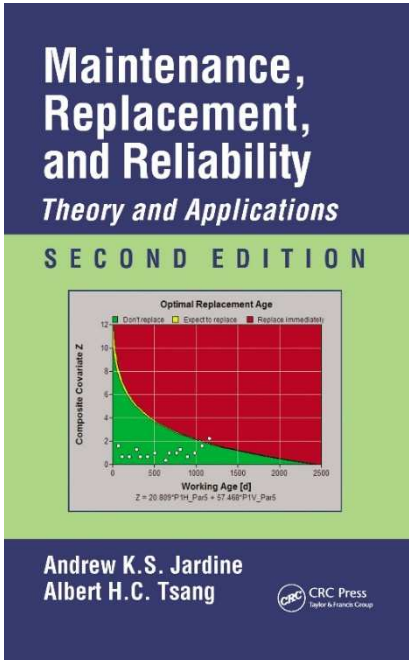
SLOW MOVING/INSURANCE SPARES

Underlying mathematics explained in following textbook, Section 2.11, Page 76



REAL WORLD RESEARCH

MANAGING RISK: A SPARES OPTIMIZATION TOOL CALLED SMS

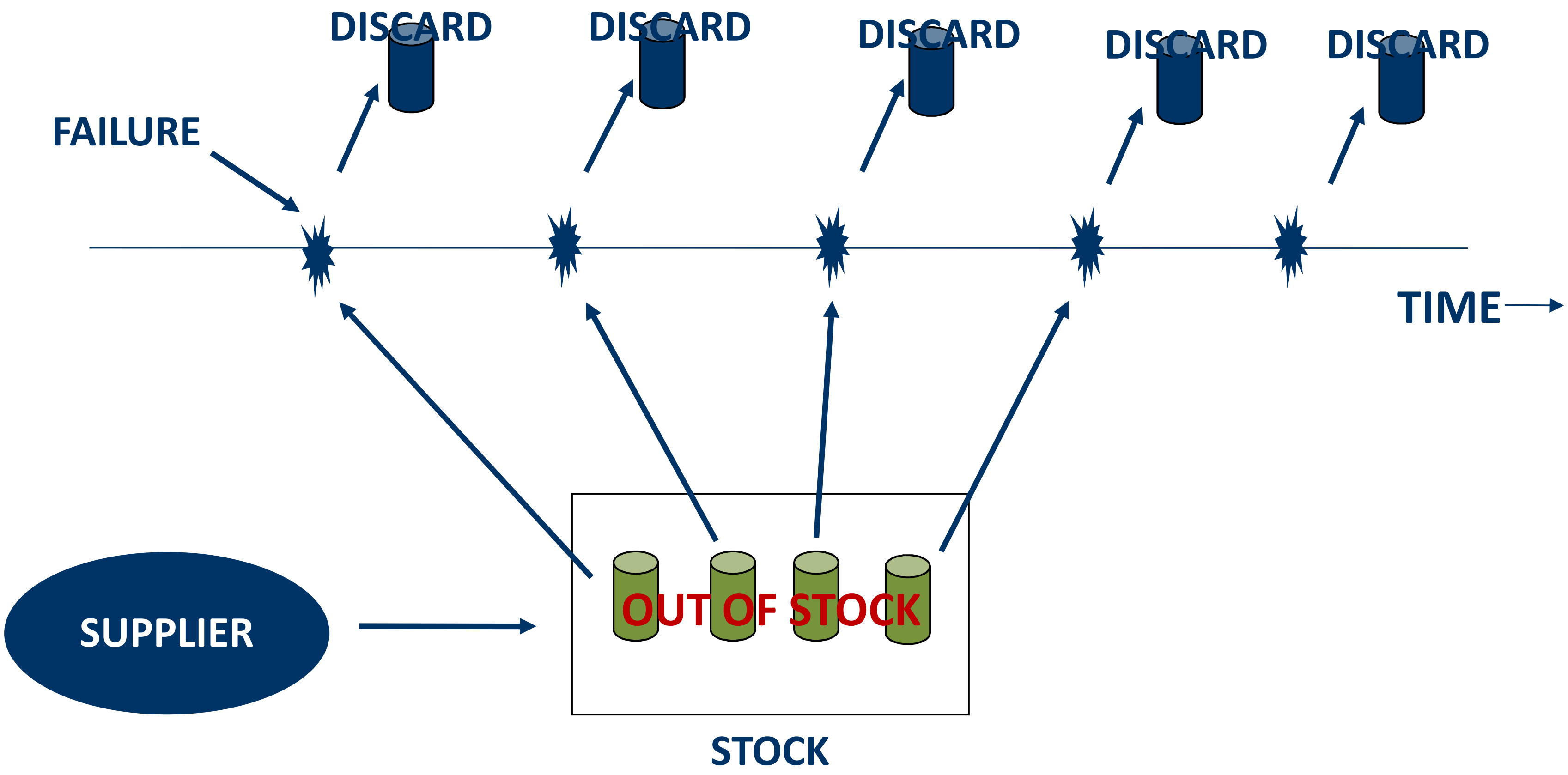
Developed in collaboration with organizations who are members of a consortium supporting applied research at the University of Toronto into Evidence-Based Asset Management such as Utilities, Military, Airports, Mining and Process Industries.

