

# Mathematical Models for Optimal Reliability Decisions

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IOP-IPCR Symposium  
System Availability Up; Life Cycle Cost Down  
December 2, 2010

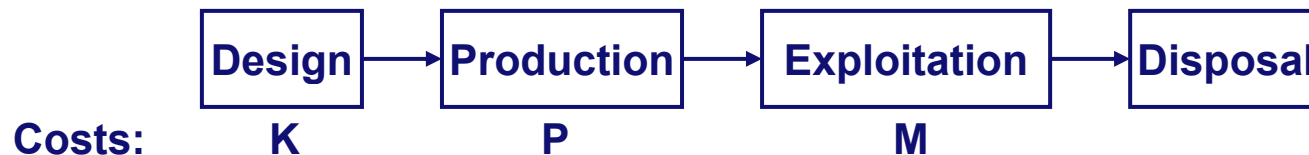
**TU** / **e** Technische Universiteit  
Eindhoven  
University of Technology

Where innovation starts

# Motivation

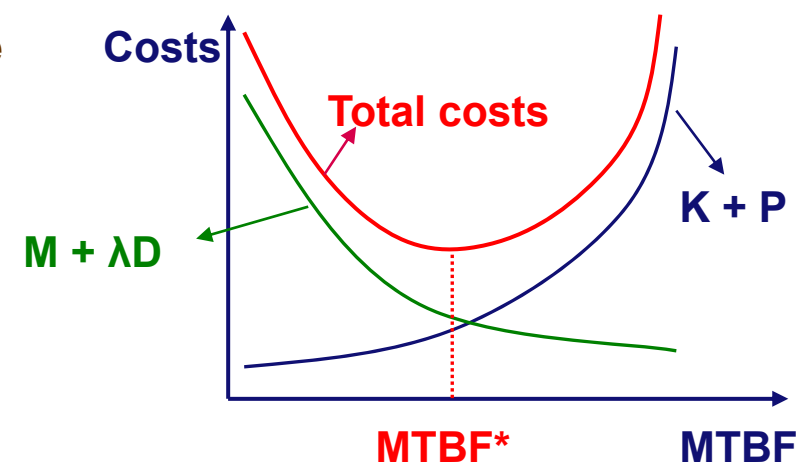
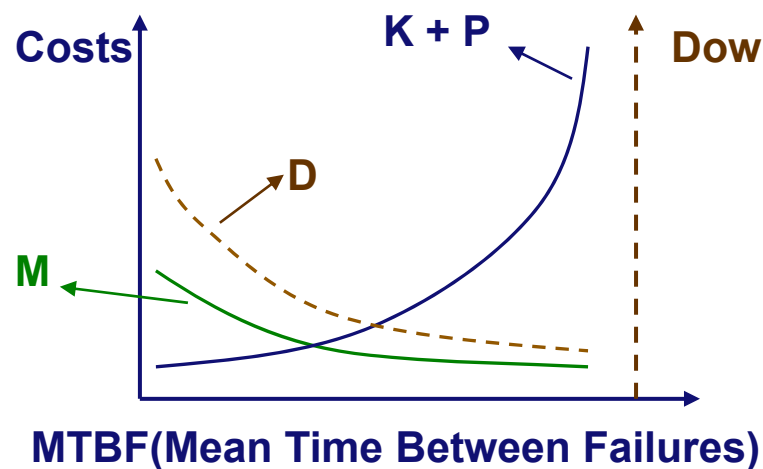
## Capital Goods

- Lifetime: 10-30 years
- Availability is crucial
- Life Cycle Costs (LCC)  
or Total Cost of Ownership (TCO)
  - **Downtime costs ~ 50% of TCO**
  - **Maintenance costs + Downtime costs ~ 75% of TCO**



# Reliability Decisions

- Reliability levels of components
- Redundancy



**$K(\text{MTBF})$** : Design costs  
 **$P(\text{MTBF})$** : Production costs  
 **$M(\text{MTBF})$** : Maintenance costs  
 **$D(\text{MTBF})$** : Downtime

$\lambda$ : Downtime cost rate

# Key Aspects and Costs

## Key Aspects

- Multiple systems
- Spare parts inventory
  - Emergency procedure
  - Spare parts inventory level is optimized
- Critical components

