Strategic Management of Spare Parts in Closed-Loop Supply Chains

A System Dynamics Approach

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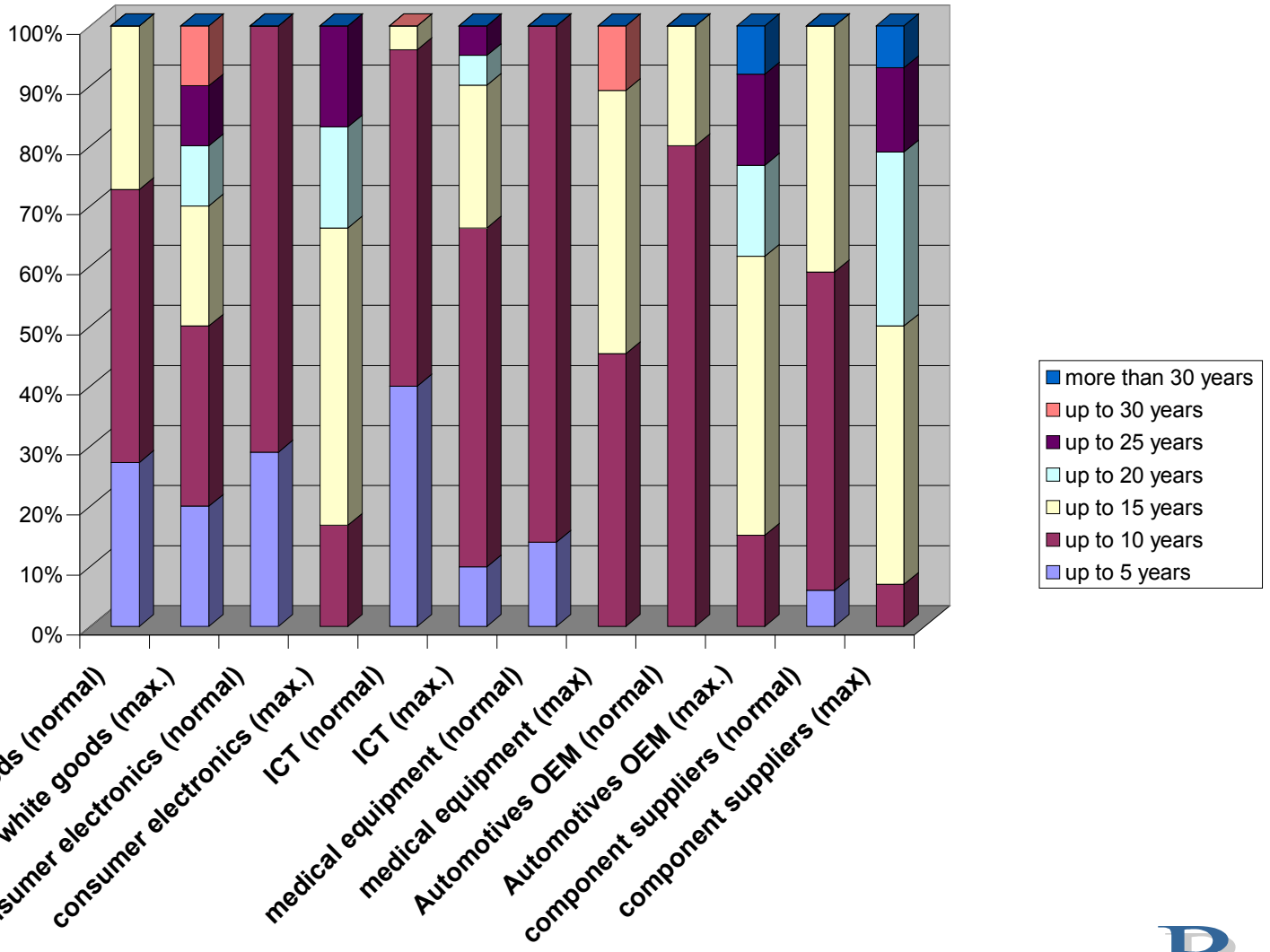
Presentation Outline

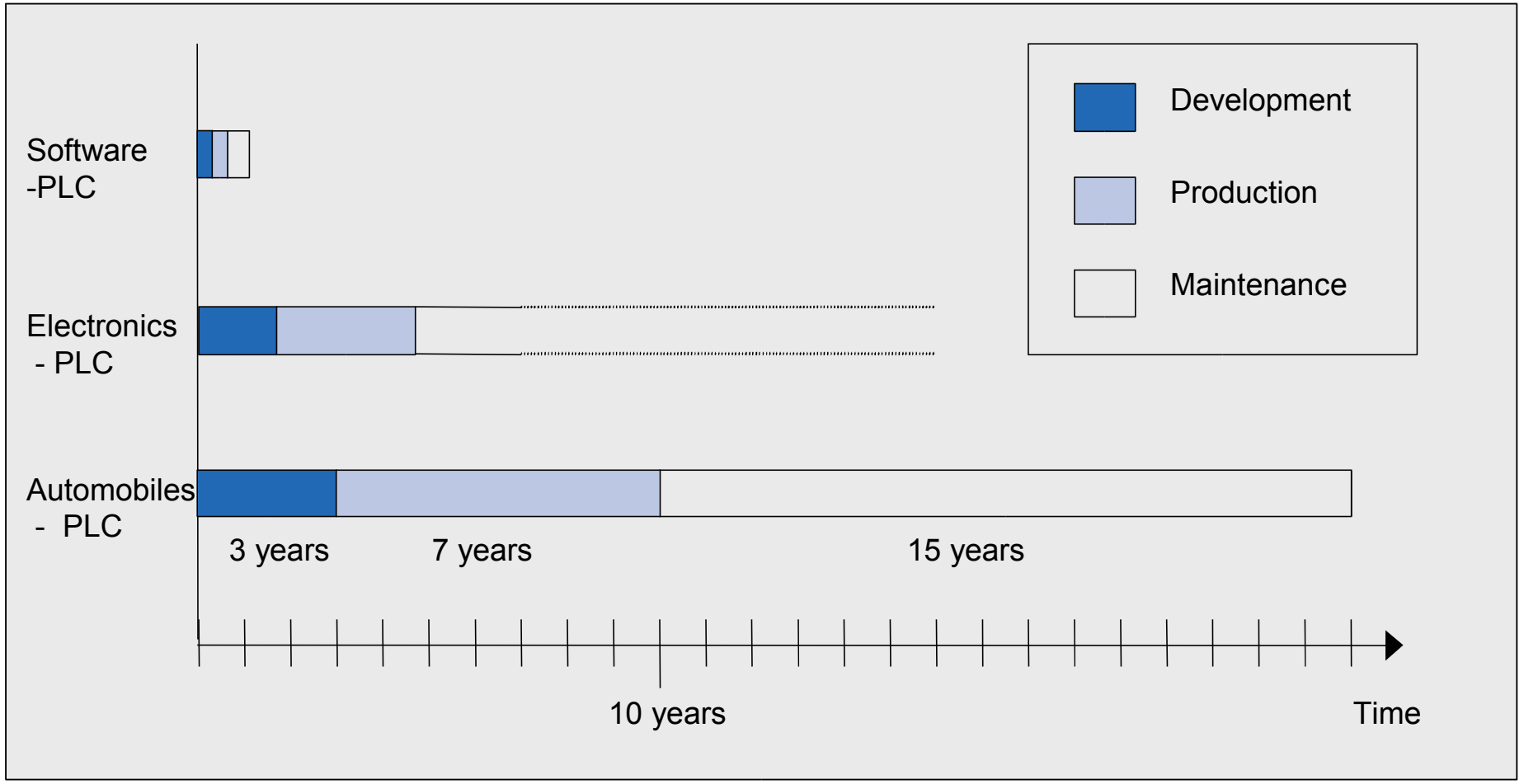
1. Introduction
2. Management of spare parts in the final-service phase
3. Closed-loop supply chains for parts recovery
4. System Dynamics Model
5. Strategies and results
6. Concluding remarks

Guaranteed spare parts supply (Germany)



