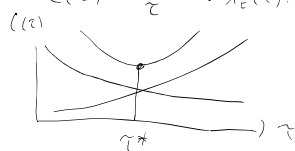


Funktor = Verb + Substantiv  
pumpen Wasser

MRT = Mean Down Time  
= MLD + MRT  
MLD = Mean Logarithmic Delay  
MRT = Mean Repair Time

FC = Forebyggende uddeltal = FAR sister  
 KV = Konigevende -11- = ETTA -11-

$$C(\tau) = \frac{C_{FV}}{\tau} + \lambda_E(\tau) \cdot C_{subf}$$


Heute: *unabhängig*

Soll

Ist

Vorteilhaftigkeit

Highway

|      |     |
|------|-----|
| MS61 |     |
| MS62 | RCM |
| MS63 | RCM |

Tid

- Analyse der Systemfunktion

## RCM

### Analyse av systemfunksjon

Hvordan feiler de?

Hva kan vi gjøre for å forebygge  
med hensyn på å balansere

- Sikkerhet
- tilgjengelighet
- kostnad
- M, L, Ø
- Omkomme
- :

### Ulike typer

Funksjonsfeitanalyse

FMEA = Failure mode and effect analysis

RCM = Reliability centered maintenance

Innervell fast vedlike

### FMEA - Funksjonsfeitanalyse

Hva er systemet sine funksjoner (f. eks. oppdrift / funksjon)

Funksjon = Verb + Substantiv

+ hvem

Hovedfunksjon

Tilleggsfunksjon, feil, negative moment

Når vi får funnet funksjonene, finner funksjonsfeil  
= hva er funksjon

Ranger funksjonsfeilene, Rødt, gult, grønt

For de viktigste, for tilhørende komponenter

MSI / Komponenter  $\Rightarrow$  FMEA

FMEA = Failure mode effect and criticality analysis

= Tabell-dreie

| MSI | FM | FA | Z(t) | - |  |  |  |
|-----|----|----|------|---|--|--|--|
|     |    |    |      |   |  |  |  |

### Funksjon : pumpe

Dykte vann fra A til B, 800 l/min

Holdt tett

Forbakte at vi har en feil

Antagelser av oppnevnte modus/diagnose

Feilmode: Hvordan feilen viser seg i et systemet uten for

F. eks. pumper ikke

-11- for lite

$\neq$  Årsake

### Feilårsak

• Direkte årsak / underkomponent, Reg. v. utløst

• Rotårsak

- Dårlig vedlikehold

- i et brudd

- i et design

Feilmekanisme

Systemfeilmekanisme

Fysiske og kjemiske prosesser  
som leder til feil

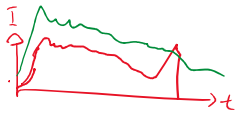
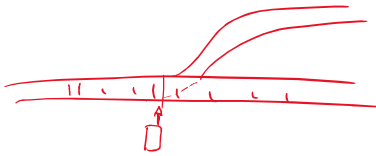
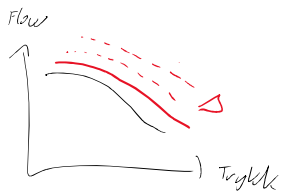
- Sikkerhet

- Korrupsjon

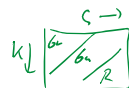
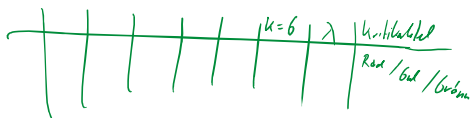
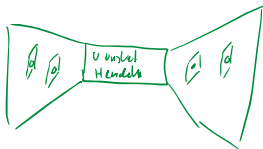
- Utmattelse