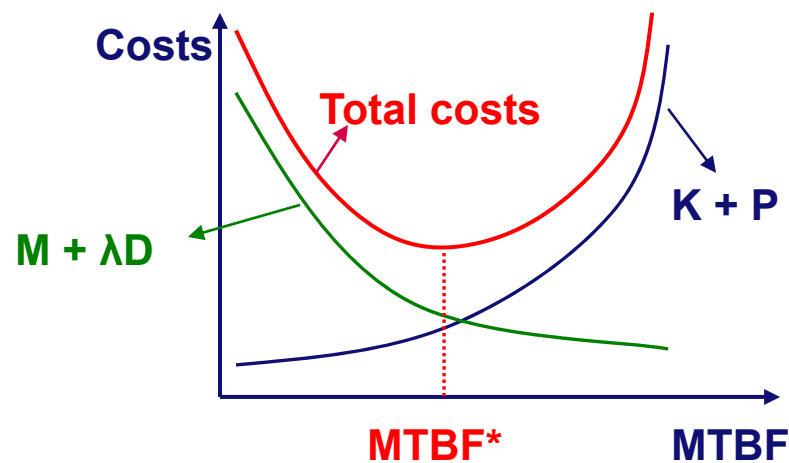
## Costs Factors Incorporated

- Design and production costs (acquisition costs)
- Spare parts inventory costs
- Maintenance costs
- Downtime costs (availability constraints)

# Reliability Decisions - Results

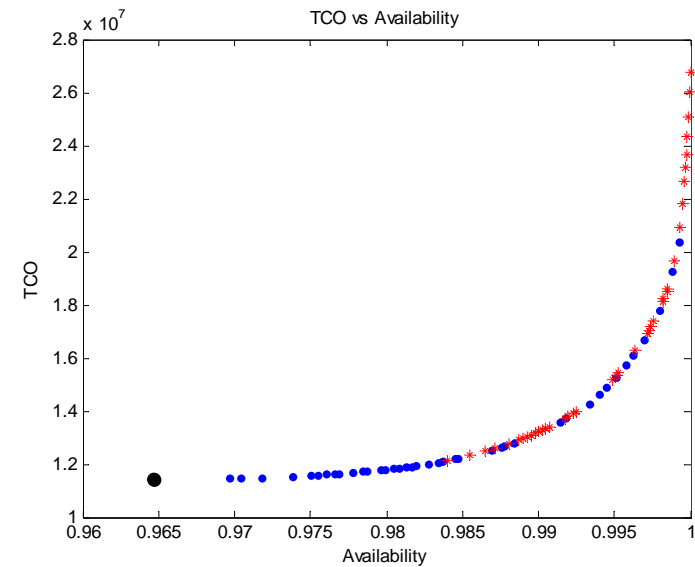
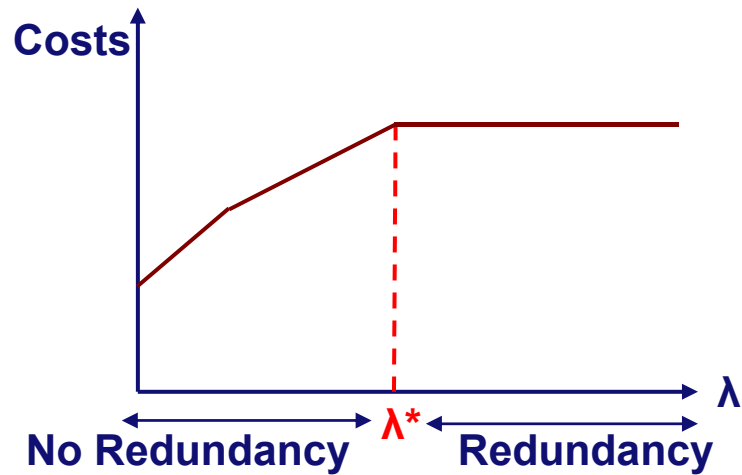
## Reliability levels of component

- Optimal MTBF increases as a function of
  - number of systems
  - downtime cost rate (availability requirement)
  - system lifetime



# Reliability Decisions - Results

## Redundancy



25 systems with 40 components

# Effects of the Research

- **New product development**
  - Deals with suppliers
  - Options for customers
- **Service logistics**
  - Service contracts
  - Service operations
  - Spare parts inventory



