Developing a Maintenance Strategy and Setting Performance Targets

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1 Synopsis

Cost Effective Maintenance Management is a goal for many companies. An obvious step to achieving cost effective maintenance includes selecting the appropriate maintenance strategy.

Areas often neglected in the process include defining availability and reliability requirements, measuring performance correctly or even identifying assets satisfactorily. Factors such as fault and failure modes, criticality and information management also need to be considered. Using the wrong maintenance technique can waste time, money and resources, and often has no effect on improving or maintaining availability. Incorrect or poorly defined performance targets can limit or prevent measurement and hence management, control and optimisation.

The following are covered in this paper:

- What are key stages in setting up a maintenance program
- What factors allow measurement of cost effectiveness
- What are some of the common areas of weakness companies overlook

2 Introduction

Cost Effective Maintenance Management is a goal for many companies. Obvious steps to achieving cost effective maintenance include selecting appropriate maintenance strategies and techniques.

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The following are covered in this paper:

- What are key stages in setting up a maintenance program
- What factors allow measurement of cost effectiveness
- What are some of the common areas of weakness companies overlook

"You cannot manage what you cannot measure"

– Attributed to Bill Hewlett (1930-2001), Co-founder of Hewlett-Packard

Many organizations try to carry out maintenance without implementing or managing some key stages. They may then use Key Performance Indicators (KPIs) in their attempt to quantify the cost effectiveness of their chosen approach, but unless each stage has been carried out effectively, they usually find it difficult or impossible to measure the effectiveness of their maintenance.

One of the most cost effective maintenance techniques is condition based maintenance, but it is often implemented incorrectly, and therefore its effectiveness cannot be measured.

2.1 Setting Up a Maintenance Program

When setting up a maintenance program, a number of key stages must be carried out. A typical sequence of key stages in implementing maintenance is shown in Figure 1 below.

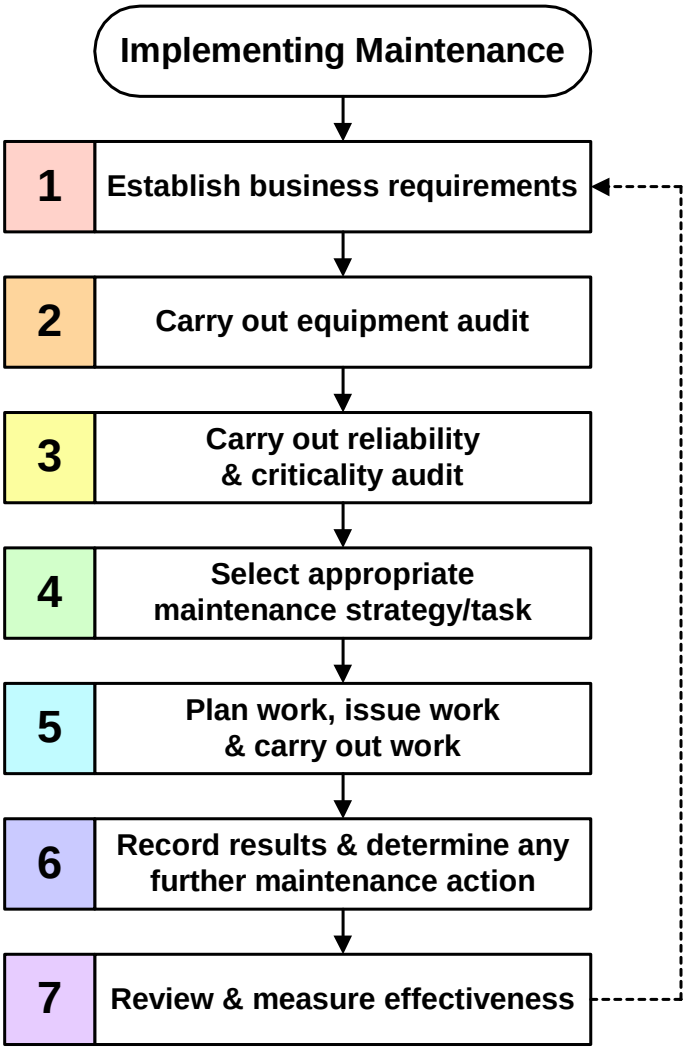

Figure 1 – Overview of Typical Maintenance Implementation Stages

Many organizations try to carry out maintenance without implementing or managing some of the above key stages. They may then use Key Performance Indicators (KPIs) in their attempt to quantify the cost effectiveness of their chosen approach, but unless each stage has been carried out effectively, they usually find it difficult or impossible to measure the effectiveness of their maintenance.