Ihde et al. 1999

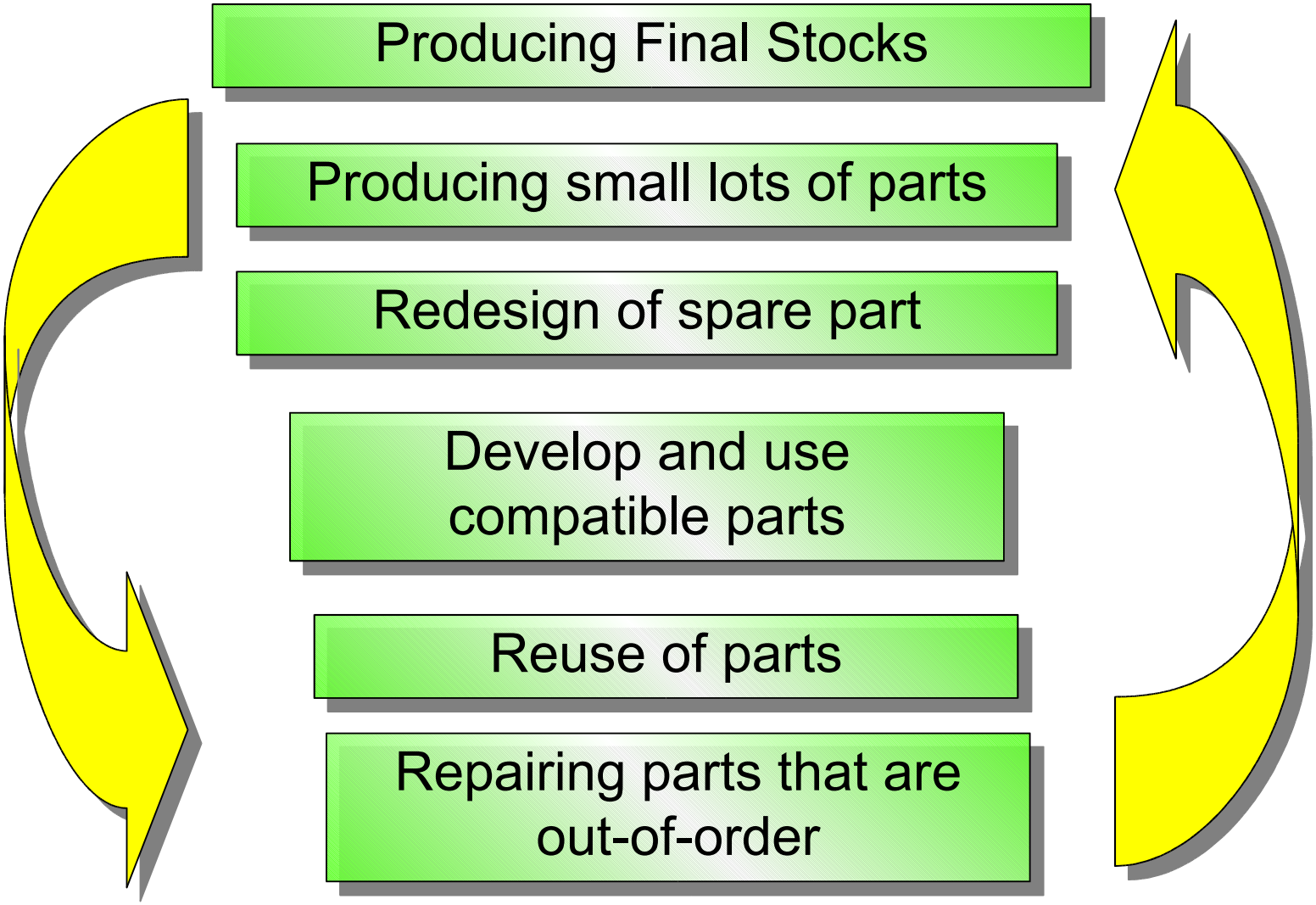
Product life cycles in the electronic and automotive industry



Management of spare parts in the final-service phase

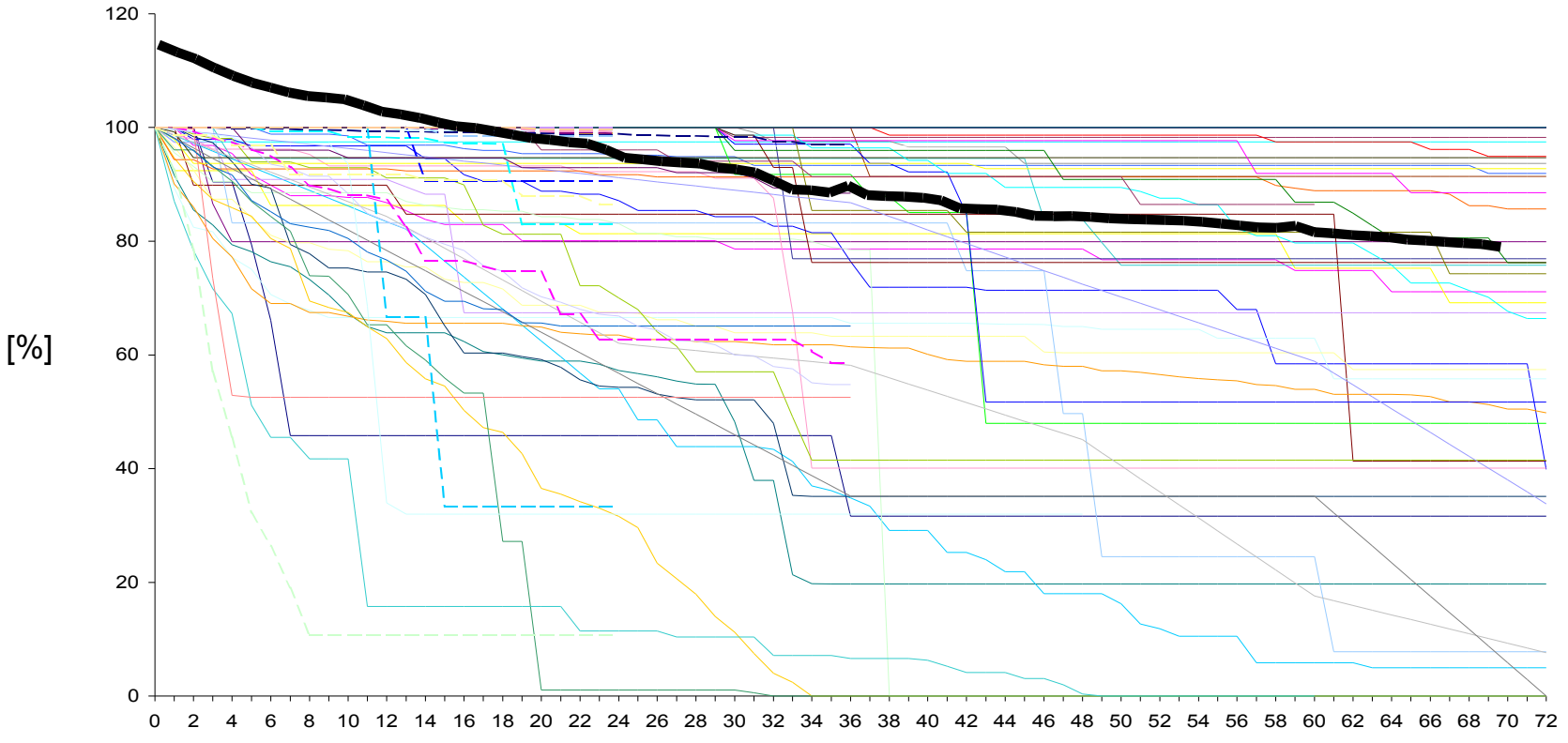
- Producers have to assure spare parts supply for the average lifetime of the product
- Losing economies of scale
  - production volume diminishes rapidly after the production phase is stopped
- Limited flexibility of production equipment
- Discontinued supply of electronic components that are provided from outside suppliers

Strategies to ensure the ability to supply spare parts during the final service phase



Study on final orders (automobile supplier)

➔ **normalized Inventory, 71 final orders, final service phase 15 years**



Example: part discontinued 04/97, out of stock 12/2000, time to redesign 6 Month

Management of spare parts in the final-service phase

- Characteristics of Final Order Policy
  - Build up final stocks that lock up a lot of capital
    - Agfa-Gevaert: 16.5 – 22 Mio. € (30 – 40% of total spare parts inventory)
  - Underestimation of demand
    - Producers have to compensate customers for delivery delay
    - Producers often have to redesign the spare part
  - Firms often fail to monitor final stocks adequately

Integrating parts recovery in spare parts management

- More operational flexibility
- Chance to reduce final stocks and
- Chance to reduce stock-outs
- Closed-loop supply chains are difficult to control
- Uncertainties in
  - Returns volume
  - Timing of returns
  - Yield of recovery
  - ...

