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# User Guide for Condition Maintenance Interval Optimization Model

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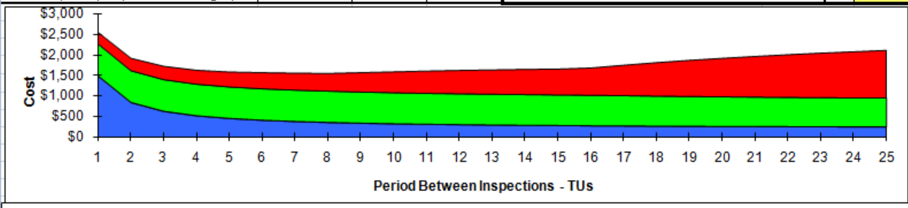
# User Guide for Condition Maintenance Interval Optimization Model

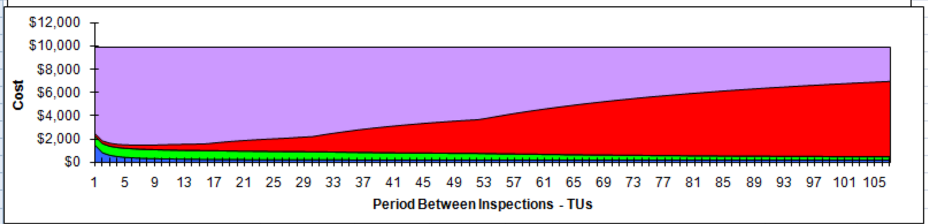
The model is a Microsoft Excel spreadsheet that estimates the optimal condition inspection interval for operating plant and equipment to minimise the number of inspections and the chance of having equipment fail before the next inspection.

Data is entered into selected fields of the spreadsheet and used to populate the calculation tables, which then return the results shown in the remainder of the table.

The curves on the charts are drawn by the model. The upper chart is a high resolution copy of the left-hand side of the lower chart and 'magnifies' that section of the plot.

| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | MONITORING INTERVAL OPTIMISATION (Todd/Witt Method) | | | | | | | Results For | |
| 2 | Equipment Type & Failure Mode | Main Hoist Gearbox | | | | | | 9/09/2009 7:41 | |
| 3 | Condition Based Maint. Method | Simple Analysis - with occasional Vibration and Oil Analysis | | | | | | | |
| 4 | Failure mode failure rate | (Failures/yr) | λ | 0.1 | Predictability Characteristics | | | MTBF = 10 (yr) | |
| 5 | Cost of an Unpredicted Failure | ($/Failure) | CBdPF | $100,000 | % Problems Not Predicted by Method | FrtFNotPred | 0% | Detects All Modes | |
| 6 | Cost of a Predicted Failure | ($/Failure) | CPrPF | $8,000 | Typical warning time(50% failed -Weeks) | MedWtW | 40 | StDev = 20.7 (Wk) | |
| 7 | Monitoring Cost | ($/Inspection) | CMPI | $25 | Short warning time (5% failed - Weeks) | ShtWtW | 6 | %Go Early | Exact |
| 8 | Monitoring Cost Overheads | ($/yr) | CPMPYr | $200 | Operate To Failure (OTF) Cost p.a. | | $10,000 | 3% | $1,607 |
| 9 | Shortest Response Time | (Weeks) | RTShortW | 0.2 | Minimum Cost to the Business p.a. | | $1,560 | $1,639 | Nearest Wk |
| 10 | Ineffective Inspections | | FrtIneflnspt | 5% | Minimum Cost Monitoring Interval (Wk) | | 8.0 | 4.0 | |
| 11 | Graph Scale 1 Tu = | 1.0 | Weeks | | Saving on OTF p.a. | | $8,440 | $8,361 | |
| 12 | i.e. Last point (25) on Hi Res graph = | 25.0 | Weeks | | Monitoring Cost p.a. | | $363 | $525 | |
| 13 | i.e. Last point (107) on Low Res graph = | 107.0 | Weeks | | Return on Investment p.a. | | 23.3 | 15.9 | |




StDev (Wk) =

Cumulative

CBMOPTF

Ready

## Nomenclature and Definitions

TU Time Units in weeks –specifies the size of the increments on the horizontal axis
OTF Operate to Failure – running the equipment until it breaks down

## Spreadsheet Inputs Explained

The allowed spreadsheet inputs are those fields coloured 'light green'. These are:

- **Equipment Types and Failure Mode** – the name of the equipment and what failure types being are monitored.
- **Condition Based Maintenance Method** – the range of technologies being used to detect the range of failures.
- λ (lamda) - the annualised failure rate during the random period of equipment life determined from the maintenance history of the equipment

- **CBdPF** - the total business-wide cost of a breakdown, which includes all production losses, business impact costs, and maintenance costs

- **CPrPF** - the total cost of doing a planned repair where production and maintenance have scheduled the work and production impact is minimised

- **CMPI** – the total direct cost of doing the condition monitoring inspection

- **CPMPYr** – the total indirect costs of doing the inspection, including all overhead costs and penalties.