2.2 Making Maintenance Measurable

Setting up a maintenance management system which can then be measured and its cost effectiveness rated depends on carrying out the key stages shown in Figure 1. Each stage has a number of steps which are necessary for the design and implementation of subsequent steps. Each step then allows the performance of the assets being maintained to be measured, and the performance of the maintenance management program.

The following quotations are appropriate to highlight the importance of being able to measure the effectiveness of any process.

"Until you can measure something and express it in numbers, you have only the beginning of understanding"

– William Thomson [Lord Kelvin (1824-1907)]

"You cannot manage what you cannot measure"

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"Those who speak most of progress measure it by quantity and not by quality"

– George Santayana [US (Spanish-born) philosopher (1863 - 1952)]

"How you measure the performance of your managers directly affects the way they act"

– Gustave Flaubert [French novelist (1821 – 1880)]

3 Implementation Phases

Setting up a maintenance program can be viewed in four phases which are:

- Initial set-up
- Routine operation
- Obtaining useful KPIs
- Optimisation and Review

A typical example of typical detail steps in each stage is shown in Figure 2. The right hand columns, under the heading “phase” show the four main phases of the process.

The measurements or key performance indicators shown in Figure 2 Step 7 can only be measured if the set-up and routine steps have all been carried out. For example, if assets are not labelled adequately and uniquely, issued work and feedback cannot be done properly.

Example Detail of Typical Maintenance Management Set-up			Phase			
Step		Detail	Set up	Routine	KPI	Optim.
1		**Establish business requirements**				
	1.1	What is the required availability	y			y
	1.2	What is the required reliability	y			y
	1.3	What is the expected life of the assets	y			y
	1.4	What is the available budget	y			y
2		**Carry out equipment audit**				
	2.1	Identify assets & sub-assets	y			y
	2.2	Create & test asset codes	y			y
	2.3	Label assets & sub-assets	y	y		y
	2.4	Update database	y	y		y
3		**Carry out reliability & criticality audit**				
	3.1	Estimated availability & reliability	y			y
	3.2	FMECA, FMEA, FTA, Root cause failure analysis	y			y
	3.3	Maintenance history, pareto analysis, reliability databases	y			y
4		**Select appropriate maintenance strategy/task**				
	4.1	Condition monitoring task	y			y
	4.2	Inspection task	y			y
	4.3	Preventive maintenance task	y			y
	4.4	Corrective maintenance task	y			y
	4.5	Re-design	y			y
5		**Plan work, issue work & carry out work**				
	5.1	Create/update job catalogue		y		y
	5.2	Estimate/update resources		y		y
	5.3	Create/update check-off lists		y		y
	5.4	Schedule CBM, PPM, corrective or breakdown maintenance		y		y
	5.5	Issue & allocate work		y		y
	5.6	Carry out work		y		y
6		**Record results & determine further action**				
	6.1	Record results		y		y
	6.2	Diagnose faults		y		y
	6.3	Re-schedule work		y		y
	6.4	Initiate further work		y		y
	6.5	Feedback results		y		y
7		**Review & measure effectiveness**				
	7.1	Failure rate, MTBF, MTTR, Downtime			y	y
	7.2	Availability & reliability			y	y
	7.3	Percentage CBM, PPM, Corrective, Breakdown etc			y	y
	7.4	Spares used			y	y
	7.5	Actual budget expended			y	y

Figure 2 – Example Detail of Typical Maintenance Management Set-up

Key: Setup = Initial program setup, Routine = Routine operation,
KPI = Key Performance Indicator, Optim. = Optimisation and Review

3.1 Initial set-up

Initial set up includes the following steps:

Step 1. Establishing business requirements

Step 2. Carrying out an equipment audit

Step 3. Carrying out a reliability & criticality audit[1]

Step 4. Selecting the appropriate maintenance strategy and combination of tasks.