Case Study:
Spare parts management in closed-loop supply chains

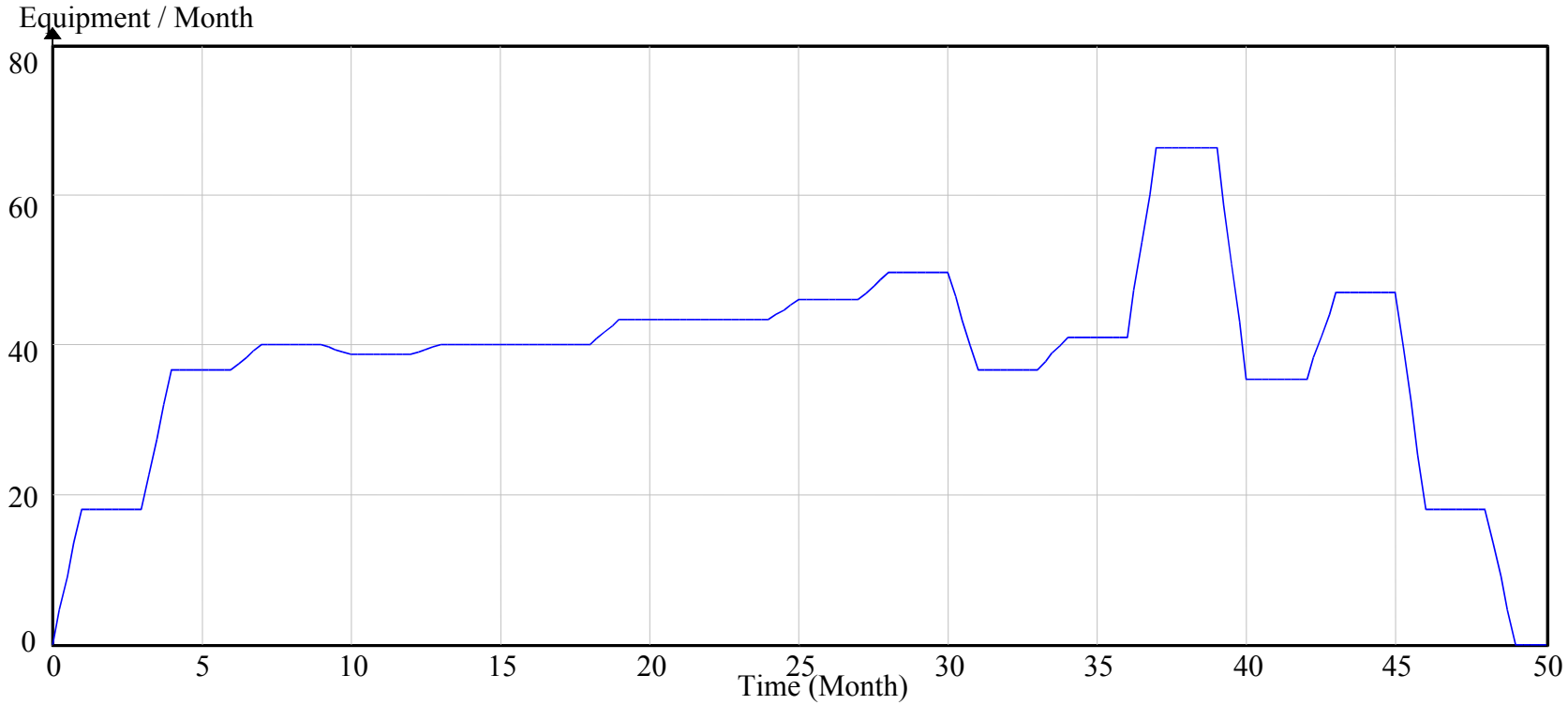
AGFA: ADC Compact

medical diagnosis device which scans and digitizes data from x-ray films

End of Production: 2001

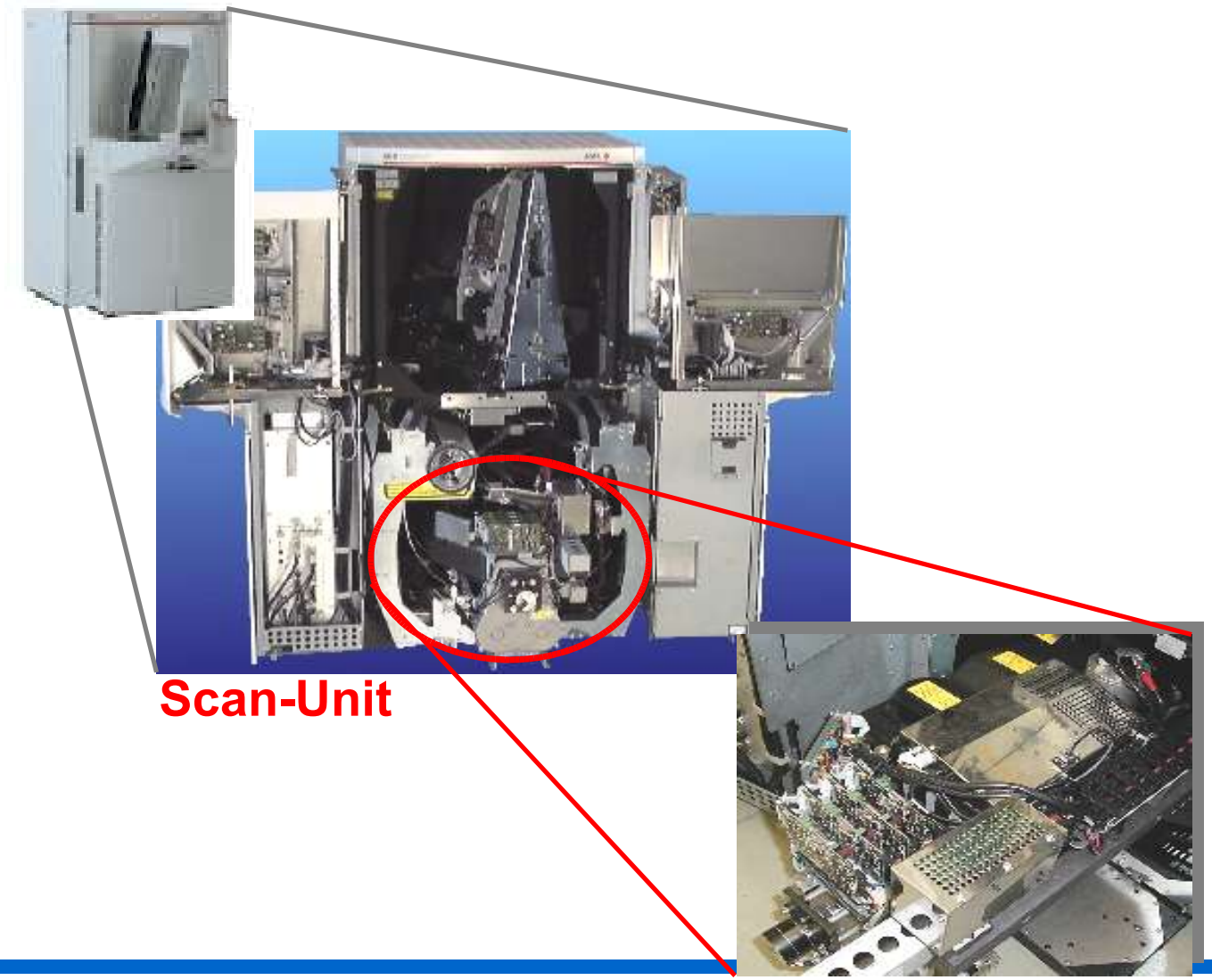
End of Service: 2008

Product Life Cycle of the ADC Compact

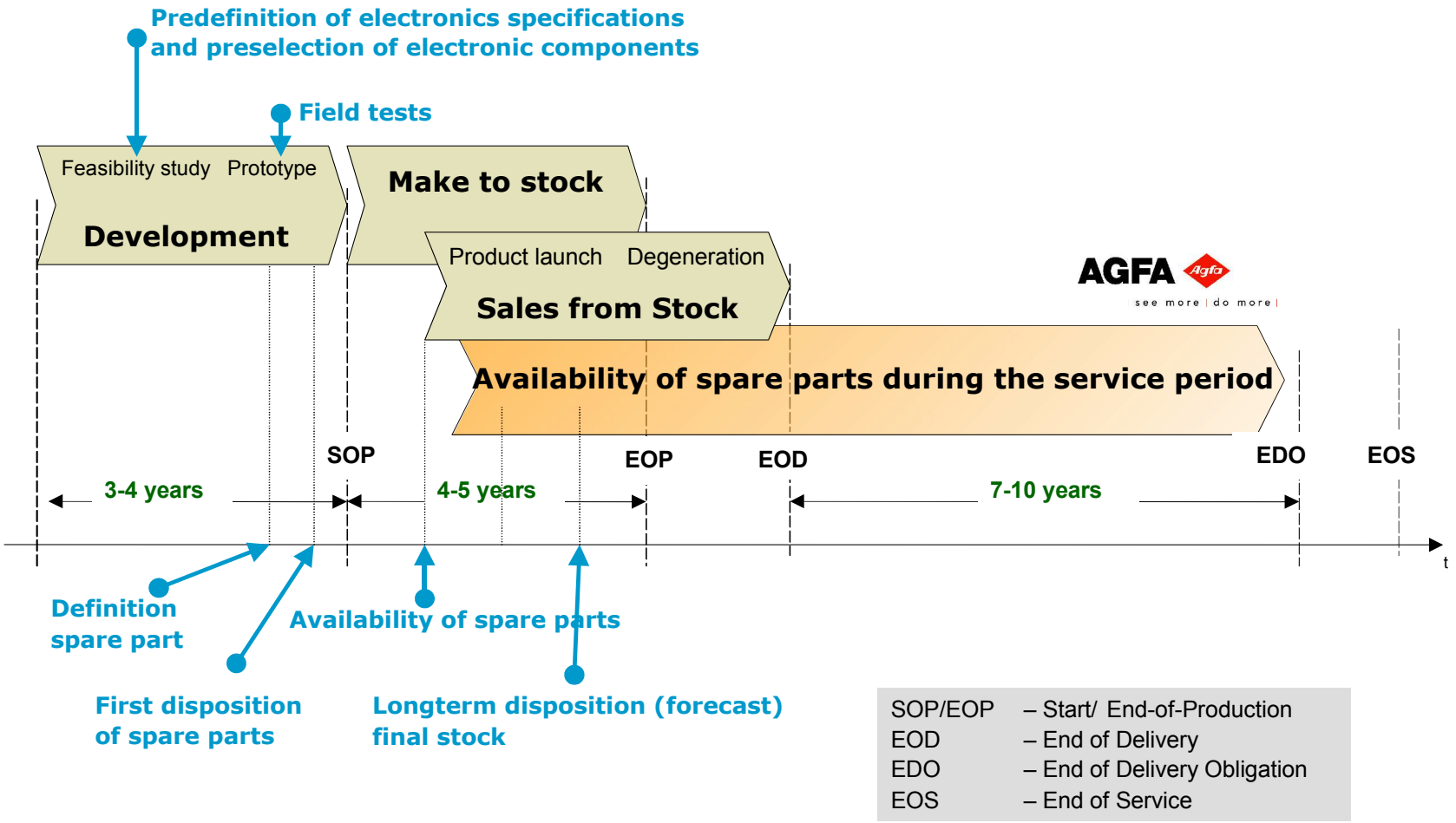


Production phase (1998 – 2001)
Total sales: 1920 pieces of equipment

Working Example: Scan-Unit of the ADC Compact

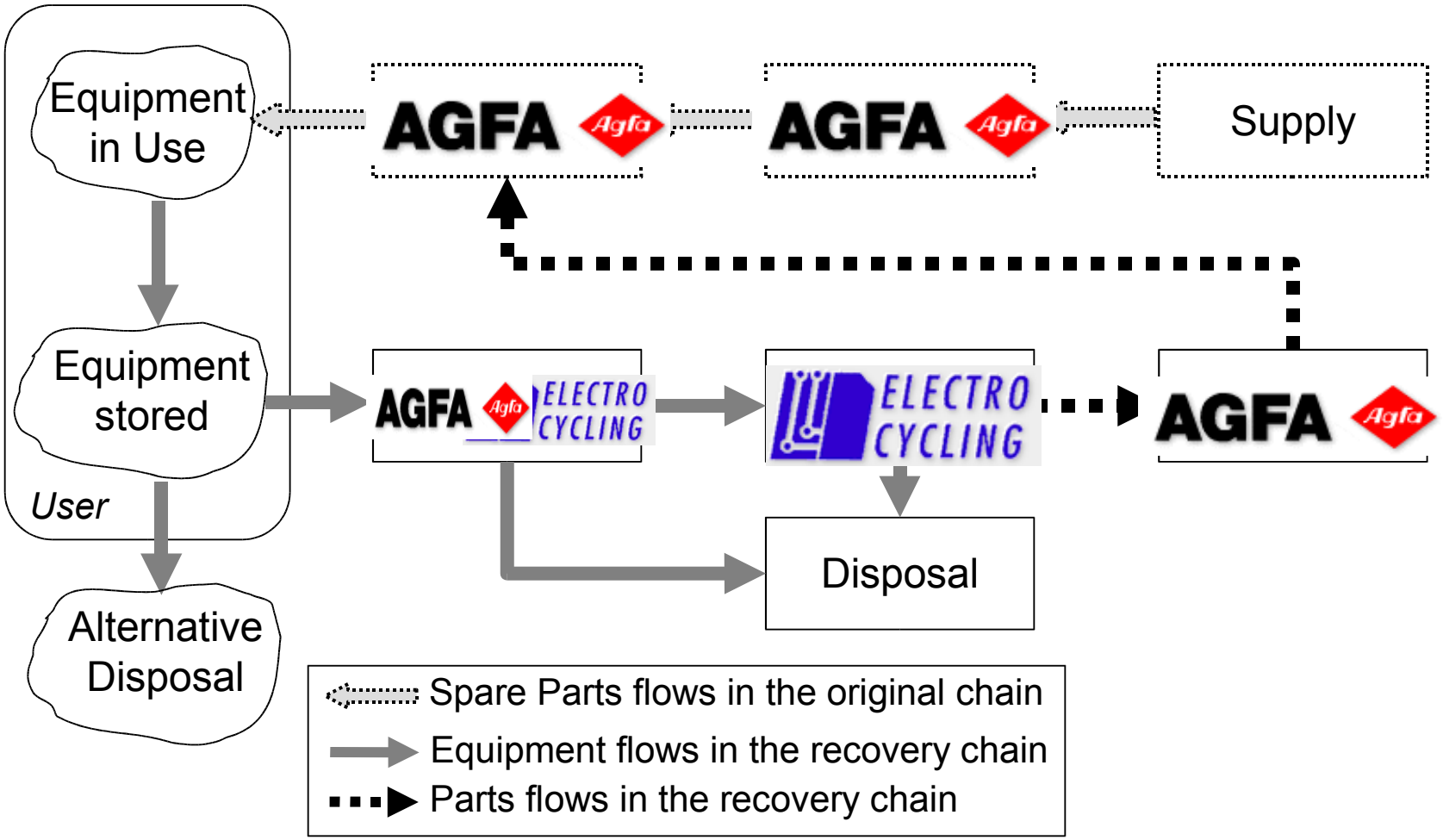


Strategic Management of spare parts at Agfa



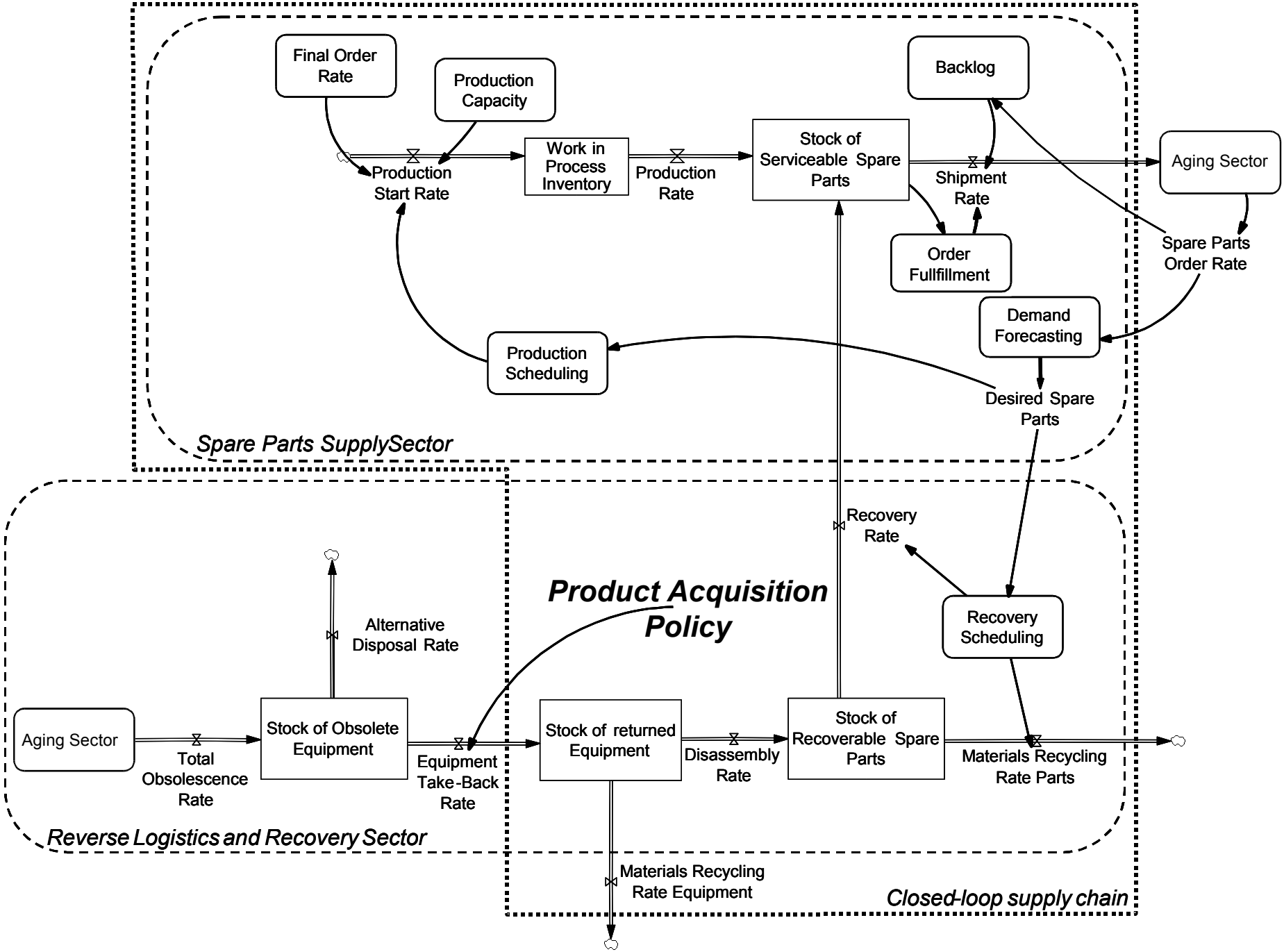
SOP/EOP	– Start/ End-of-Production
EOD	– End of Delivery