- Korrupsjon

- Ising



Bowtie

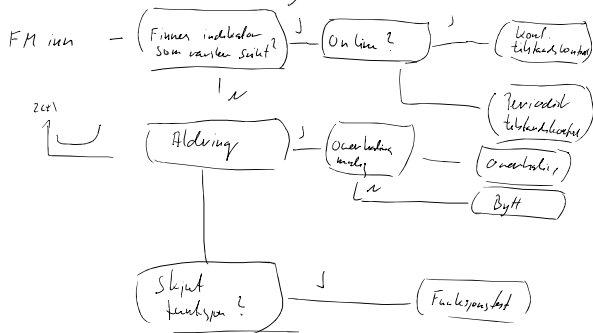


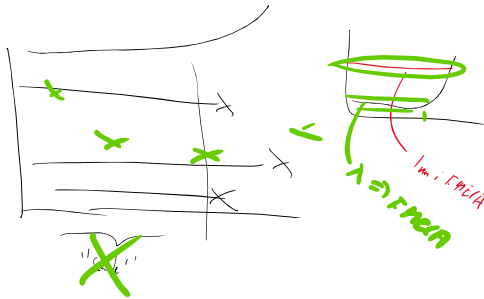
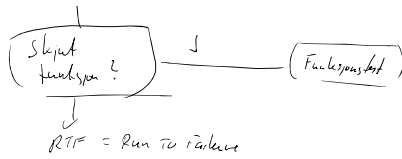
Rend (bud) kunden FV-programm

3 situationen

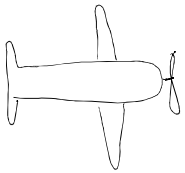
- 1) Tidkunds info varar kommande för.
- 2) Nya tidkundsinfo men aldrig.
- 3) Skript funktion

RCM Beslutningslogik



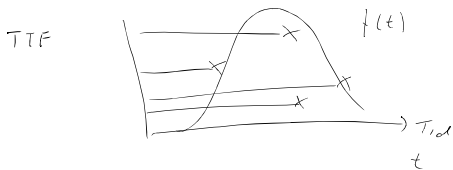


Syklus  
 Traktor  
 FFA  
 $V_{pde} \Rightarrow MS = \text{Maximal sig. item} = \text{Komponent}$   
 FMA  
 FMA / Mechanism  $\rightarrow$  Lett "last"  
 T1166

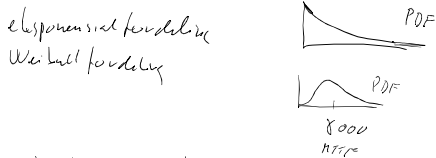


$$P(TTF > 10) = R(t) = e^{-\lambda \cdot 10}$$

Exp,  $MTTF = 10000$ ,  $\lambda = \frac{1}{10000}$



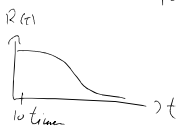
$f(t) = \text{Scunsgungshet teltitet} = \text{PDF}$



$F(t) = \text{kumulierte Verteilungsfunktion}$

$$F(t) = P(TTF \leq t) = \int_0^t f(u) du$$

$R(t) = 1 - F(t) = \text{Overlebenswahrscheinlichkeit}$   
 $= P(TTF > t)$



Exponential:  $R(t) = e^{-\lambda t}$   
 wenn  $\lambda = \text{fehlerrate} = \text{Wahrscheinlichkeit}$   
 $= \text{Schadensintensität}$

Weibull:  $R(t) = e^{-(\lambda t)^\alpha}$   
 $\alpha = \text{alterungsparameter}$   
 $\lambda = \text{intensitätsparameter}$

Funktionssymbol:  $E(X)$

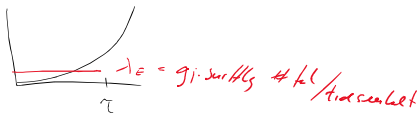
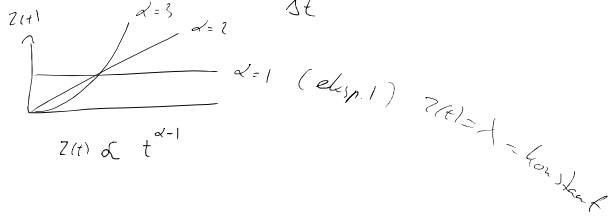
$$= \int_0^{\infty} t \cdot f(t) dt = MTTF = \text{Mean Time To Failure}$$

Exponentialfunktion:  $MTTF = 1/\lambda$

$$\text{Weibull} \quad MTTF = \frac{1}{\lambda} \cdot \Gamma(1 + \frac{1}{\alpha})$$