SPARE PARTS PROVISIONING: SLOW-MOVING SPARES

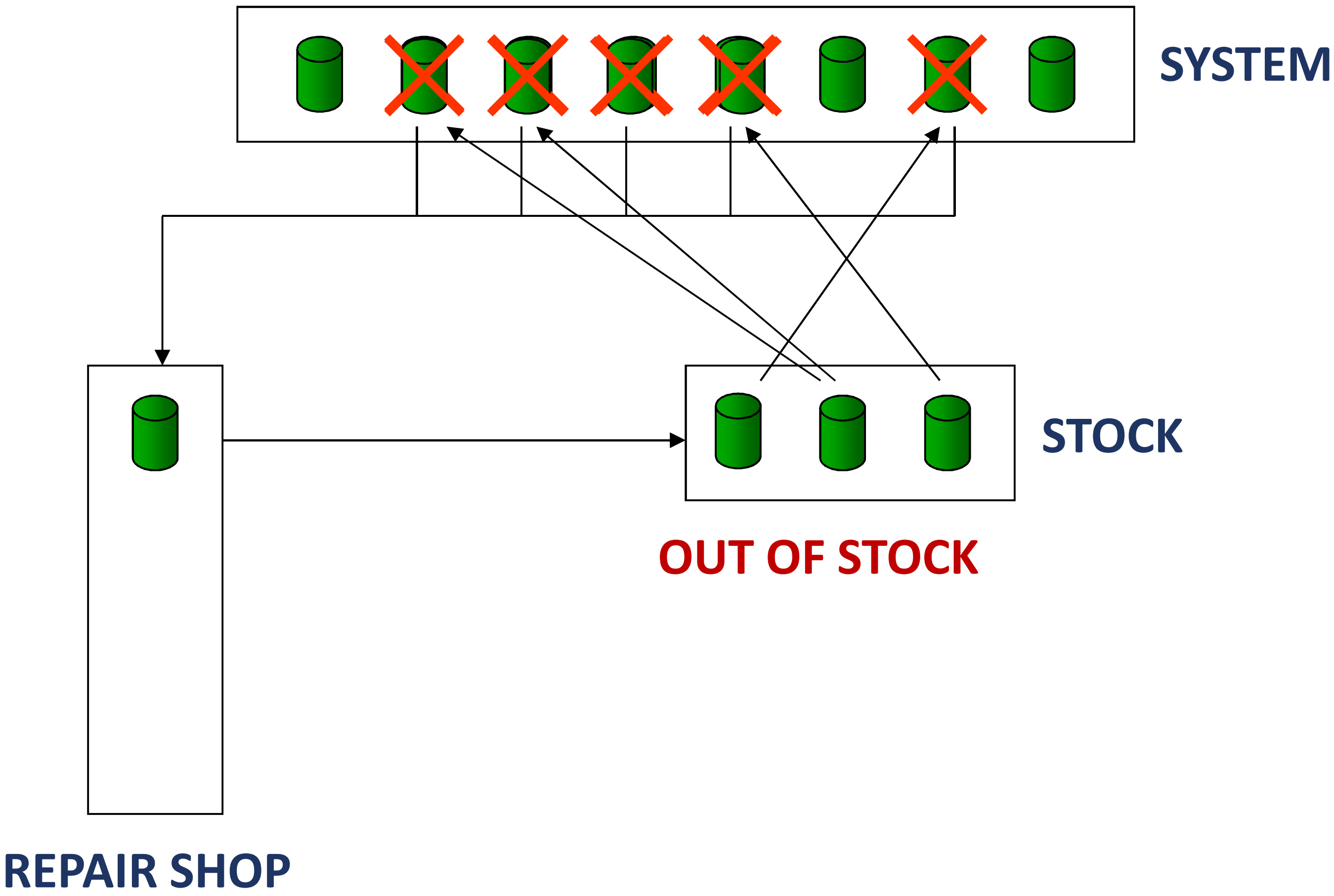
⟨SMS⟩™

Spares Management Software

NON-REPAIRABLE SPARES



REPAIRABLE SPARES



CRITERIA FOR DECISION MAKING

1. Instant reliability (Maintainer)
2. Interval reliability (Stores)
3. Cost minimization (Finance)
4. (Process) Availability (Plant Manager)