EDO	– End of Delivery Obligation
EOS	– End of Service

Closed Loop Supply Chain for Parts Recovery



System Dynamics Model

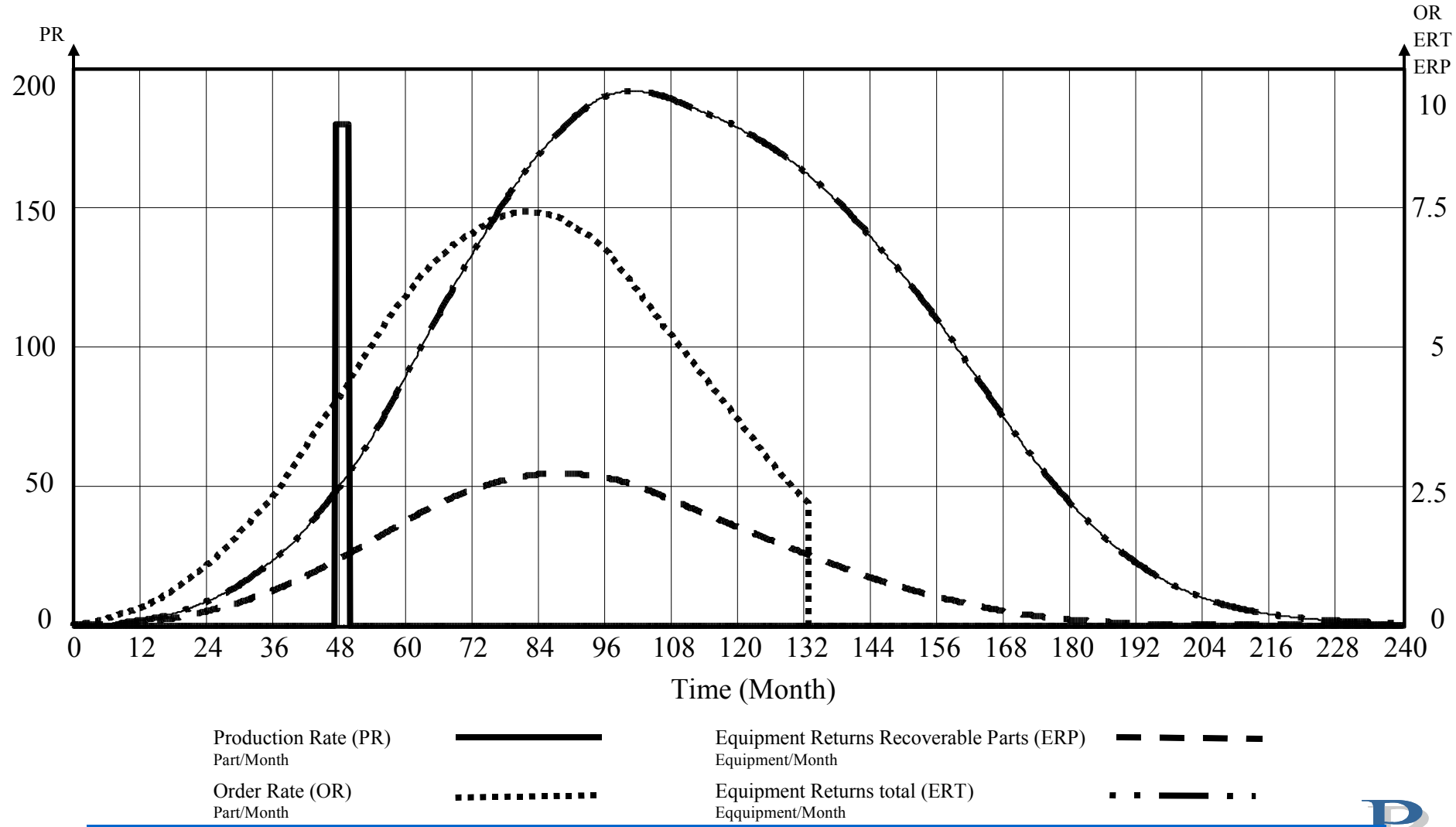
- **System Dynamics**
  - very effective tool in representing the dynamics of management systems
  - enables the user to develop a better understanding
    - of the effects of changes, and
    - supports him in designing alternative policies that result in an improved system performance
  - SD was developed by Jay Forrester at the MIT in the 1960´s
  - applied in many areas such as product development, project management, and supply chain management, among which is a popular explanation of the bullwhip effect