**A workbook including tools**

**Tools are available at:**

**<http://www.utwente.nl/mb/ompl/iop-ipcr/>**



Vanderlande Industries

# Praktische implicaties Life Cycle Costing Tools

IOP Conferentie  
2 december 2010

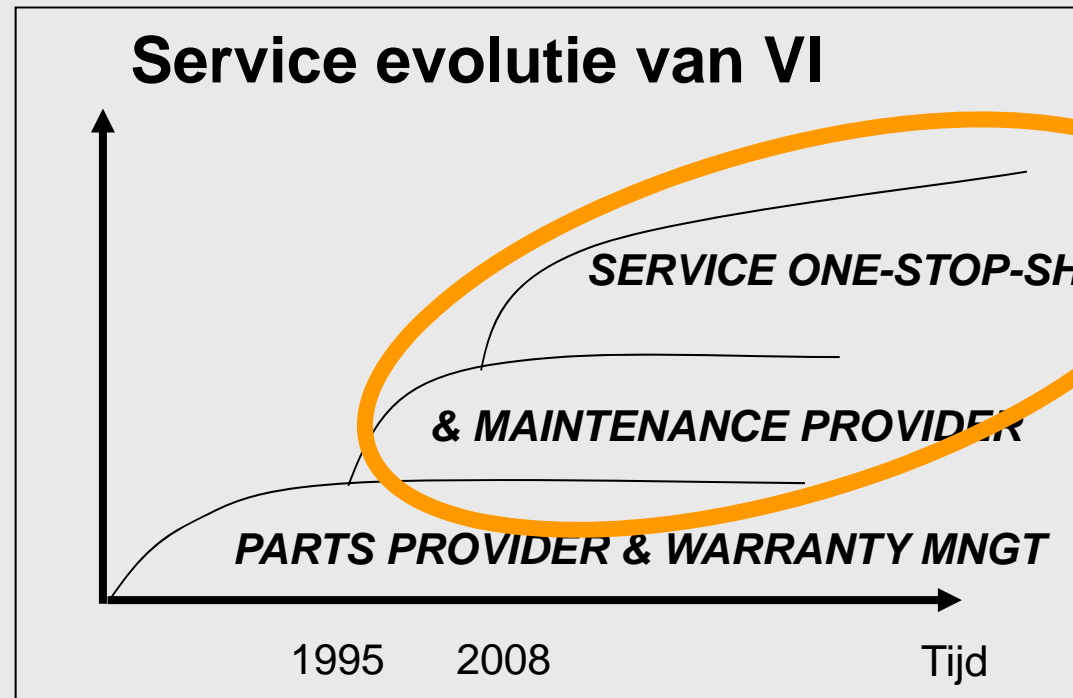
## Vanderlande Industries, Radj Bachoe

- Geïntegreerde logistieke oplossingen
  - 60 jaar ervaring
  - Ontwerpen,
  - Implementeren,
  - Operatie
  - Service



- 2000 medewerkers waarvan 40% in de service dienstverlening
- Omzet 655 Mio in 2009