- **RTShortW** – the quickest time in which the inspection can be organised, which is also the period when no condition monitoring is possible to detect an initiated failure.

- **FrtInefInspt** – the percentage of inspections that are wrongly done and produce no monitoring of the failure conditions.

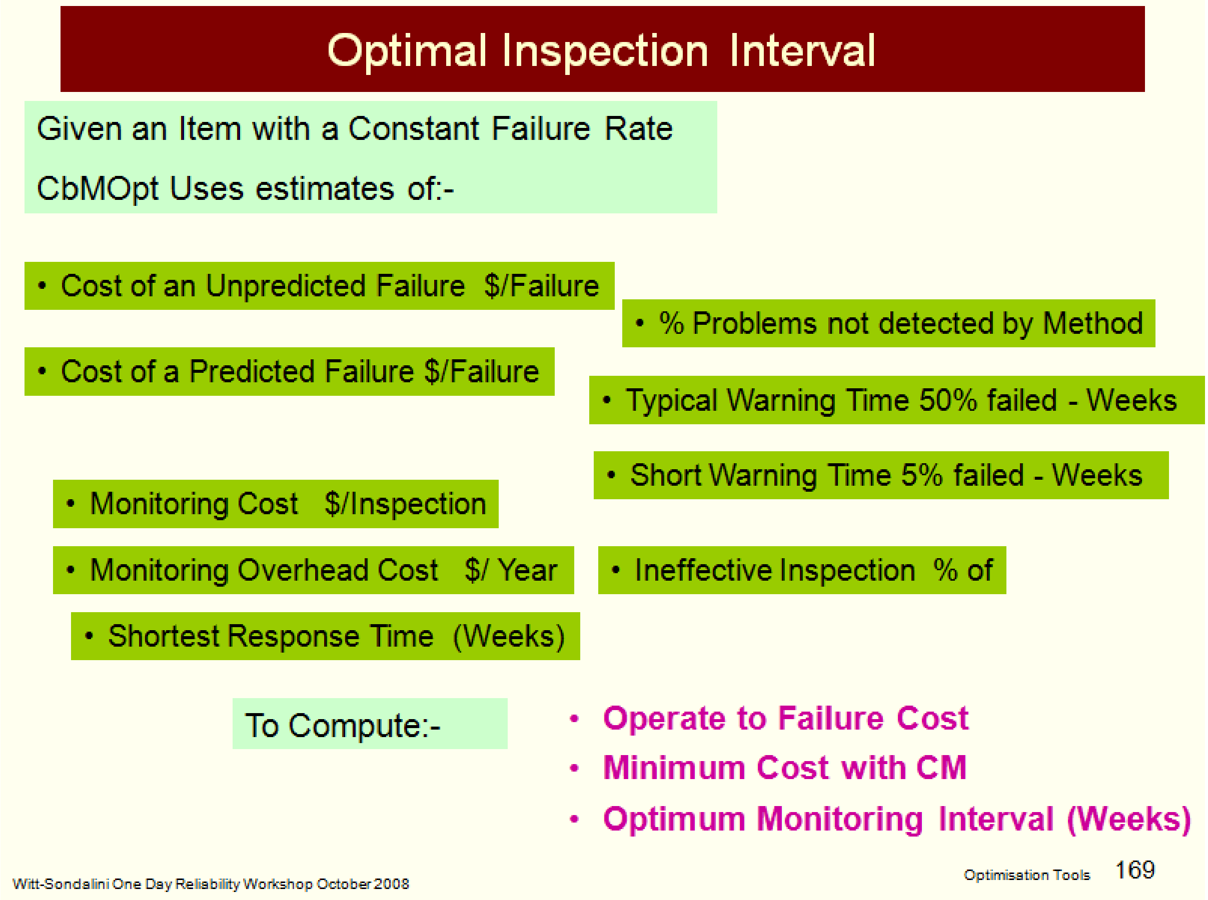
- **FrtFNotPred** – the percentage of developing failures in the equipment that the monitoring method will miss. Beginning failures not identified by the technologies used for monitoring will continue to a breakdown.

- **MedWtW** – the time by which 50% (half) of failures have happen. For example, if for an item of plant that failed twice in the past, the longest time to a failure is 100 weeks, and the soonest is 50 weeks, the 50% time is 75 weeks.

- **ShtWtW** – this is the time by which 5% of failures have happened. For example, if for an item of plant that failed twice in the past, the longest time to a failure is 100 weeks, and the soonest is 50 weeks, the 5% time is 51.25 weeks.

- **3% Go-Early** – Because the curves are flat near the minimum, for only 3% increase in cost you may inspect more frequently. By paying 3% more you can be additionally cautious and reduce the time between inspections (like paying a bit more for an extended warranty if you want to be more cautious). You can work to a higher percentage of cost and lower the level of risk to even shorter time intervals.