Final Order Rate
Production Capacity
Backlog
Production Start Rate
Work in Process Inventory
Production Rate
Stock of Serviceable Spare Parts
Shipment Rate
Aging Sector
Order Fullfillment
Spare Parts Order Rate
Demand Forecasting
Production Scheduling
Desired Spare Parts
Spare Parts SupplySector
Recovery Rate
Product Acquisition Policy
Recovery Scheduling
Alternative Disposal Rate
Aging Sector
Total Obsolescence Rate
Stock of Obsolete Equipment
Equipment Take-Back Rate
Stock of returned Equipment
Disassembly Rate
Stock of Recoverable Spare Parts
Materials Recycling Rate Parts
Reverse Logistics and Recovery Sector
Materials Recycling Rate Equipment
Closed-loop supply chain

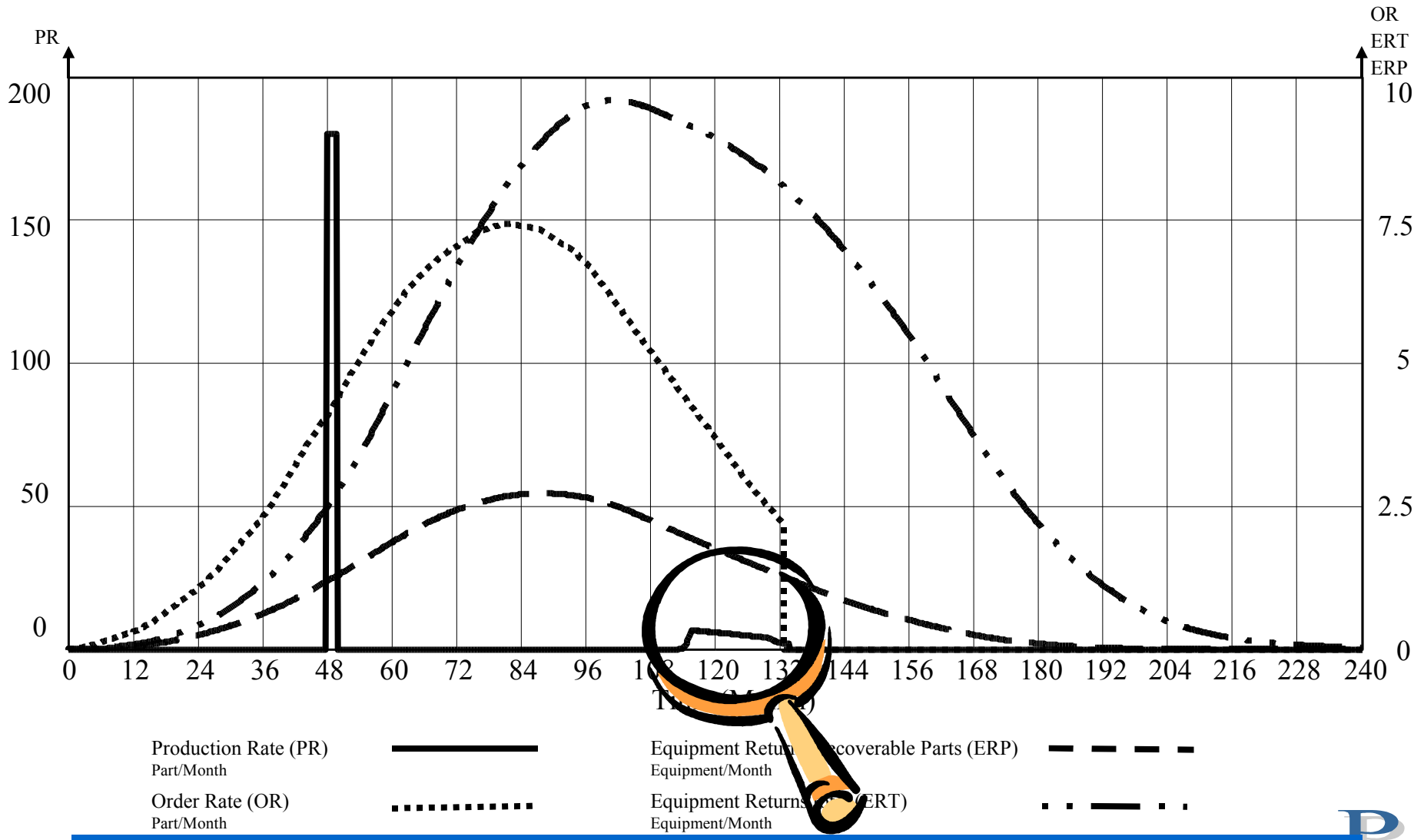
Characteristics of strategies

	recovery of parts considered	Product acquisition	mid-term forecast	Long term schedule	Stocking recoverable parts
Base Case					
Base case with forecast			■		
Recovery waste stream	■				
Recovery with aquisition	■	■			
Systemwide inventory policy waste stream	■		■		
Systemwide inventory with aquisition	■	■	■		
Early warning system waste stream	■		■	■	
Early warning system with aquisition (EWA)	■	■	■	■	
Stocking recoverable parts	■				■
SRP + EWA	■	■	■	■	■

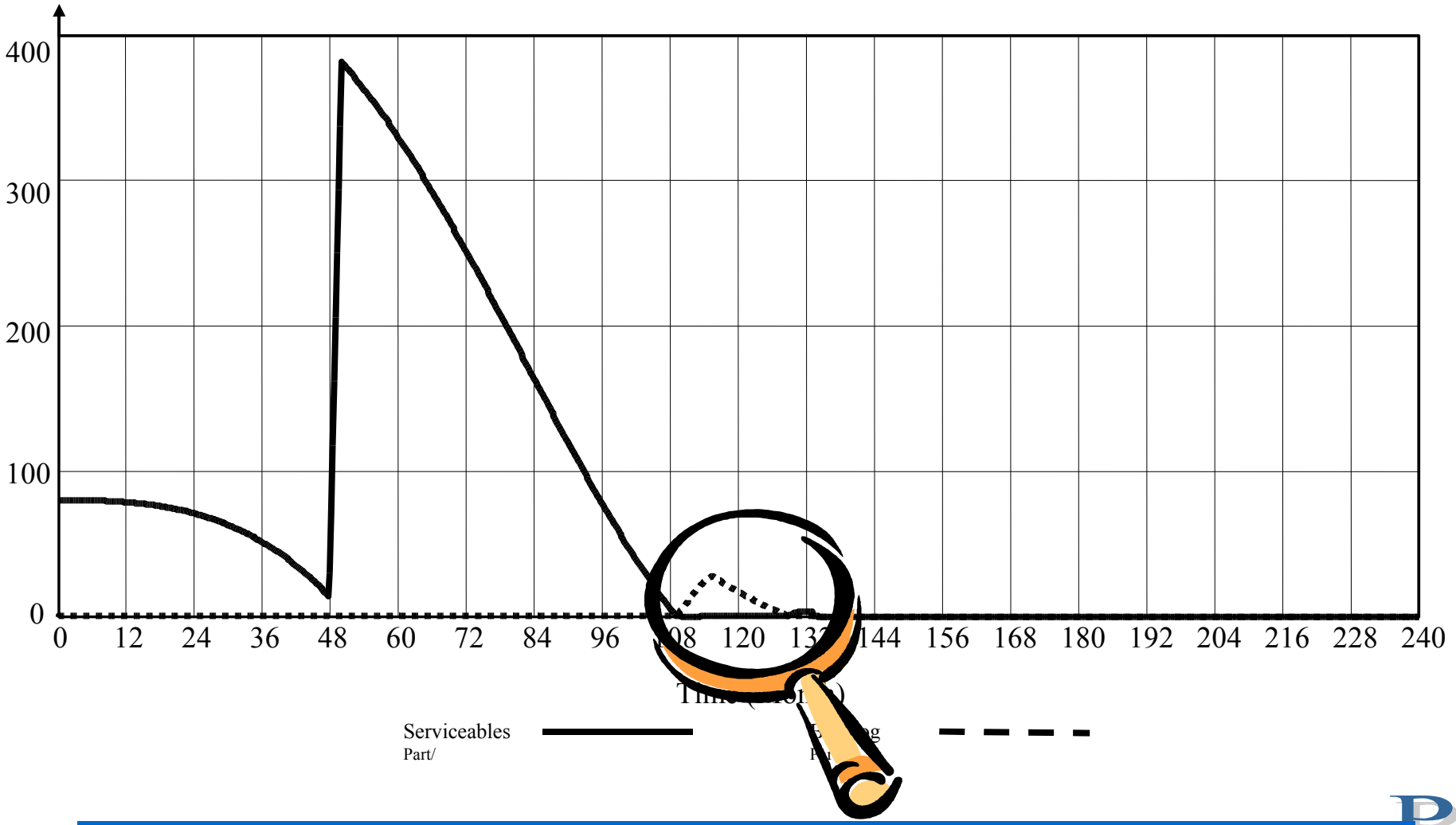
Base case: Optimal final stock; no recovery, no redesign