$P(t)$  = gemessene Funktion

$$Z(t) = \text{Schadensintensität} = P(TTF \in [t, t+\Delta t] | TTF > t)$$



$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

$$P(TTF > x+t | TTF > t)$$

$$\begin{aligned} t &= 8000 \\ x &= 10 \end{aligned} = \frac{P(TTF > x+t \cap TTF > t)}{P(TTF > t)}$$

$$= \frac{P(TTF > x+t)}{P(TTF > t)} = \frac{R(x+t)}{R(t)}$$

$$= \frac{e^{-(x+t)\lambda}}{e^{-\lambda t}} = e^{-(x+t)\lambda + \lambda t} = e^{-\lambda x}$$

$$\frac{e^{-\lambda(x+t)}}{e^{-(t+t)\lambda}}$$



Fehleranalyse für analysierendes physikalisches System  
FTA

Trin 1: Find TOPP-Beurteilung des vorgegebenen Systems  
TOPP: { Ungerade, Paralel } = ungerade Beurteilung



Hier: Binär  
Hier: 1. Kugelballen  
Hier: Nachspiel

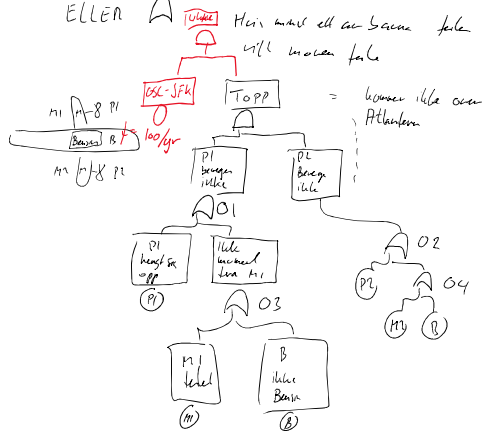
2. Konstruieren der FTA

Start mit TOPP  
Speziell um darzustellen  
Kette durchgezogene bis TOPP  
und hier für OB oder ELLER-Porten

OG: : Alle Baum bis "unten" / "oben" für at machen - " - "

ELLER: Hier muss es der Baum sein

ELLEN A  Hier muss ich eine Sache klar  
stellen


$$\begin{aligned} & \{ \text{TOPP} \} \quad \text{I} \\ & \{ \text{OI}, \text{OZ} \} \quad \text{II} \\ & \{ \text{PI}, \text{OZ} \} \quad \text{III} \\ & \{ \text{OS}, \text{OZ} \} \quad \text{III} \\ & \left. \begin{aligned} & \{ \text{PI}, \text{PZ} \} \quad \text{I} \\ & \{ \text{PI}, \text{OZ} \} \quad \text{I} \\ & \{ \text{OZ}, \text{PZ} \} \quad \text{I} \\ & \{ \text{OZ}, \text{OZ} \} \quad \text{I} \end{aligned} \right\} \text{IV} \end{aligned}$$

$\{D1, P2\}$   
 $\{D1, K2\}$   
 ~~$\{D1, B\}$~~   
 $\{K1, P2\}$   
 ~~$\{B, P2\}$~~

$\{K1, B\}$   
 ~~$\{B, K2\}$~~   
 ~~$\{B, B\}$~~

$\{K1, P2\}$   
 ~~$\{B, P2\}$~~

$\{B\}$

Kulturmengen: Mengen an Basislandeschen (0) son  
er sllle al om alle inatteffer vill ogsa  
TOPP inatteffe

Minimal Kluftmaß: Kluftmaß soll nicht kleiner werden als ein viertes der statischen Kluftmaße.

Kun Honeydew er orden 1 er de ubegste

4) Kwalitatieve analyse

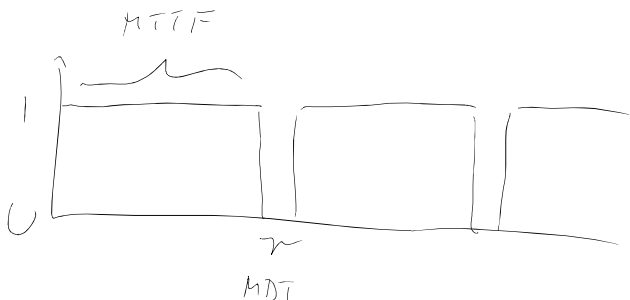
Liste minimale Kaufmengen in steigender Reihenfolge