## Explanation of Theory Behind the Model


Optimal Inspection Interval
Given an Item with a Constant Failure Rate
CbMOpt Uses estimates of:-
• Cost of an Unpredicted Failure $/Failure
• % Problems not detected by Method
• Cost of a Predicted Failure $/Failure
• Typical Warning Time 50% failed - Weeks
• Short Warning Time 5% failed - Weeks
• Monitoring Cost $/Inspection
• Monitoring Overhead Cost $/ Year
• Ineffective Inspection % of
• Shortest Response Time (Weeks)
To Compute:-
• Operate to Failure Cost
• Minimum Cost with CM
• Optimum Monitoring Interval (Weeks)
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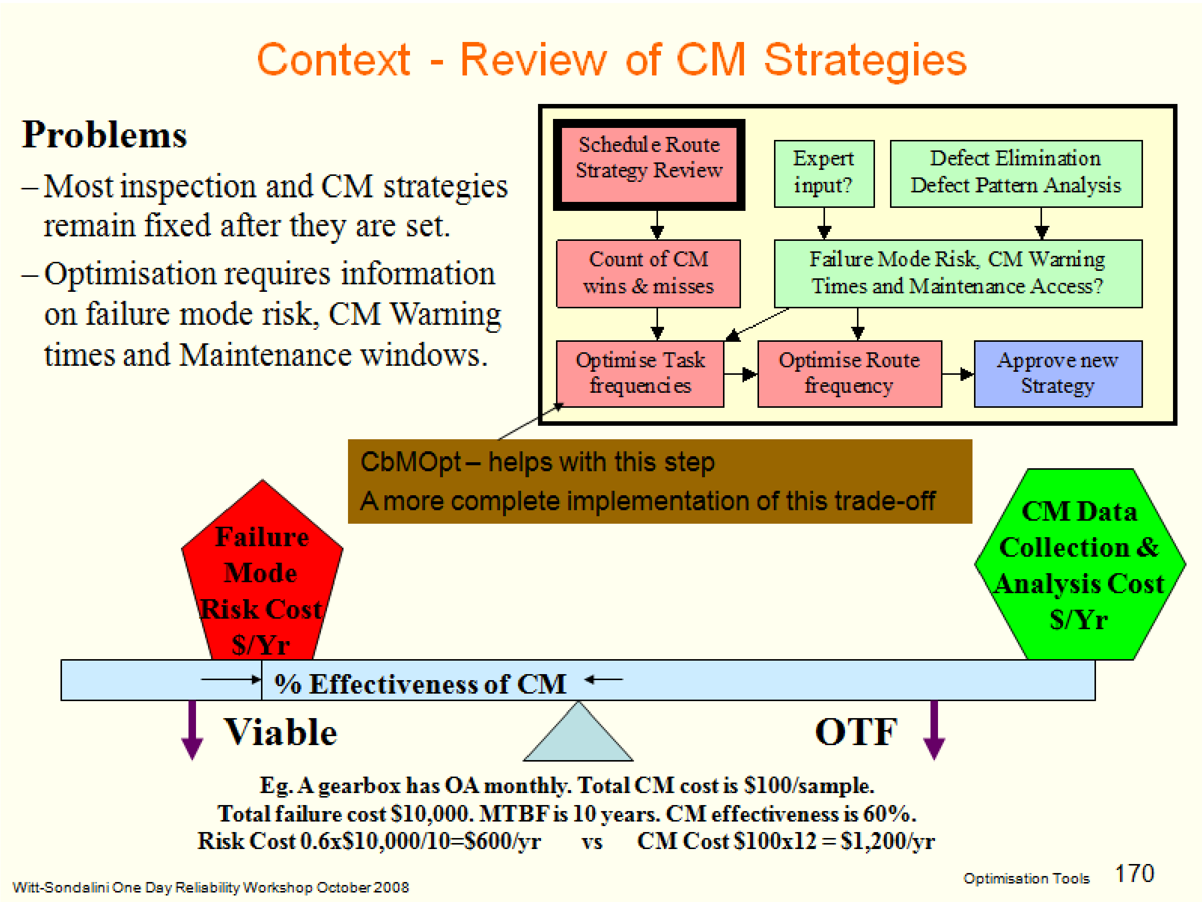
Context - Review of CM Strategies
Problems
– Most inspection and CM strategies remain fixed after they are set.
– Optimisation requires information on failure mode risk, CM Warning times and Maintenance windows.
Schedule Route Strategy Review
Expert input?
Defect Elimination Defect Pattern Analysis
Count of CM wins & misses
Failure Mode Risk, CM Warning Times and Maintenance Access?
Optimise Task frequencies
Optimise Route frequency
Approve new Strategy
CbMOpt – helps with this step
A more complete implementation of this trade-off
Failure Mode Risk Cost $/Yr
CM Data Collection & Analysis Cost $/Yr
% Effectiveness of CM
Viable
OTF
Eg. A gearbox has OA monthly. Total CM cost is $100/sample.
Total failure cost $10,000. MTBF is 10 years. CM effectiveness is 60%.
Risk Cost 0.6x$10,000/10=$600/yr vs CM Cost $100x12 = $1,200/yr
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