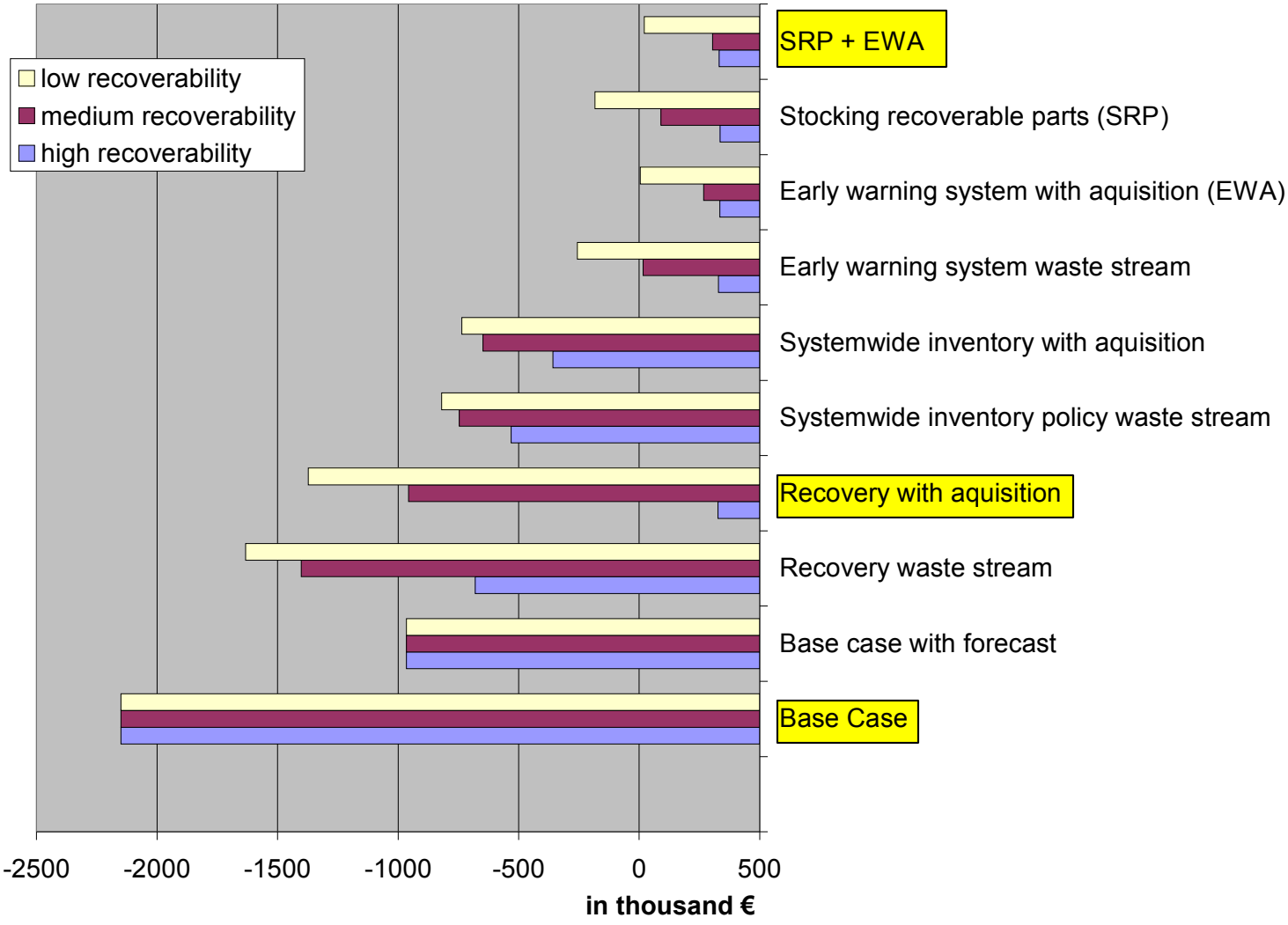
Base Case: Optimal final stock – 20%, no recovery, redesign



Base Case: Optimal final order – 20%, no recovery, redesign



Comparison of results (net present value)



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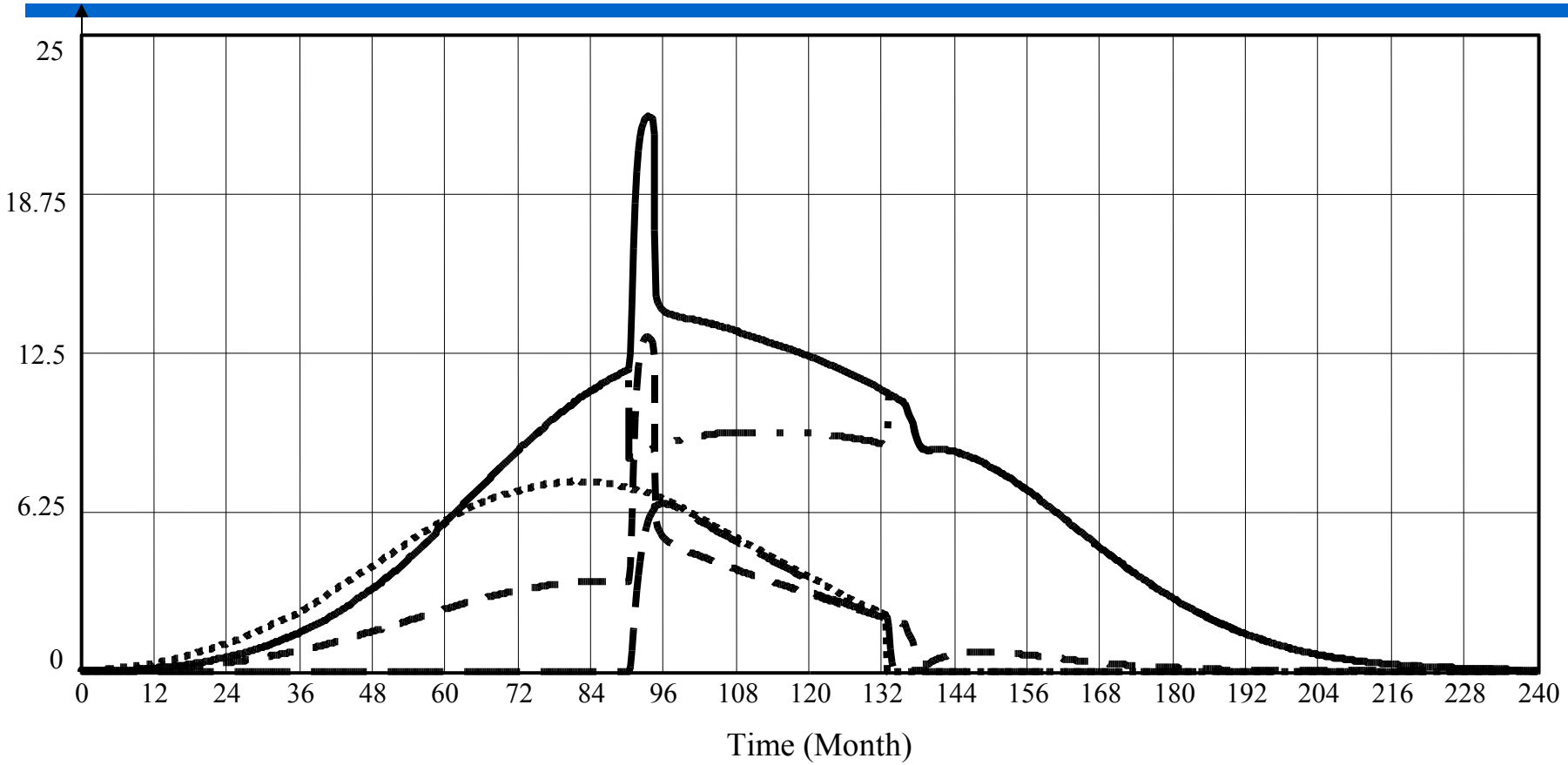
SRP + EWA	■	■	■	■	■