CONVEYOR SYSTEMS: ELECTRIC MOTORS (TABLE 2.12)

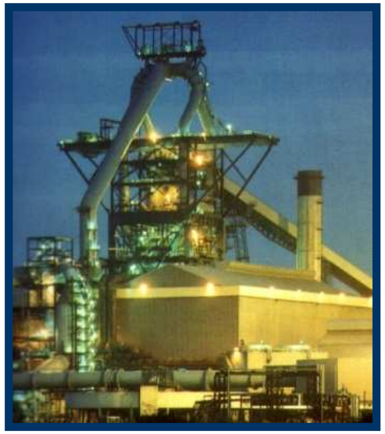
SCENARIO	Number of motors	62
	Planning Horizon	1825 Days (5 years)
RELIABILITY AND MAINTAINABILITY	MTBRemovals	3000 Days (8 years)
	MTTRepair	80 Days
COST	Cost of spare motor	$15,000
	Value of unused spare	$10,000
	Cost of emergency spare	$75,000
	Downtime cost	$1000/day
	Holding cost	$4.11/day

QUESTION: HOW MANY SPARE PARTS TO STOCK?

RESULTS: REPAIRABLE MOTORS

- **Instant reliability:** 95% reliability requires **4 spares**
- **Interval reliability:** 95% reliability requires **7 spares**
- **Cost minimization:** requires **6 spares**
- **Availability of 99%:** requires **2 spares**

NON-REPAIRABLE FUME FAN SHAFT: STEEL MILL



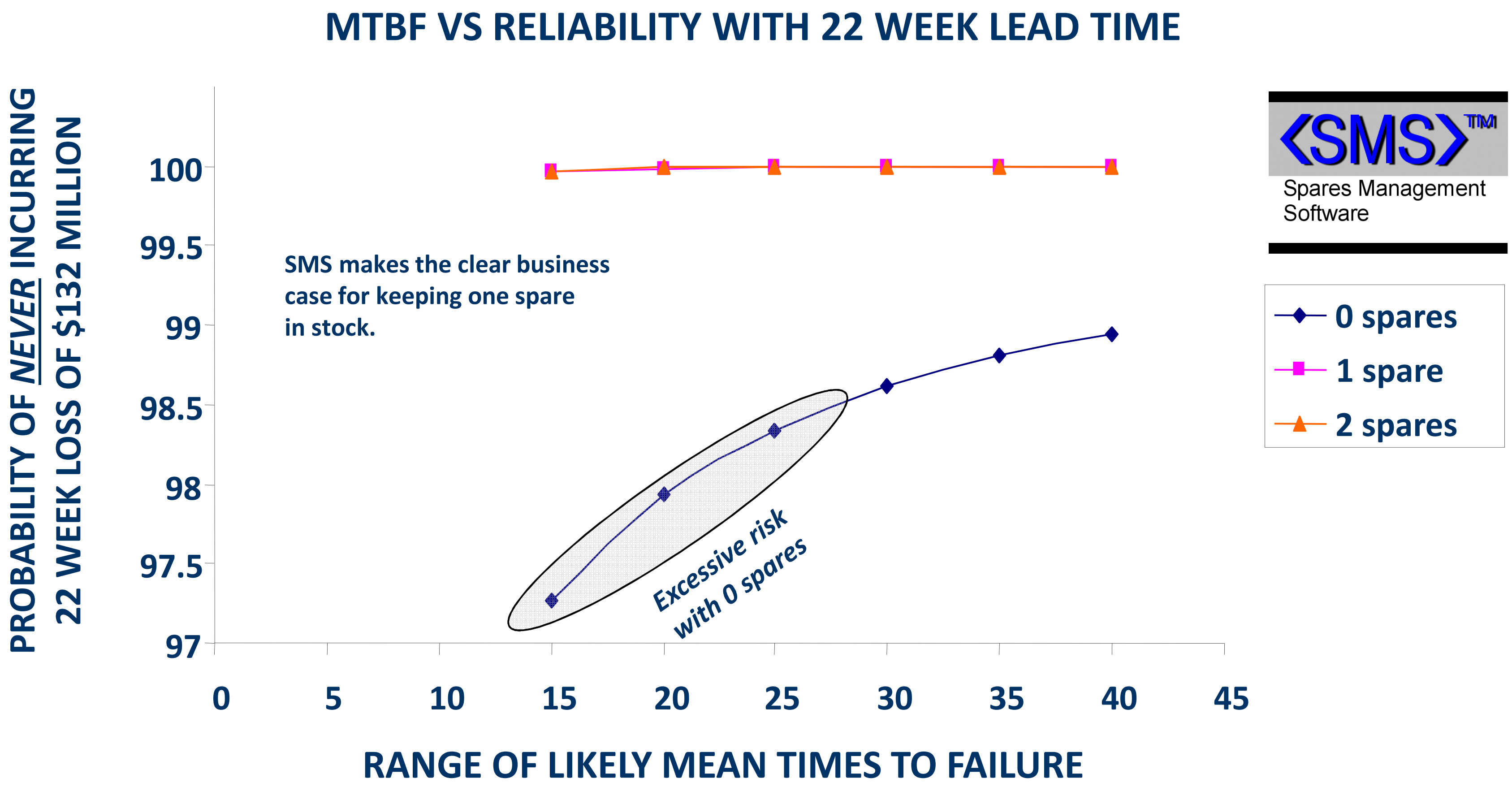
SPARES PROVISIONING OPTIMIZATION PROJECT