It is important to recognise that maintenance is primarily failure mode and criticality driven, and needs to match the availability requirements of the business. Steps 1 to 3 are therefore important precursors to being able to carry out Step 4. It is important to match the technique to failure mode and criticality. Tools such as failure mode and effects analysis[2] (FMEA) and failure mode effects and criticality analysis (FMECA), reliability databases[3], reliability centred maintenance[4], and analysis of historic information should be used.

3.1.1 Selecting a Maintenance Strategy

Selecting and appropriate maintenance strategy and choosing one or more techniques becomes a simpler decision when the failure modes are understood. A schematic of the decision process in selecting an appropriate maintenance strategy or maintenance technique is shown in Figure 3.

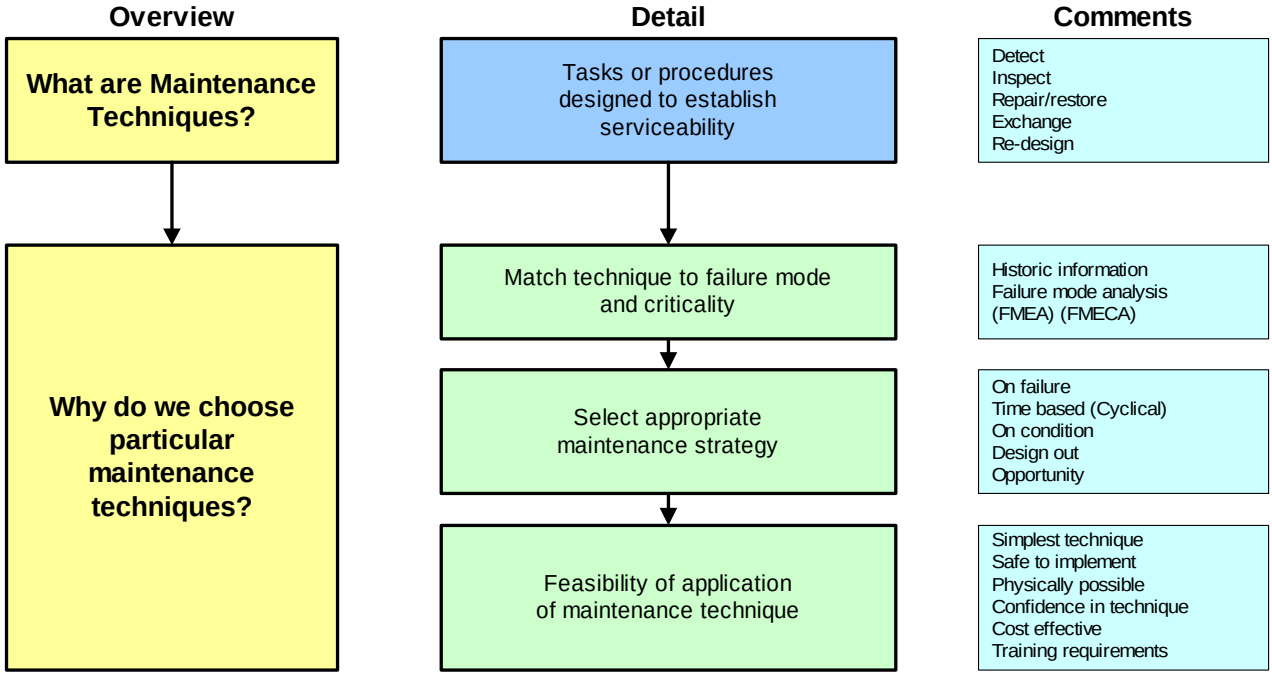

Figure 3 – Selecting Maintenance Strategies & Techniques

3.1.2 Condition Based Maintenance

One of the most cost effective maintenance strategies is condition based maintenance. However it still requires structured implementation and careful management.

The development of International Standards in the field of condition monitoring and diagnostics has led to a more formal approach to implementation. The parent Condition Monitoring Standard is ISO 17359 – Condition monitoring and diagnostics of machines – General guidelines[5]. It concentrates on guidelines for condition monitoring and has an implementation flow diagram which contains the stages shown in Figure 4.