5 Quantitative analysis

# Komponente

### 3 Situation

1) Reparaturkomponent



$$A = \text{Teilenergie} = \frac{K_{TTF}}{K_{TTF} + K_{\eta T}}$$

$V = 6 - 11 =$

$$\frac{MDT}{Mitf + MDT}$$

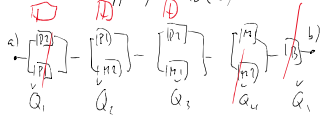
$$q_i(t) = \begin{cases} \text{NOT} \cdot \lambda \cdot E_i \\ 1 - e^{-\lambda \cdot E_i \cdot t} \\ \lambda \tau_i \end{cases}$$

$$P_r(\text{TOPP imstrücker}) = Q_0(t)$$

a)

$$q_{p1} = 10^{-2}$$

$$Pr(TOPP \text{ i standstille}) = Q_0(t)$$



$$q_{A1} = 10^{-6}$$

$$q_{A2} = 10^{-6}$$

$$Pr(A|B) = Pr(A) \cdot Pr(B)$$

hvis A og B er uafhængige

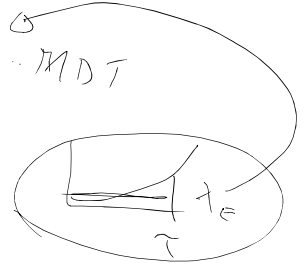
$$Pr(A \cup B) = Pr(A) + Pr(B)$$

$$Pr(A \cap B)$$

$$q_c = U \sim \frac{MDT}{MTTF} = \lambda \cdot MDT$$

$$= R(\text{komponent ikke virker})$$

$$MTTF + MDT$$



Hvordan forskellen på en sandsynlighed og en frekvens?

$F_0$  = Frekvens af TOPP-handelen

$$= q_{p1} \cdot q_{p2} \cdot t + q_{p1} \cdot q_{p2} \cdot t + \dots$$

2 Ikke eksponentiel komponent

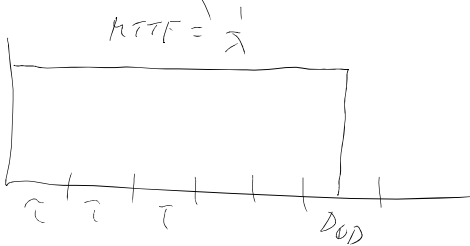
$$q_i = 1 - e^{-\lambda t}$$

,  $t$  er "mission time",  $t_0$  time.

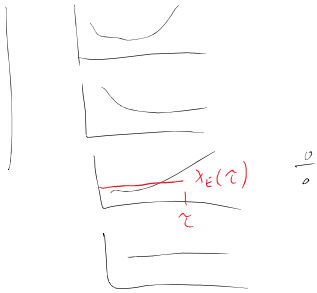
$$= q_i(t), \lambda = \lambda_E$$

3 Skjult funktion, trænger funktionstest

$$q_i = \frac{\lambda \cdot \tau}{2}, \tau = \text{interval for funktionstest}$$



$$q_i = \lambda_0 \cdot MDT = \lambda \cdot \frac{MDT}{2}$$

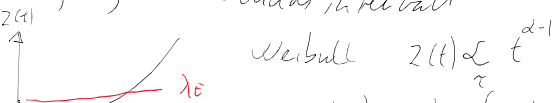


Th?

Alder / drifttid / km

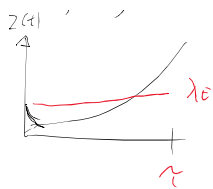
Funktionstest

Alders og vedligeholdelsesinterval



$$\text{Weibull } Z(t) \propto t^{\alpha-1}$$

$$\left[ \frac{1}{1 + \frac{1}{\alpha}} \right]^{\alpha-1}$$



Weibull  $z(t) \propto t^{\alpha-1}$

$$\lambda_E(\tau) \approx \frac{1}{\tau} \int_0^{\tau} z(t) dt = \dots = \left[ \frac{\Gamma(1+\frac{1}{\alpha})}{\Gamma(1+\frac{1}{\alpha})} \right]^{\alpha-1} \cdot \tau^{\alpha-1}$$

