

Annual versus lifetime

Life time failure probability: $P_{fn} = \Sigma P_i$

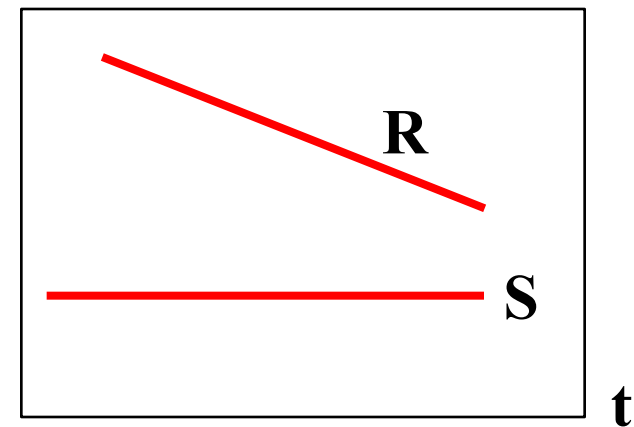
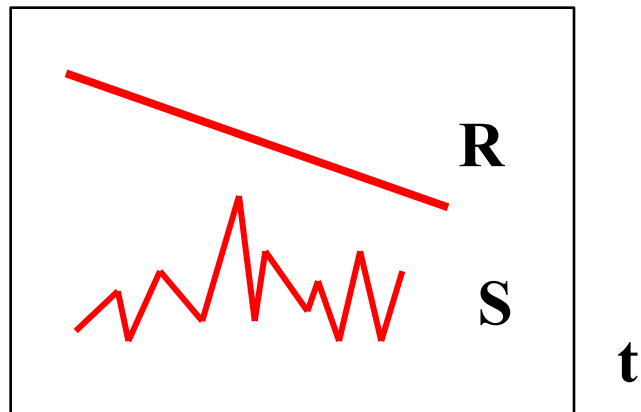
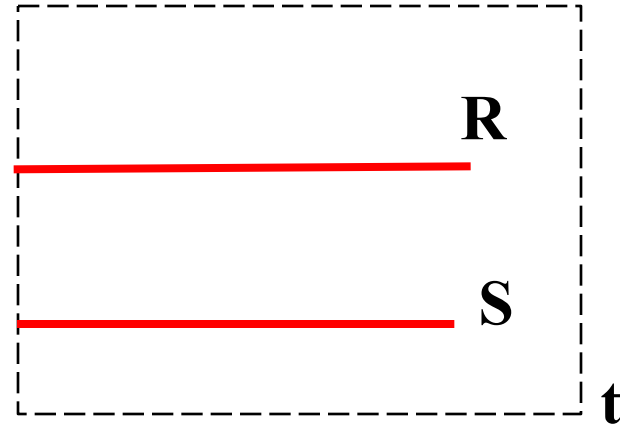
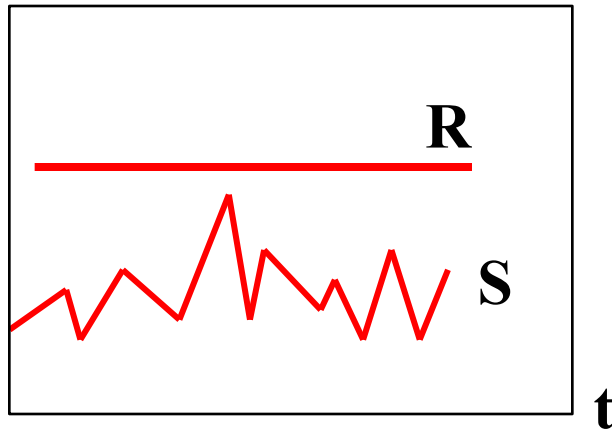
Annual failure probability: $P_{fa} = \max P_i$

$$\begin{aligned} P_i &= P(g_i < 0 \cap g_{i-1} > 0 \cap g_{i-2} > 0 \dots) \\ &\approx P(g_i < 0 \cap g_{i-1} > 0) \\ &\approx P(g_i < 0) \end{aligned}$$

