- Durability is “safety” / “serviceability” over time ...
- Safety and serviceability (=reliability) of the “virgin” bridge should be used as a baseline.
- Observation may be used directly used to update safety and serviceability both
 - qualitatively and
 - quantitatively.

Future work

- Definition of simplified structural system for different types of bridges
 - Load rating practice in Europe
- Definition of likelihood definitions for available observation types in
 - Germany
 - Switzerland and
 - EU (COST Action TU 1406)
- Development of Bayesian networks & updating procedures