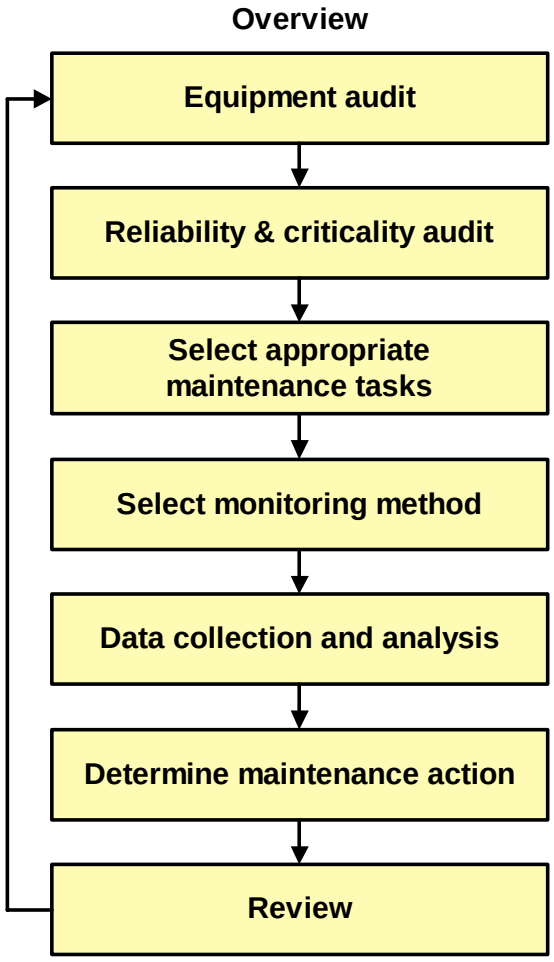

Figure 4 – ISO 17359 Implementation Stages

This is similar to Figure 1, and again, effectiveness can only be assessed if each stage is carried out properly. For example: assets must be clearly identified, codified and labelled, and the feedback of information must be done correctly.

3.1.2.1 Comments

Recent benchmarks carried out for a variety of organisations revealed the following comments:

- The majority of work done is ether traditional time and task based PPM, and on-failure or improvement project remedial work.
- There is little evidence of any significant initiatives into condition based maintenance.
- There are a range of equipments at all sites which will benefit from a condition based approach.
- Asset labelling quality, clarity and location needs improving.

3.2 Routine Operation

Routine operation includes the following steps:

Step 5. Plan work, issue work & carry out work

Step 6. Record results & determine further action

These are routine administrative activities and are opportunities to optimise time on task and reduce re-keying of data.

3.2.3 Selecting/Evaluating a CMMS

Since the routine operation is a combination of repeat cyclical activities and reacting to unplanned failures, the choice of strategy and the computerised maintenance management system (CMMS) or enterprise resource planning (ERP) can greatly influence whether administration is reduced or increased.

The result of the first 4 implementation steps dictates the requirements for a CMMS or ERP system, not the converse.

3.2.3.1 Comments

A recent benchmark for a blue chip organisation revealed the following observations regarding their well known leading CMMS:

- Data analysis features are limited in the CMMS.
- Feedback on work completed is limited.
- Record of parts and materials used is on paper Work Order and not transferred back into CMMS.
- The CMMS system has limited capability and modifications are time consuming ..
- No use of electronic data capture paperless systems or PDAs. Maintenance planning reporting and analysis is currently cumbersome.
- CMMS has limited long term work planning features and planning is achieved using Excel
- No vent trunking inspections, or plant room cleanliness tasks in evidence.
- There is an apparent lack of cleaning routines including inspections & sampling of extracts.
- The CMMS inventory module is not in use locally.

A benchmark on routine maintenance carried out by a contract facilities management provider for a large multi-site service organisation concluded:

- Poor Transferability of Maintenance Data
- Leakage of Maintenance Data
- Inconsistent Sub-Asset Identification

3.3 Obtaining Useful KPIs

Once the previous steps have been carried out, the appropriate Key Performance Indicators can be generated and used. These need to be factors which highlight whether the business objectives are being met and then cascade down through the organisation to provide useful control and measurement points.