P_i = probability of failure in year i ($i=1..n$)

g_i = limit state function for year i

4 basic cases



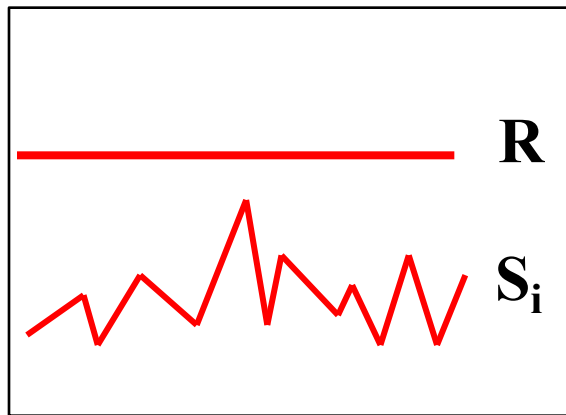
Standard case

- ULS
- SLS deflection
- SLS cracking mechanical actions

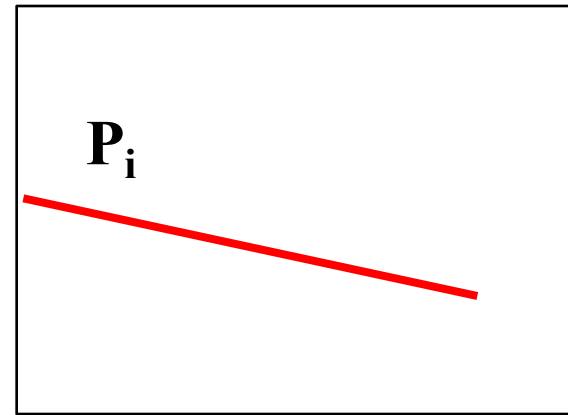
$$g_i = R - S_i$$

R is resistance constant in time

S_i is stationary randomly fluctuating



time



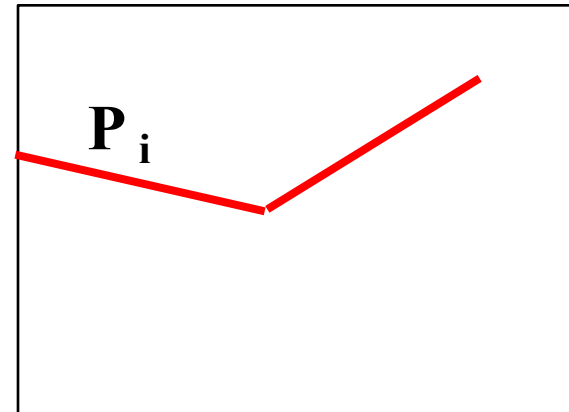
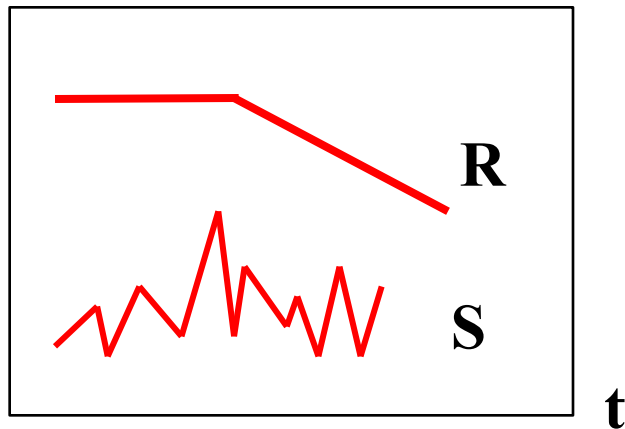
time

$$P_{fn} = P(R - \max S_i < 0) < \text{target} = \Phi(-3.8) \quad (\text{in 50 a})$$

$$P_{fa} = P(R - S_1 < 0) < \text{target} = \Phi(-3.8) / n_{eq} \approx \Phi(-4.2)$$

Including (gradual) degradation

- Fatigue
- Corrosion



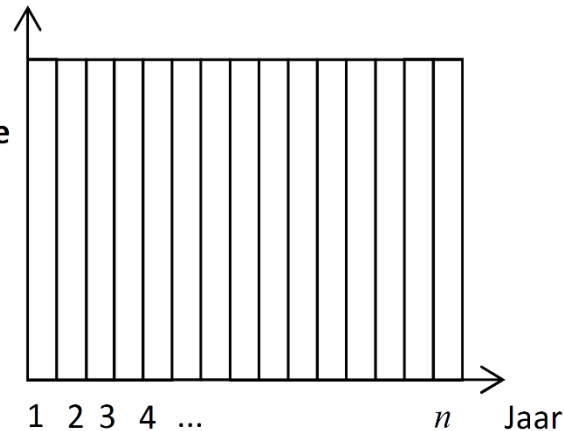
$$P_{fn} \approx P(R_n - \max S_i < 0) < \text{target} = \Phi(-3.8) \quad (\text{in } 50 \text{ a})$$

$$P_{fa} = \max \left\{ \begin{array}{l} P(R_1 - S_1 < 0) \\ P(R_n - S_n < 0) \end{array} \right\} < \text{target}$$

