“Keeping track of both ends.....”

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Republishing note: The following is based on a larger Report, the important points are reproduced here in a modified form.

Modelling the Maintenance and Engineering Cycle.
Engineering and Maintenance personnel are under steadily increasing financial and technology related pressures. Unfortunately relatively few simple Engineering Management Tools or Techniques have been produced to ease their load, this paper introduces one such Technique which is explained using an example.

Model Objective.

1. Provide advance warning of increased system maintenance costs and system failures, hence provide the ability to optimise staff numbers and parts inventory to match the situation.

2. If possible provide a measure of "System Efficiency".

Operating the Model.

Very few situations are truly sudden or unexpected, experienced personnel can anticipate most situations provided they have access to the relevant information, this reasoning forms the Basis of the Model/Technique.

Typically the Model is:

- Designed, initialised and monitored by the Engineering department.

- Maintained and updated by bookings/facilities/operations personnel, who continuously report the results back to the Engineering and Financial Departments.

Model Design and Assumptions.

The Model is simple and may be run on a Spreadsheet, the results may be e-mailed to the various parties.

1. Determine the critical or important "Attributes" of the device or system monitor.
(Tip: initially these should be simple, obvious and be easily verified/observed)

2. Determine the "Parameters" which "control" or "determine" the above.
(Tip: initially these should be simple, obvious and be easily controlled/observed)

3. Define the "Constraints" (failure/problem levels) in 1 and 2.
(Tip: manufacturer specifications and experience are typical sources of this information)

4. Define the relationships between 1, 2, 3.
(Tip: initially these should be simple and obvious)

5. Collect the data.

6. Collate the new data with the previous data.

7. Compare the results against the Constraints.

8. Interpret the results and pass the information to the relevant parties.

Steps 5 to 8 are repeated continuously.
Given suitable observation and experience, Steps 1 to 4 may be repeated to refine the Model.

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Phone: 61 3 9870 3051 Fax: 61 3 9870 2765 Mobile: 0427 047 167 International: 61 427 047 167
internet: http://www.cabelabels.com.au email: support@cabelabels.com.au
P. O. Box 267 Ringwood, Melbourne, Australia, 3134. 5 Albany Close Ringwood North, Melbourne, Australia, 3134.

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<u>Model Example</u>

It is assumed that the individual designing/creating the Model understands the Subject, as some skill is required in selecting the Parameters, Constraints and Relationships.

This example Model has been kept simple and extremely general so it may be modified to suit many different applications (ie. used as a "Template" or starting point and expanded as required).

For simplicity the Model contains the following limitations:

1. Linear Trends are used to perform the modelling, polynomial, sinusoidal or exponential Trends are also useful and may be substituted if desired.

2. Simple or direct relationships are used here, complex interrelationships may be derived between parameters and substituted if desired.

	A	B	C	D	E	F	G	H
1	**Controlling Variable**							
2	Operating Hours	100						
3								
4	**<u>Parameters</u>**	**<u>Initial Value</u>**	**<u>+/- hr</u>**	**<u>Current Total</u>**	**<u>Constraint</u>**	**<u>Units</u>**	**<u>Fail Value</u>**	**<u>Notes</u>**
5	**Basic Information**							
6	Last Failure	0	1	100	500	Hours	500	Hours between Failures
7	Routine Maintenance	0	1	100	1000	Hours	1000	Service Due
8	Service Life	0		100	87600	Hours	87600	10 Years - End of Useful Life
9	Service Life (as percent)			0%	100	%	87600	10 Years - End of Useful Life
10								
11	**Analog Parameters**							
12	Accumulated Drift/hr	0%	0.001	0.1	1	%	100%	100% = Continuous Drift
13								
14	Temp Sensitivity		5%		10	%	100%	100% = Totally temp. Dependent
15	Temp Conditions		5%		10	%	100%	100% = Totally Unstable
16	Accumulated Temp Effect	0%		0.25	T.B.D	Merit		Large Number => Large Risk
17								
18	**System Parameters**							
19	Path Sensitivity		100%		10	%	100%	Is System Sensitive to Paths
20	Creates Paths		20%		100	%	100%	Does System Create Paths
21	Combines Paths		20%		100	%	100%	Does System Combine Paths
22	Accumulated Path Effect	0%		40.00	T.B.D.	Merit		Large Number => Large Risk

The above is a "snapshot" of the Model running in an Excel Spreadsheet, the spreadsheet is available (see Further Information below).

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Controlling Variable.