Recovery acquisition: 60% final stock, 65% return quota, high recoverability



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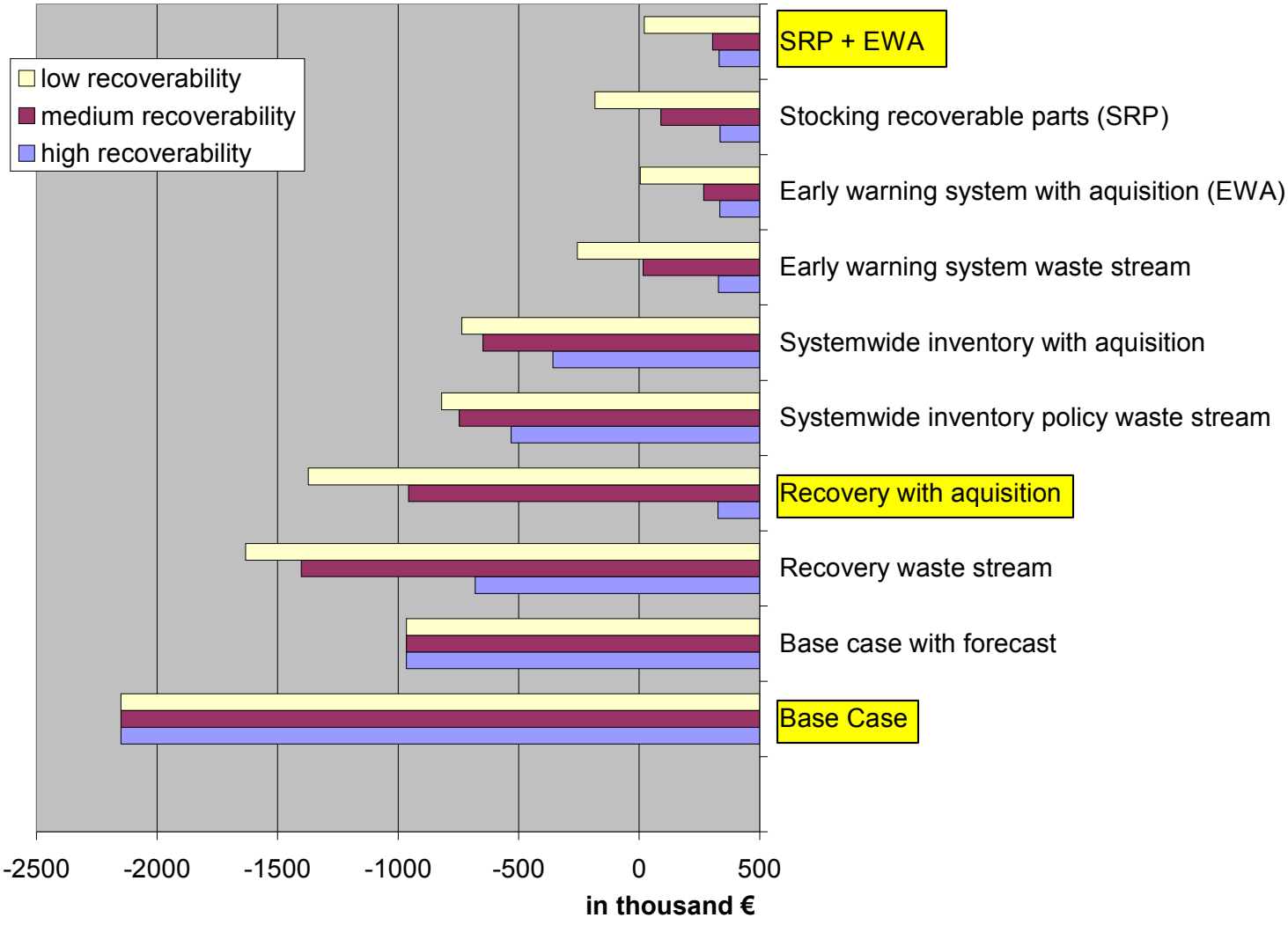

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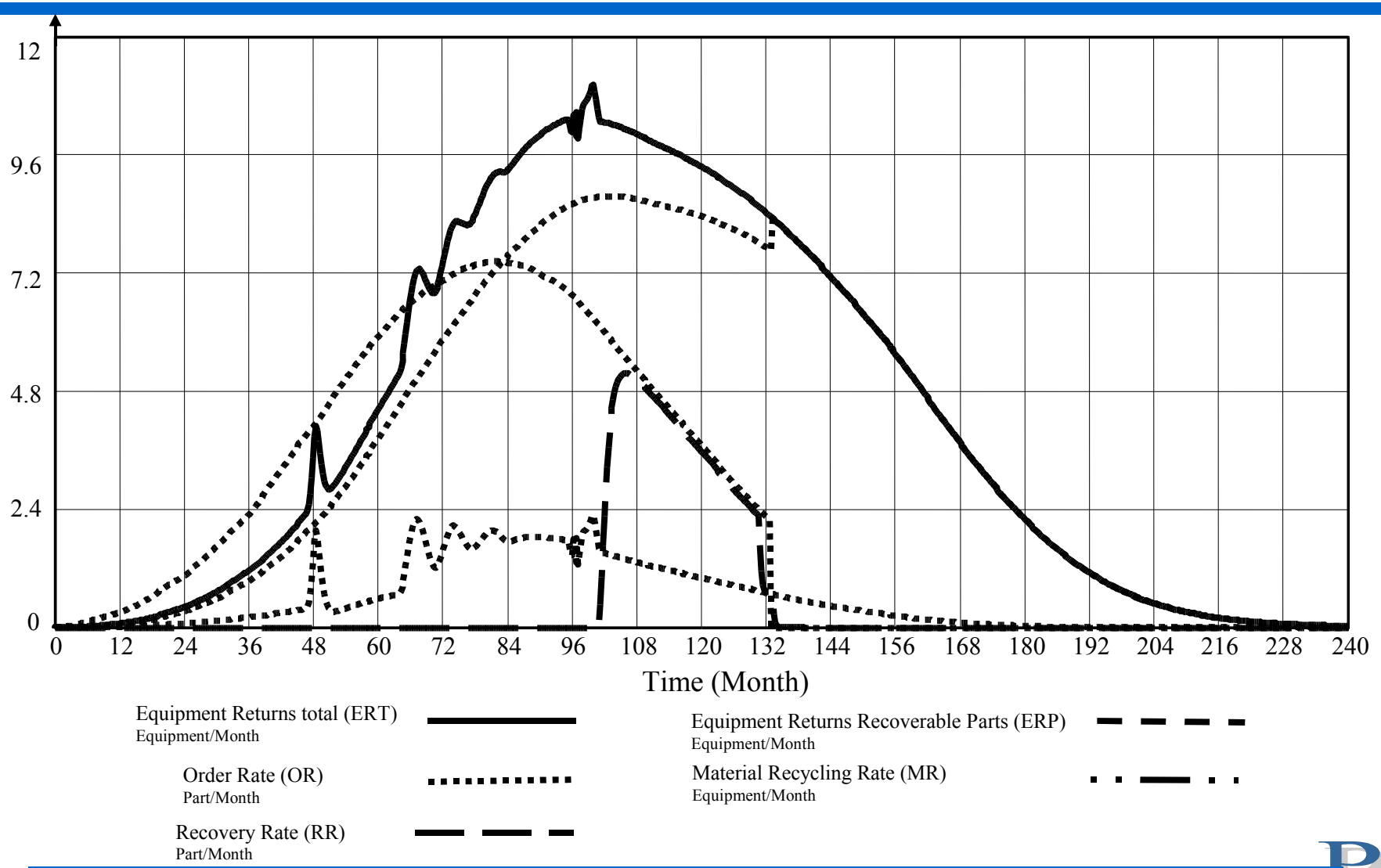
SRP + EWA	■	■	■	■	■

Stocking recoverable parts + early warning system:

75% final stock, 50% return quota, low recoverability



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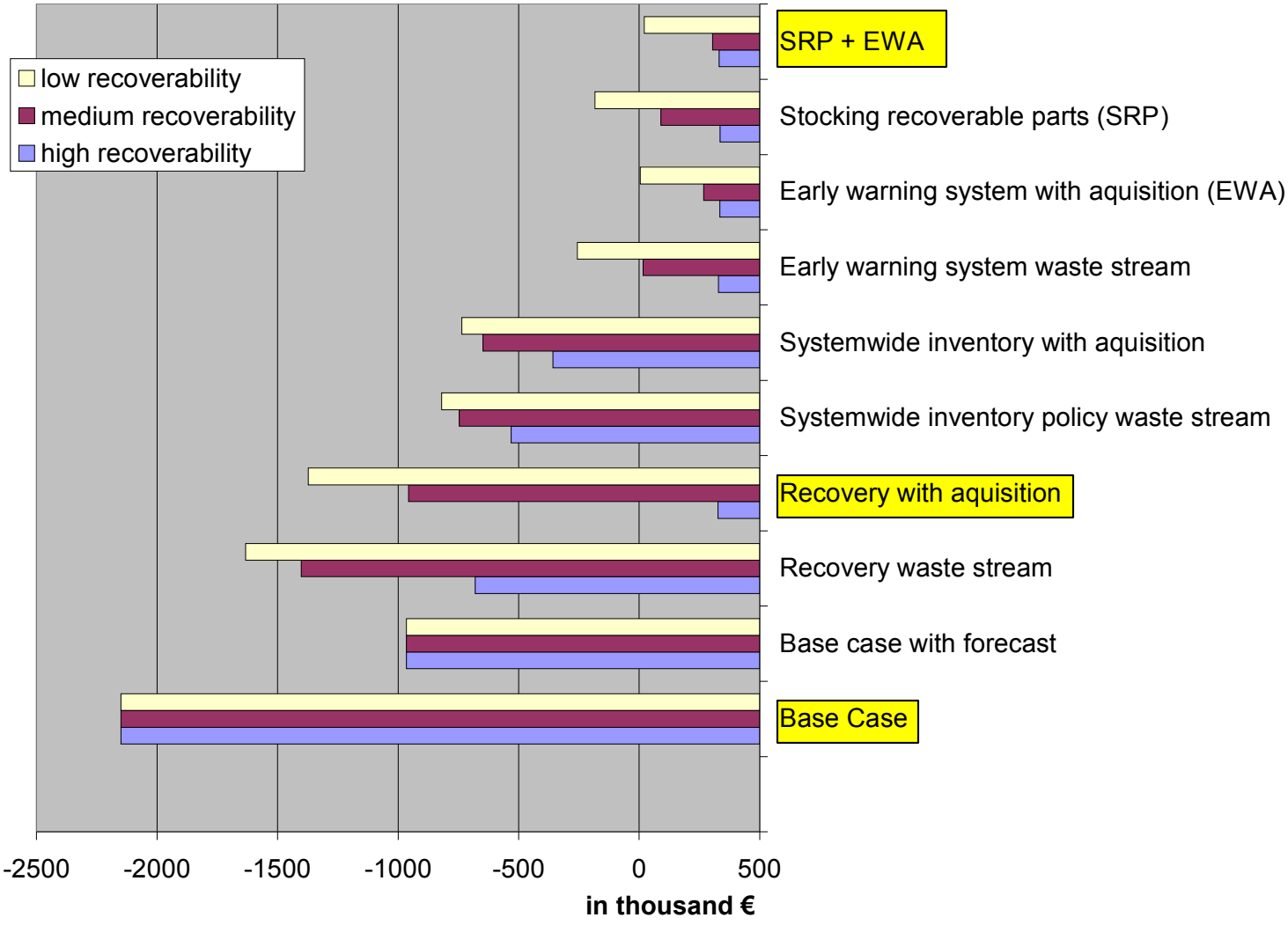