(if R or dR/dt may increase in time, P_{fa} should be checked for all years)

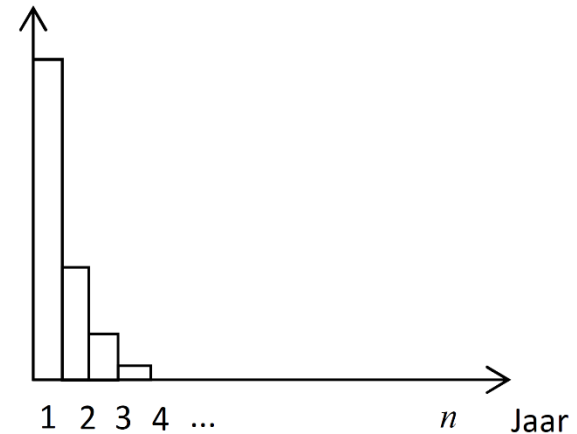
A. Geen correlatie tussen de jaren

Kans op falen in jaar i gegeven geen falen in voorgaande jaren



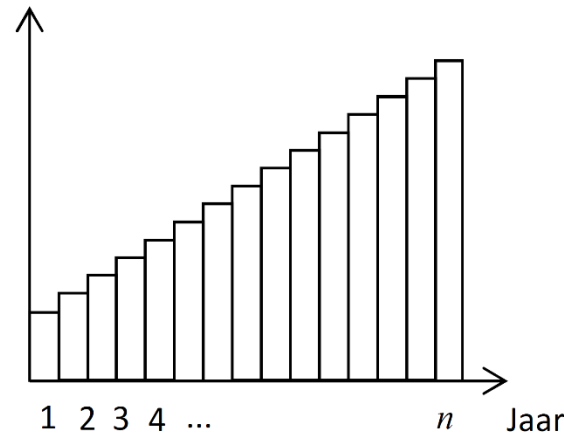
B. Correlatie tussen de jaren groot

Kans op falen in jaar i gegeven geen falen in voorgaande jaren

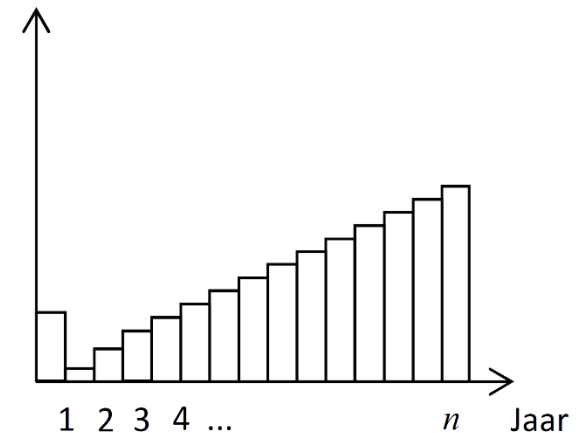


C. Geen stijgende belasting en/of degradatie (stationair)

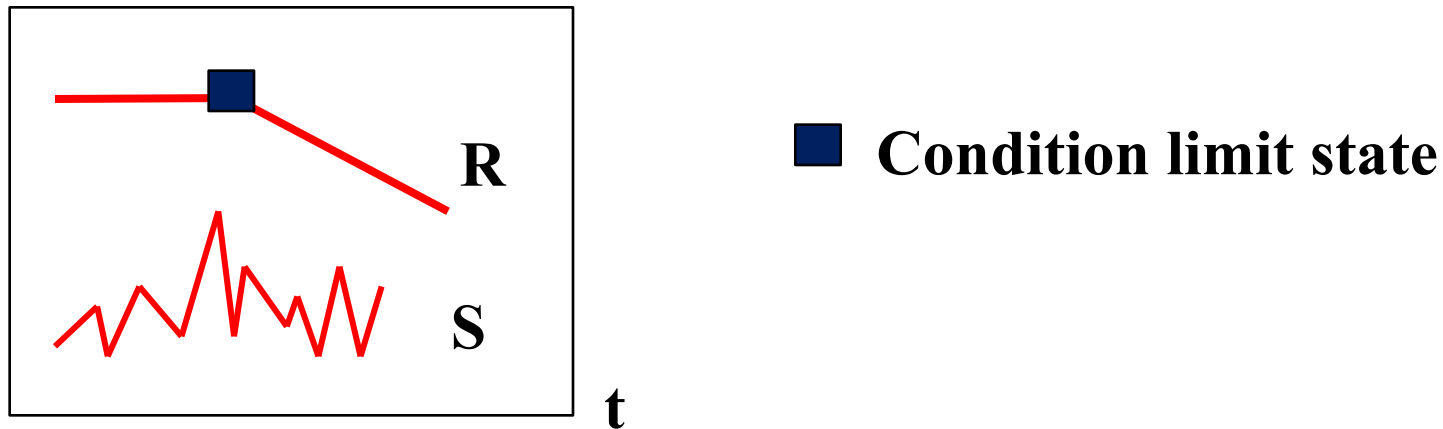
Kans op falen in jaar i gegeven geen falen in voorgaande jaren