- Part: Fume fan shaft used in a Blast Furnace
- Decision: Should there be 0 or 1 spares?
- Complication:
  - Part has long lifespan (25-40 years).
  - Long lead time (22 weeks).
  - If part fails, results are catastrophic (loss of almost $6 million per week).
  - Inventories are trying to be minimized.

SMS WAS USED TO QUANTIFY THE RISK INVOLVED IN NOT HAVING A SPARE

DECISION SUPPORT

THE RESULT


MTBF VS RELIABILITY WITH 22 WEEK LEAD TIME
PROBABILITY OF NEVER INCURRING 22 WEEK LOSS OF $132 MILLION
100
99.5
99
98.5
98
97.5
97
0
5
10
15
20
25
30
35
40
45
RANGE OF LIKELY MEAN TIMES TO FAILURE
SMS makes the clear business case for keeping one spare in stock.
Excessive risk with 0 spares
<SMS>TM
Spares Management Software
0 spares
1 spare
2 spares

REPAIRABLE COMPONENTS – HAUL TRUCKS

- **OPEN PIT MINING OPERATION IN SOUTH AMERICA**
- **HAUL TRUCK POWER TRAIN COMPONENT: COMPONENT X**

REPAIRABLE COMPONENTS – DATA / 1

GENERAL

- 6,600 operating hours per truck per year (average fleet utilization)
- Preventive replacement policy at 9,000 operating hours in place

TIME TO REPLACEMENT

- Two parameter Weibull distribution, fitted using Weibull++
  - 171 events: 86 failures, 85 suspensions (preventive replacements)
  - Beta = 0.8565
  - Eta = 14,650 operating hours
  - Mean time to replacement = 6,420.3 operating hours

REPAIRABLE COMPONENTS – DATA / 2

TIME TO REPAIR

- Based on estimations provided by maintenance personnel
- Estimated MTTR = 452 operating hours

COST OF DOWNTIME AND HOLDING COSTS

- Downtime: estimated using operational indicators (value of lost production, $2,173.3 / op. hour)
- Holding: 25% of the value of the part per annum ($1.51/ op. hour)

REPAIRABLE COMPONENTS – DATA SUMMARY

PARAMETER	VALUE
Number of components in operation	78
MTBReplacements (μ)	6420.3 (op. hours)
Planning horizon (T)	6600 (op. hours)
MTTRepair (μ_R)	452 (op. hours)
Holding cost for one spare	$1.51 per op. hour (25% of value of part/annum)
Cost of plant downtime for a single component	$2173.3 per op. hour

SMS CAN PERFORM THE OPTIMIZATION BASED ON FOUR CRITERIA

REPAIRABLE COMPONENTS – RESULTS

CASE & OPTIMIZATION CRITERIA	OPTIMAL STOCK LEVEL	ASSOCIATED VALUES
Interval Reliability (goal = 95%)	15	Reliability = 98.05% (for stock=14, Rel.=94.99%)
Instantaneous Reliability (goal = 95%)	10	Reliability = 97.53% (for stock=9, Rel.=94.75%)
Availability (goal = 99%)	6	Availability = 99.14 %
Cost minimization	14	Total cost per unit time = $23 Inst. Reliability = 99.94%