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Concluding Remarks

- Recovery of parts can be beneficial to provide customers with spare parts
- system dynamics to test various policies to control the closed-loop supply chain
- different forms of product take back (active product acquisition and waste stream)
- different policies
  - when to stop sending recoverable parts to materials recycling
  - when to acquire units of equipment with recoverable parts
  - when to begin to redesign a spare part.
- necessary to strengthen the monitoring of final stocks as well as the stocks of recoverable parts within closed-loop supply chains.
- Improving information exchange between producers of EEE and recycling companies

Attachments and Data

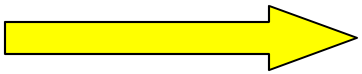
Parameter

- **Service time:** 7 years
- **Redesign time:** 6 months
- **Redesign costs:** 1,5 Mio. €
- **Production costs after redesign:** 200% of production costs during normal phase
- **Out of pocket costs for new and recovered parts:** 50 € per month and part
- **Scrapping or material recycling costs:** 22,5 € per part
- **Reverse logistics costs (transportation and deconstruction):** 42,4 € per part
- **Product acquisition costs:** depend on the proportion of discarded equipment with recoverable parts => max. 200% of reverse logistics costs
- **Out of pocket costs for disassembled scan-unit:** 1 € per month and part
- **Disassembly costs:** 45 € per scan-unit
- **Rate of interest:** 8% per year

Scenario Parameter

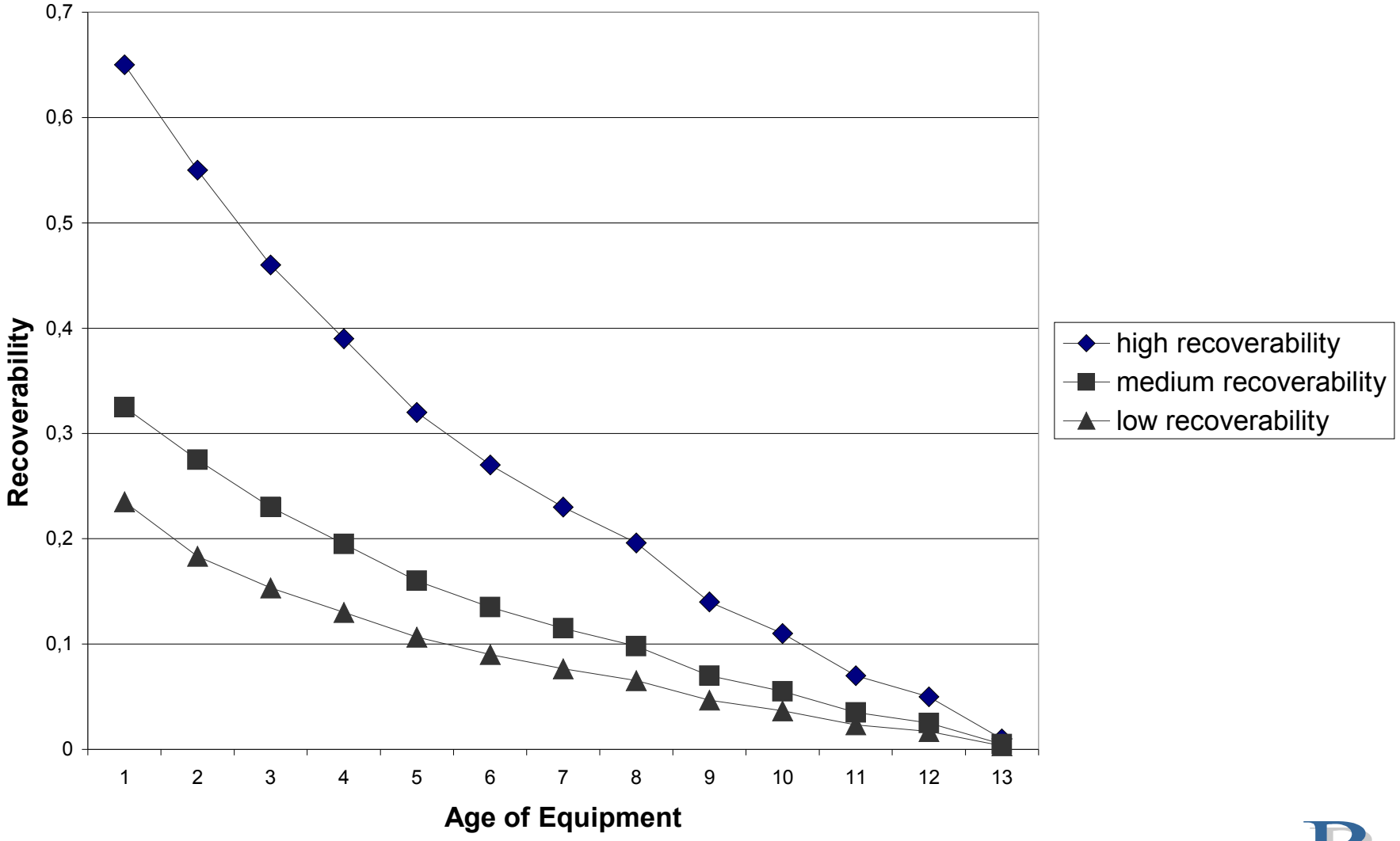
- **Return Quotas:** 50% - 90%
- **Final Stock:** 60% - 100%
- **Recoverability:** high, medium, low

5 % steps

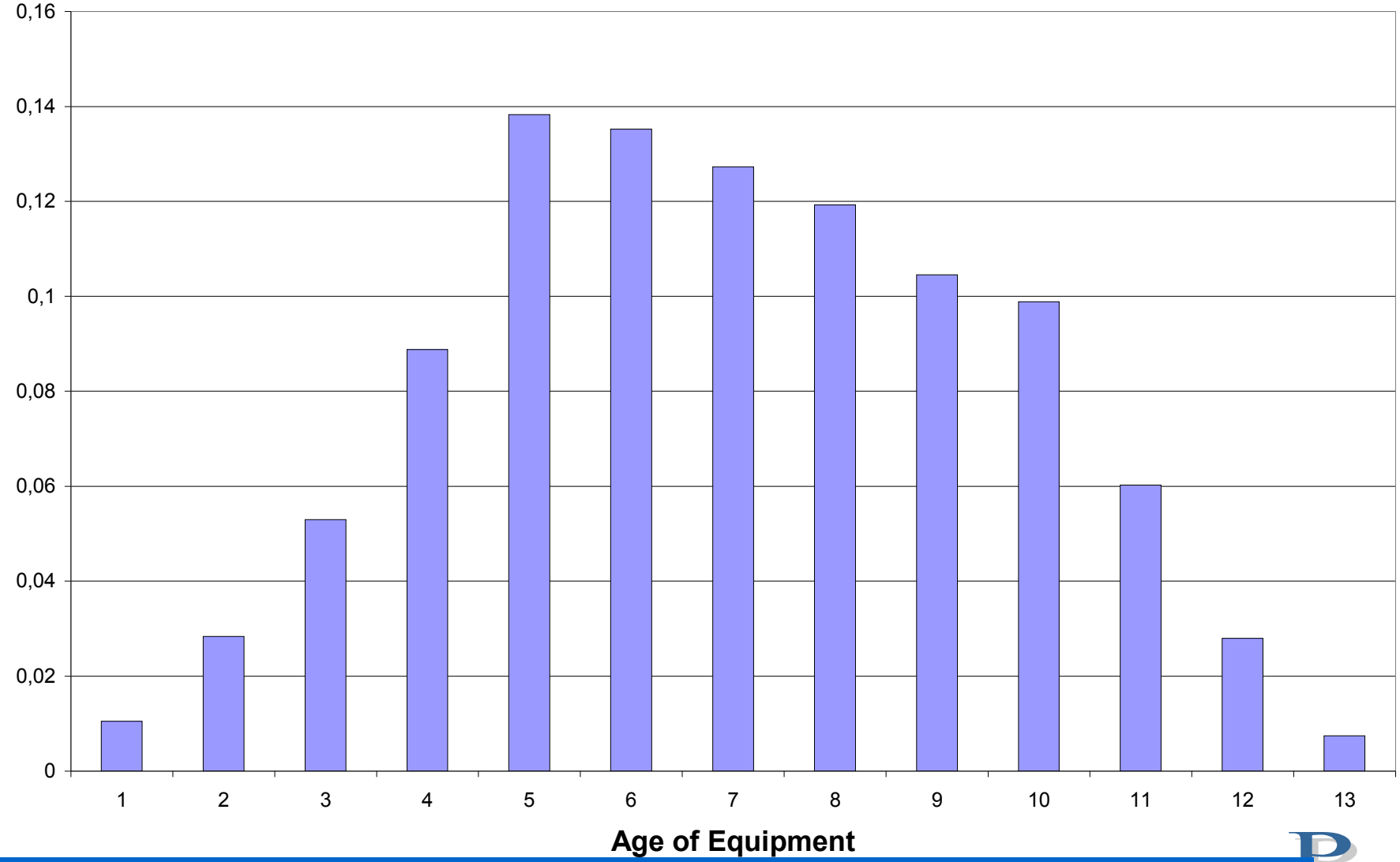


9 x 9 x 3 = 243 simulation runs per strategy

Recoverability scenarios



Probability mass function of equipment return time



Probability mass function of repair