Kans op falen in jaar i gegeven geen falen in voorgaande jaren



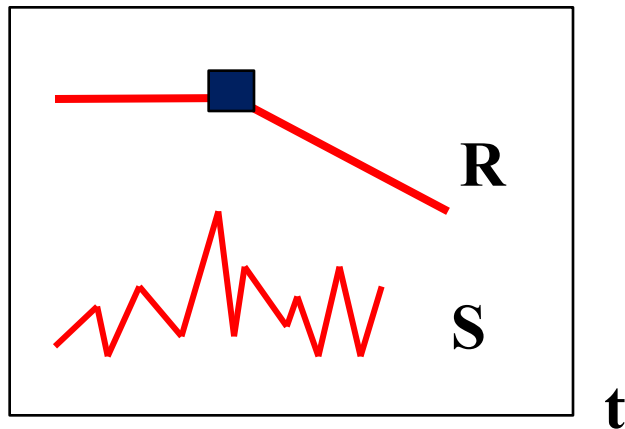
Including (gradual) degradation



$$P_{fn} < P(R_n - \max S_i < 0) < \text{target} \quad (\text{say } \Phi -3.8) \quad (\text{in } 50 \text{ a})$$

$$P_{fa} = \max \left\{ \begin{array}{l} P(R_1 - S_1 < 0) \\ P(R_n - S_n < 0) \end{array} \right\} < \text{target}$$

Including gradual degradation



■ Condition limit state

$$P_{fn} = P(R_1 - \max S_i < 0) < \text{target} = \Phi(-3.8) \quad (50 \text{ a})$$

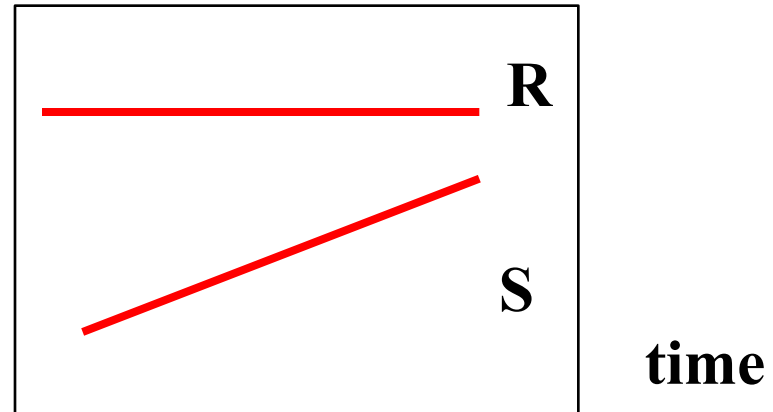
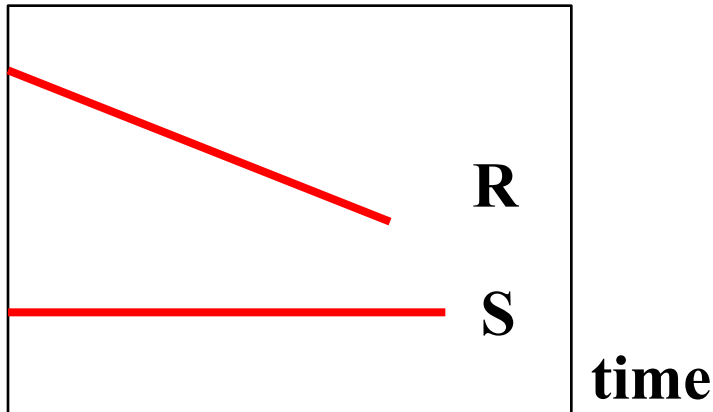
AND

$$P(\text{conditional limit state}) < 0.01-0.1$$

???????

Non fluctuating actions

- SLS cracking environmental actions
- CLS depassivation



$$P_{fn} = P(R_n - S < 0) < \text{target} = \Phi(-1.8) \quad (\text{in } 50 \text{ a})$$

$$P_{fa} = P(R_n - S_n < 0 \cap R_{n-1} - S_{n-1} > 0 ..) = \text{????}$$