Operating Hours. This is the variable to be adjusted as many devices/systems are heavily dependent upon their accumulated hours of operation. By varying this value we observe the changes in the Model.

Columns A to H contain the numerical values of the various parameters being monitored or derived by the Model.

A: Name:	Parameter.
B: Initial Value:	Starting Value for the Parameter.
C: +/- hr:	Variation in the Parameter as time increases (per hour).
D: Current Total:	Current Value of the Parameter taking Operating Hours, Initial Value and variation into account.
E: Constraint:	Value at which the parameter's value requires attention or investigation by Engineering.
F: Units:	Units for the calculation.
G: Fail Value:	Parameter Value at which serious problems are likely.
H: Notes:	A few words of explanation.

Rows 5 to 22 contain "User specified" or "Model derived" Parameters". The Parameters have been chosen to Model an analog Device or System.

Rows 6 to 9 - Basic Information:
These Parameters are typical to many Devices or Systems.

6: Last Failure:	Used to indicate reliability and flag the possibility of further failures.
7: Routine Maintenance:	Used as reminder when Device or System must be scheduled for Maintenance.
8: Service Life:	Some Devices or Systems have a lifetime that is critical (shown as Hours).
9: Service Life:	Some Devices or Systems have a lifetime that is critical (shown as Percent).

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Rows 12 to 16 - Analog Parameters.
Some of the highly critical Analog Parameters, typically these indicate the current performance and likely future performance of a device/system.

12: Accumulated Drift: Assumption is that drift will eventually Trend one direction - Long Term Drift (Short Term Drift may be Modelled by combining an offset and a sinusoidal function, eg: a + (b x Sin(c x hrs)) would provide a reasonable approach. This parameter Models the tendency for drift to be a problem.

14: Temp Sensitivity: If Device or System is sensitive to temperature changes, the % variation these changes induce. Temperature variations can have a major impact on Drift.

15: Temp Conditions: The Stability of the Temperature (constant/varying) is supplied here, low values for very stable Temperatures.

16: Accum.Temp Effect: This is a number which combines the Temp Sensitivity and Temp Conditions. The greater the value, the more susceptible the Device or System is to Temperature variations and the more likely it will encounter problems. If the drift is also temperature related and the accumulated drift rate is high also, then problems are highly likely.

Rows 19 to 22 - Parameters for Modelling System wide behaviour.
Thus far the Parameters Model a device or System in it's own context but make no account for "interconnectivity" - the way in which one devices/systems behaviour is likely to influence, or be influenced other devices/systems. The following Parameters provide the basics to address this issue.

19: Path Sensitivity: Do changes in other Connected Paths/Systems cause this System to vary, or cause problems?

20: Creates Paths: How many other Systems will be effected by problems here: "flow out effect - This feeds other Systems". (eg VDA, Routing Switcher, ADA, Vision Mixer, Audio Mixer….)

21: Combines Paths: How changes in other Systems are handled by this system: "flow in effect - This system is fed from other Systems" . (eg Routing Switcher, Vision Mixer, Audio Mixer ….)

22: Accum.Path Effect: This is a Number which combines the effects of the Paths. The greater the value, the more susceptible the System is to Path Effects. In this situation all the above (Analog, Drift, General) should be viewed very carefully as problems in this System are set to multiply throughout other systems also.

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Reading the results:

1. The personnel updating and entering the information are able to make a few simple observations about the results: Good, Bad, Unknown and report the basics very quickly.

2. In advance they can book out Devices/Systems for Maintenance, advise the need for rostering changes and raise inventory checks.

3. Engineering will still need to be consulted about the far-reaching and intricate analysis, as the relationships between System and Path are not obvious and require some thought (with some additional Parameters and calculations this may be reduced).

4. Using the Model data and the information provided in 2 above, the financial personnel will quickly observe the impact of system problems, costs and down-time. Hence a measure of "System efficiency" and suggest cost savings will be available to Management.

Conclusion:

The Modelling Technique presented here makes use of very simple and well-understood Engineering principles to provide a flexible, yet powerful Tool. One of the major advantages of the Technique is that once initialised, it is updated routinely by non-technical personnel.

Obviously there are many further enhancements possible to the model and it's implementation, the following are a few of the more obvious and easier (?) to implement:

- The use of more complex relationships (care required).
- Typically there would be a Font Page in the Spreadsheet that provided a simple way to enter the data.
- The use of some Macro's would make it possible to display OK/FAIL status on this page also, further simplifying the User Interface.
- Automatic e-mail of failed/warning results to Engineering and other operational areas.
- Plotting certain results can be very helpful.
- Limited history of points.

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