## Kostensmodell

Kostenelement

$$C_{PM} = C_{EV} = 10' \quad \text{fortgeschrittene Welle} = (\text{Dele}) + (\text{tief})$$

$$C_F = \text{Totale Fehlerrückmeldung und Suchen} = C_{CH} + C_{EP} + C_{ES} + C_{EM} \dots$$

$$C_{CH} = \text{konvergierende Wellekosten} = (\text{Dele}) + (\text{tief}) > C_{PM}$$

$$C_{EP} = \text{fortgeschrittene Produktionskosten}$$

$$= \text{Pr (komponentensuche für Systemsuche)} \cdot [C_T + C_U \cdot \text{MDT}]$$

$$C_T = \text{Trippelkosten}$$

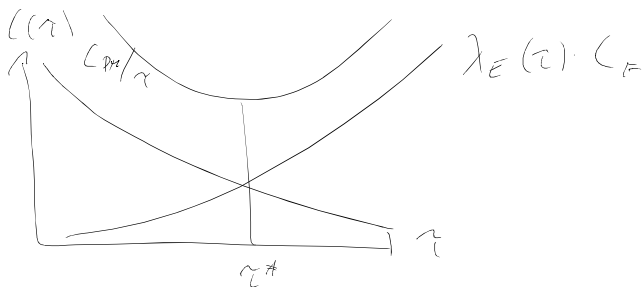
$$C_U = \text{Kosten und Nachschub pro Teilzahl}$$

$$\text{MDT} = \text{Mittelwert nach Zeit}$$

$$C_{ES} = \text{Suchkosten} = \text{Pr (komponentensuche für Welle)} \cdot \text{Kosten und Welle}$$

$$C(\tau) = \frac{C_{PM}}{\tau} + \lambda_E(\tau) \cdot C_F$$

$$= \frac{C_{PM}}{\tau} + \lambda_E(\tau) [C_{CH} + C_{EP} + C_{ES} + \dots]$$

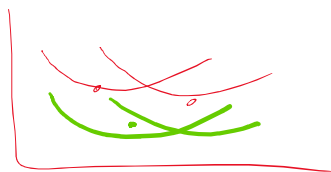


$$C(\tau) = \frac{C_{PM}}{\tau} + \left[ \frac{\Gamma(1+\frac{1}{\alpha})}{\Gamma(1+\frac{1}{\alpha})} \right]^{\alpha-1} \tau^{\alpha-1} \cdot C_F$$

$$C'(\tau) = -\frac{C_{PM}}{\tau^2} + \left[ \frac{\Gamma(1+\frac{1}{\alpha})}{\Gamma(1+\frac{1}{\alpha})} \right]^{\alpha-1} \tau^{\alpha-2} \cdot (\alpha-1) \cdot C_F = 0$$

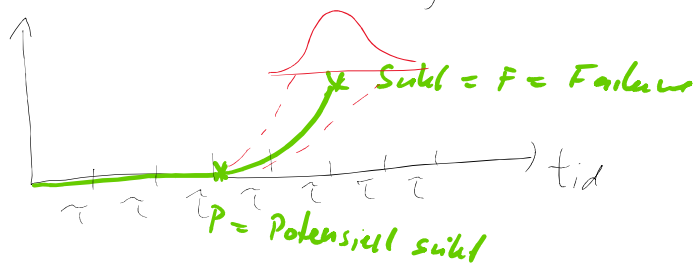
$$\tau = \sqrt[\alpha]{\frac{C_{PM}}{(\alpha-1) \cdot C_F}}$$

$$C_F = [C_{CH} + \text{Pr (komponentensuche für Systemsuche)} \cdot [C_T + C_U \cdot \text{MDT}]]$$

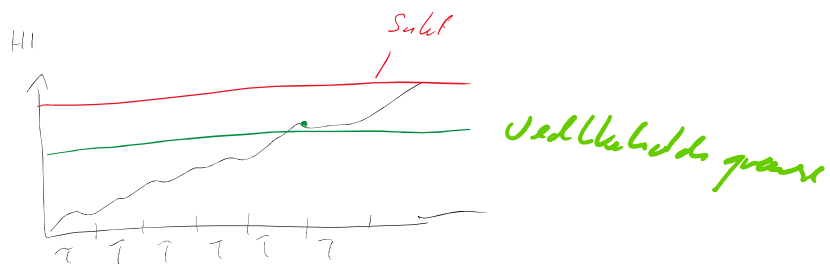


Grundering

HI = Halse indikation (Feilbetragtning)



PF-intervall



Udskudt grænse