3.3.4 KPI Hierarchy

The KPI hierarchy should be determined from the top down and not from the bottom up. This is because the highest level indicators should be designed as measures of what are important to the business in order to meet its goals and objectives. Using a top-down approach ensures that all indicators from the lowest functional level up will support the overall business objectives that have been set for the company. If the indicators are selected from the bottom upwards they may be conflicting rather than supportive.

The KPI hierarchy can be best described as a pyramid comprising Business, Financial Performance, Efficiency/Effectiveness and Working/Functional Performance indicators.

It can be useful to link the pyramid to the responsible levels of management in the company.

All KPIs should be linked to corporate business goals. Most departments or functions cannot be evaluated using a single KPI.

More often than not multiple measures and multiple forms of measurement are necessary.

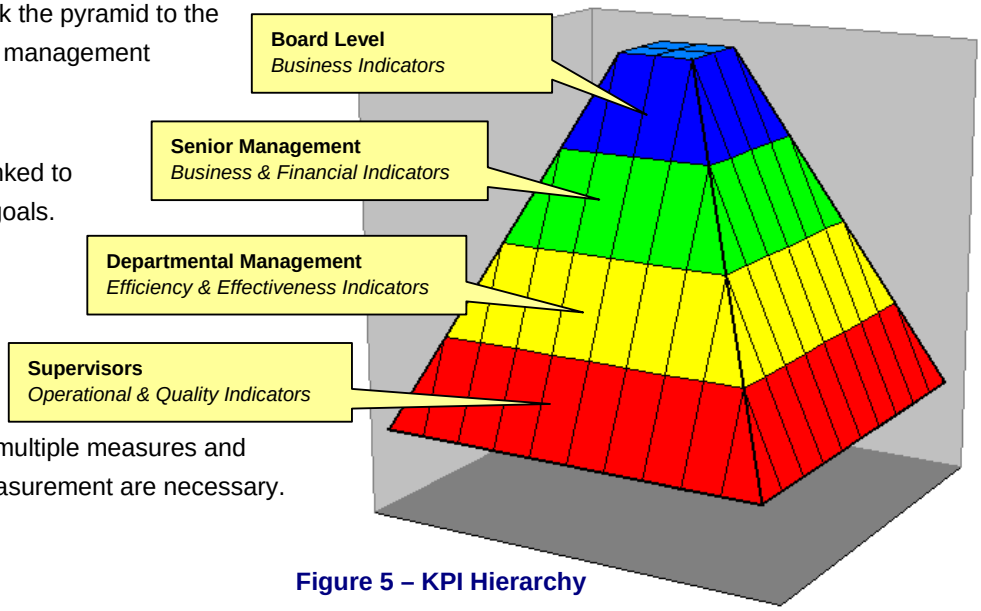

Figure 5 – KPI Hierarchy

3.3.4.1 Comments

Recent benchmarks for a variety of organisations, some using contract maintenance and some directly staffed noted the following:

- Contractor Incentives and KPI's Need Review
- KPIs do not encourage availability or reliability improvements.
- Alignment of management objectives between departments needs review
- KPI's were not performance related and needed review

3.4 Optimisation and Review

Step 5. Review & measure effectiveness

All steps will need revisiting periodically. Business requirements can change – production output changes, raw material price changes, replacement of obsolete plant, reinvestment etc. Assets failure modes change through life. KPIs also need to be flexible to highlight weak areas and enable improvements easily to be tracked.

For example: Maintenance strategies may require modification if the expected performance or life of an asset or system is changed by changes to the business.