## Vanderlande Industries, Service

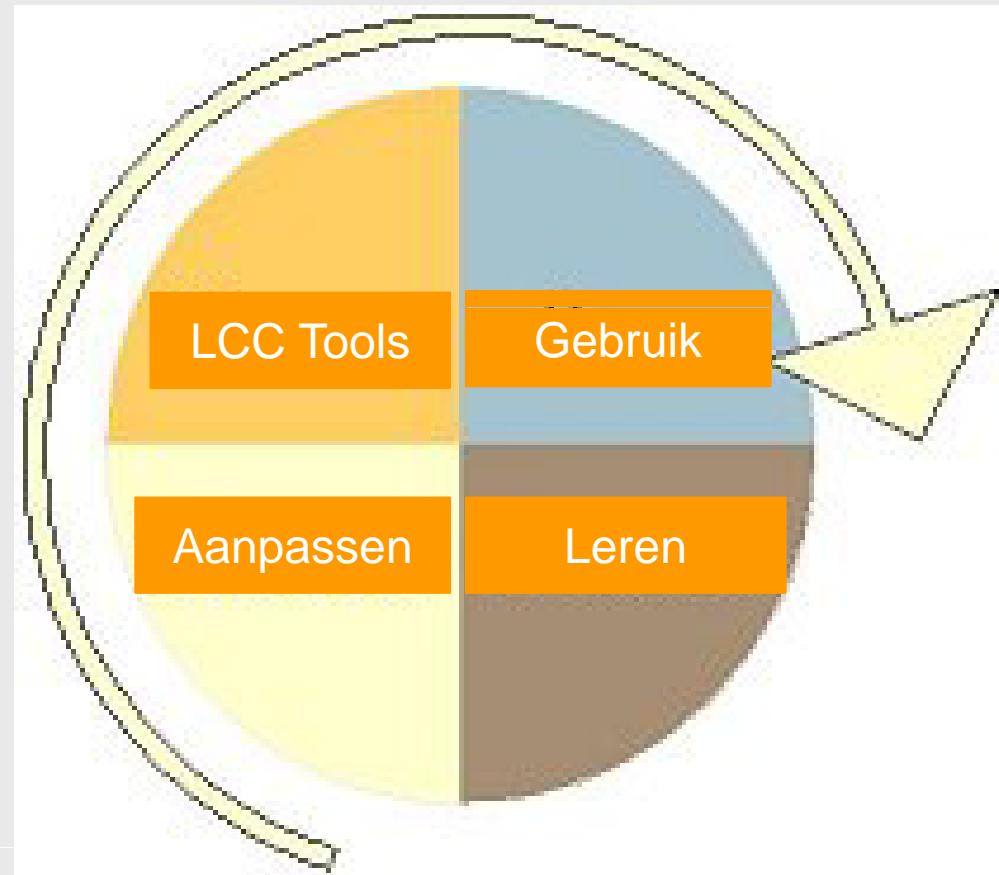


Van Re-actief naar Pro-actief

Van onderdelen leverancier naar kennis center

## Key issues voor Life Cycle Costing tools

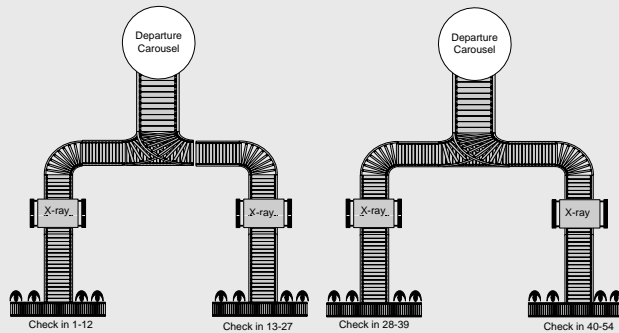
- Consistentie
- Reproduceerbaarheid
- Flexibiliteit
  
- Gebruik praktijk data
  
- De ontwikkelingen staan niet stil, het model ook niet!!



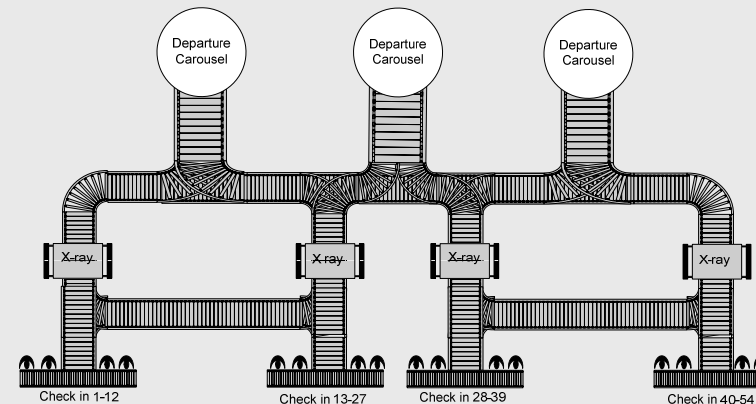
## Voorbeeld: klant propositie

Uit werk van Rutger Vlasblom,  
winnaar SLF afstudeerprijs 2010

### Basis systeem



### Alternatieve systemen



## Voorbeeld: Toeleveranciers

Impact van nieuwe materialen



Robustere besturing



Impact van End Of Life (EOL)



## Voorbeeld: Operatie modellering



Simulatie



Operatie monitoring  
Effecten interactie mens-machine



## Voorbeeld: R&D, Life Cycle Concepts



Impact van nieuwe producten  
Definitie van benodigde test data

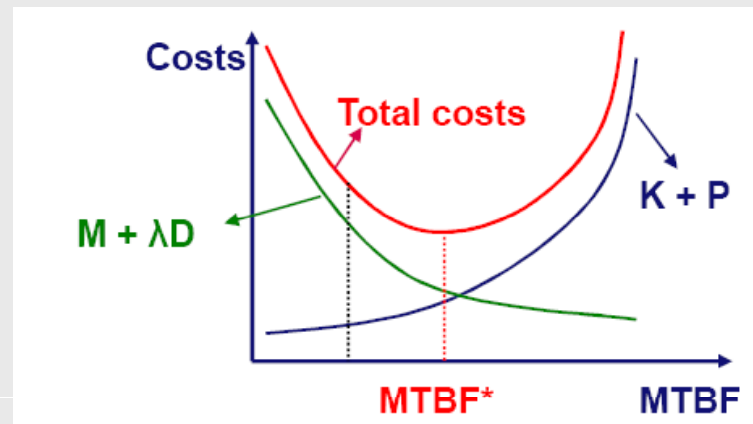


Robuust maken van het systeem  
Voorkomen van operator fouten



## Samenvatting

- Tool: Consistentie en **praktijk gegevens**
- Organisatie: Centrale kennis borging en toegang
- Toepassing: Verschillende invalshoeken eisen veel flexibiliteit



Vragen.....

