ARTICLE 1 – HOW TO USE ANALYTICS TO PREVENT THE DEFERRAL OF CRITICAL MAINTENANCE

by Michael Carman

What can asset managers do to prevent the deferral of critical maintenance? And how can they use analytics to assist with this?

When budgets are tight, or there are competing priorities for funds, deferring maintenance is an easy target for decision-makers in Finance, or Executive Budget Committees.

Yet asset managers know this myopic approach can have serious impacts: cuts to critical maintenance expenditure can accelerate asset deterioration leading to worsened performance (more defects and downtime) and higher costs in the long-run.

Wouldn't it make for a compelling funding bid if an asset manager could have at their disposal an armoury of supporting analysis with which to front their Executive and say: "Deferring maintenance for 10 years along the lines proposed will lead to net cost increases of the order of $1.8 million, with the $750,000 in savings from the deferral being more than offset by higher reactive maintenance costs and asset replacement costs being incurred earlier."

The integrity of a planned asset maintenance regime has to be fought-for, and this article will outline how analytics can be used as one weapon in the fight for funds and management attention.

TECH 1

THE PROBLEM, DEFINED

The reason that maintenance is so susceptible to deferral is because its benefits are intangible (especially early in the life of an asset) and occur a long way into the future.

The task for asset managers then, is to make the benefits of maintenance both tangible, and immediately relevant. And then to translate them into terms that decision-makers understand and care about.

This is where analytics can play a big part. Analytics is defined here as the systematic effort to collect and interpret data and apply quantitative techniques to it, in order to improve performance. In a management context, analytics is associated with a move away from decisions made on opinion, hearsay or force of personality, in favour of evidence-based decision-making.

WHAT ARE THE EFFECTS OF DEFERRED MAINTENANCE?

How do we use analytics to create a firm and credible evidence base in support of a properly-funded maintenance regime?

We need to construct a model which takes into account the magnitude, timing and sequence of impacts. To put it another way, how do the detrimental impacts of maintenance deferral specifically manifest themselves?

Taking the approach used by Koo and Van Hoy (2000) we distinguish two key impacts of deferred maintenance:

1. Assets deteriorate at a faster rate than they would otherwise, leading to the costs of replacement or renewal being incurred earlier than if maintenance was undertaken, and
2. Repairs (reactive maintenance) occur more frequently than they would otherwise and are therefore higher over the expected life of the asset.

These two effects occur because planned and preventative maintenance (hereafter simply referred to as planned maintenance for ease of reference) either don't occur, or don't occur at the frequency they should.

Our model, therefore shows the sequence of effects set out in Figure 1.

Note that reactive maintenance will occur in any case, but will occur more frequently and be progressively more costly in the absence of a proper planned maintenance regime.

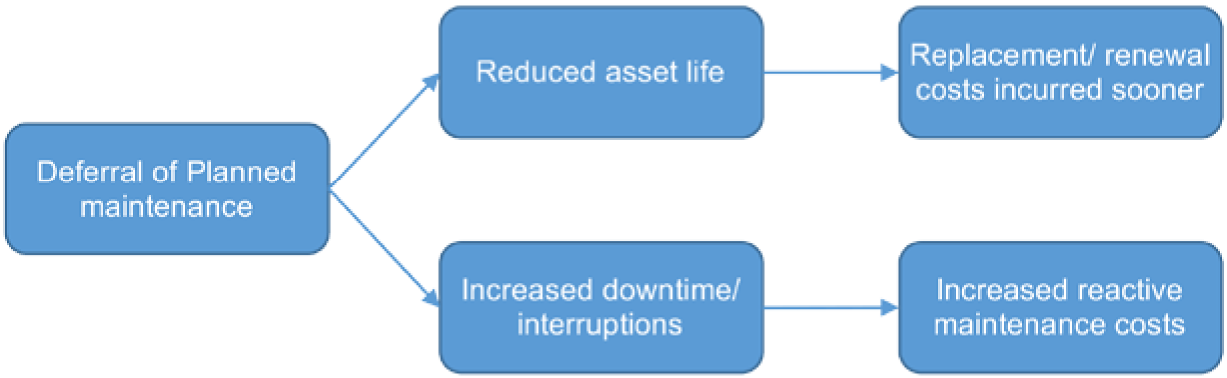

Figure 1: Effects of Deferring Planned Maintenance

QUANTIFYING THE PAIN OF DEFERRED MAINTENANCE

Asset managers typically draw on a number of tools in dealing with these issues. Asset lifecycle curves (also known as deterioration curves) plot the decline of an asset's performance with the effect of time. Less frequently used, but no less important, are cost curves which plot the increase in annual maintenance costs as an asset ages: in effect, the maintenance costs of an asset become more expensive as it slides down the steep slope of the deterioration curve. Planned maintenance has the effect of pushing the deterioration and cost curves outwards, effectively extending the life of the asset, maintaining performance levels for longer, and delaying the need to incur replacement costs. These are shown conceptually in Figure 2.

Conversely, deferring planned maintenance has the opposite effect: it pushes the deterioration and cost curve inwards from where they would otherwise have been.