3.4.5 Benchmarking

Benchmarking focuses on certain processes and evaluates their relative performance and is a useful technique to highlight areas of strength and weakness in an organisation. Organisations may be initiating a maintenance program, or have a mature system in place. The comments in the previous sub-sections all arise from recent benchmark reviews. A typical benchmark summary chart is shown in Figure 6:

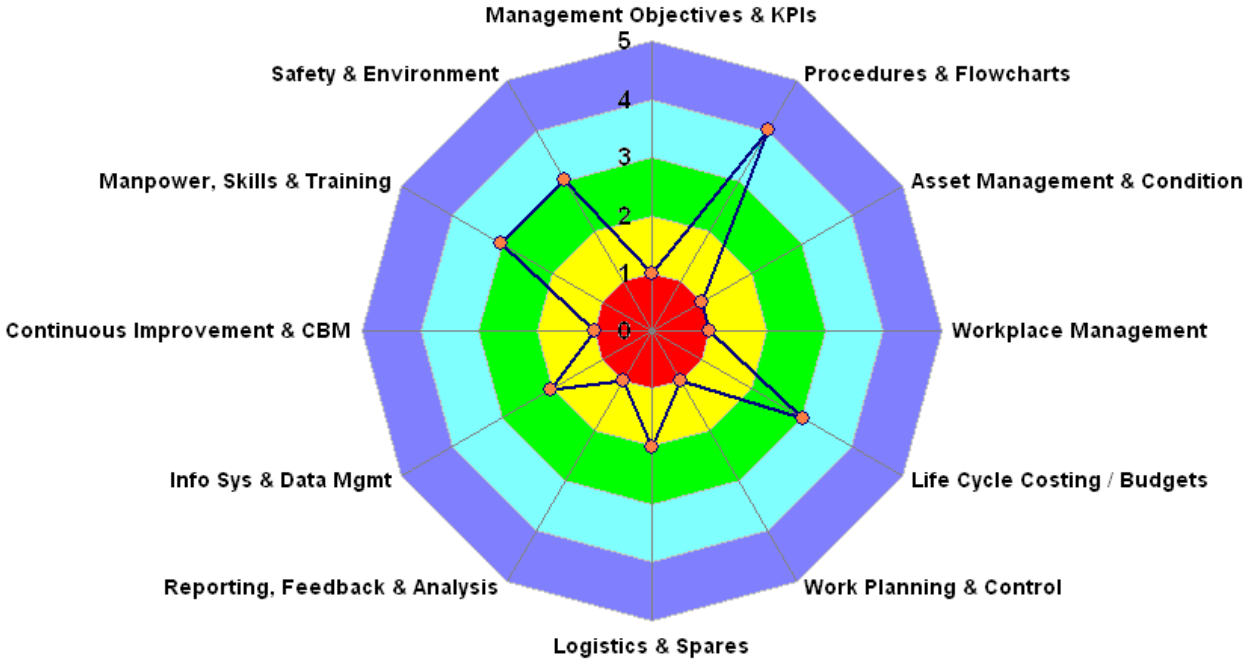

Figure 6 – Typical Benchmark Summary Radar Chart

Key: The chart above shows 12 key focus areas compared on a relative assessment scale of 0 – 5

0 – <1 = uncontrolled
1 – <2 = reactive
2 – <3 = part control
3 – <4 = full control
4 – 5 = fully optimised

4 Conclusion

To implement a successful maintenance management program and to be able to measure its cost effectiveness requires a structured implementation and management scheme.

It is first necessary to implement a maintenance program using a staged process containing key detail steps. The process should ensure that all key steps are followed.

Without clear definition of requirements, achievements and feedback, measurement is not possible.

Measurement of effectiveness through monitoring key performance indicators is only possible if each stage has been completed.

Without measurement, management and optimisation is not possible.

5 Abbreviations

CBM = condition based maintenance
CM = condition monitoring / corrective maintenance
CMMS = computerized maintenance management system
ERP = enterprise resource planning
PPM = planned preventive maintenance
FMEA = failure modes and effects analysis
FMECA = failure modes effects and criticality analysis
FTA = fault tree analysis
KPI = key performance indicator
MTBF = mean time between failure,
MTTR = mean time to repair,
Optim. = optimization

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[2] BS 5760-5:1991 Reliability of systems, equipment and components.
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[3] FARADIP.5 (FAilure RAte Data In Perspective) http://www.maint2k.com
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[4] IEC 60300-3-1 Dependability management - Part 3: Application guide
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[5] ISO 17359:2003 Condition monitoring and diagnostics of machines - General guidelines