While most asset managers are familiar with these curves as conceptual or explanatory tools, what's needed is a means of generating them with actual data, for real assets, and then deriving best estimates of the benefits of planned maintenance. This is where we put our analytics to work…

BUILDING THE MODEL

A customised model has to be built to reflect the specifics of a particular asset portfolio, and requires data on each of the following, by asset:

i. The expected useful life of the asset

ii. The replacement cost of the asset

iii. The annual cost of planned maintenance

iv. The annual cost of reactive maintenance (when planned maintenance occurs) for each phase of the asset's life

v. The annual cost of reactive maintenance in the absence of some or all of planned maintenance for each phase of the asset's life, and

vi. The amount by which the expected useful life of the asset decreases in the absence of a proper planned maintenance regime.

As with all analytics undertakings, the effort is data-intensive and requires the most effort the first time it is undertaken. Senior management commitment to the collection, cleansing and analysis of data is a necessity for any credible analytics effort. It's reassuring to note however that subsequent runs of the model and 'tweaks' require far less effort.

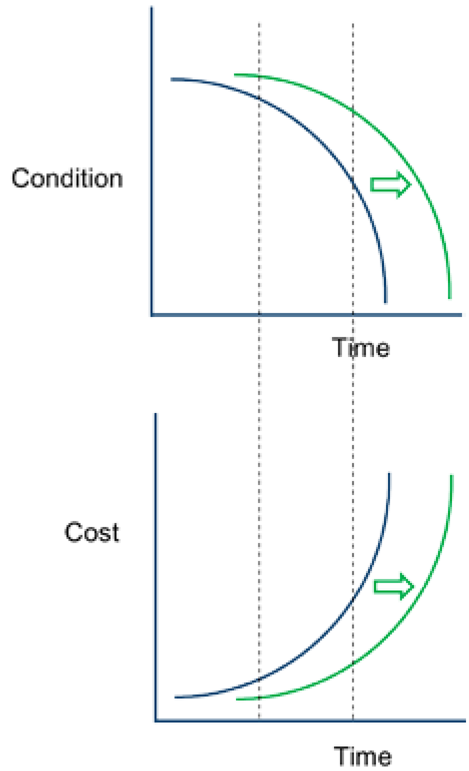

Figure 2: Deterioration Curve, Cost Curve and Effect of Planned Maintenance on Each

TECH 1

PUTTING THE MODEL TO WORK: A CASE STUDY

To see how the model works we will use an example with a single asset (a 500kW commercial steam boiler) so the concepts and calculations can be seen. The same principles apply with a whole asset portfolio, but simply on a larger scale.

The data used here are hypothetical but will serve to illustrate how the model works in practice. In our scenario, the boiler is 10 years into its expected life and has been properly maintained until now. Senior Finance staff are considering deferring maintenance on this asset for 10 years and reallocating the funds elsewhere.

The manager of this asset has collected and analysed data from within the portfolio, as well as gathering information from industry and trade publications and experts, and determined the following (financial figures are in inflation-adjusted terms):

i. The expected life of the asset when it is properly maintained is 30 years; thus 20 years remain if the asset receives proper planned maintenance

ii. The replacement cost of this asset is $85,000

iii. Planned maintenance costs $900 per annum

iv. Reactive maintenance costs when planned maintenance occurs are $500 per year for the first 10 years of the asset's life, $750 per annum for the next tranche of 10 years, and $1,100 per annum in the final 10 years of the boiler's expected useful life

v. Reactive maintenance costs when planned maintenance is deferred for 10 years are $1,000 per annum for the second tranche of 10 years, and rise to $2,300 per annum in the last 10-year period (owing to the need for extensive asset renewal)

vi. The expected useful remaining life of the asset with 10 years of deferred planned maintenance reduces from 20 years down to 17 years.

The data in items iii, iv and v above enable us to construct cost curves for this asset, as shown in Figure 3.

Figure 3: Annual Planned and Reactive Maintenance Costs

With this information in hand, we now construct two scenarios: one with a proper planned maintenance regime, that is with maintenance not deferred (which serves as a comparator) and the other with deferred maintenance. The impact of deferred maintenance is the difference between the two scenarios. We'll use a 20-year time horizon for the analysis.

Using the figures above, the cash flows for the remaining 20 years of the life of the boiler with planned maintenance are shown as per the graph in Figure 4.

The main thing to note is the increase in reactive maintenance in the final 10 years of the asset's life. The total maintenance expenditure over 20 years under this scenario is $36,500. Taking into account the effects of time (ie. discounting the cash flows at a rate of 7 percent) produces a net present cost of $18,730.

Figure 5 shows the graph of cash flows under the second scenario where maintenance is deferred.

The deferred maintenance scenario shows the steep increase in reactive maintenance costs at the beginning of the second 10-year period, but the standout item is the replacement cost incurred in year 17 (note that the $85,000 replacement cost is mapped against the right-hand axis). Reactive maintenance costs in the last three years reduce because the asset is a new asset.

Total maintenance expenditure over 20 years under the deferred maintenance scenario is $121,600 or a net present cost (at a discount rate of 7 percent) of $43,862.

The bottom line: deferring maintenance actually leads to costs which are $85,100 higher over the 20-year period ($121,600 minus $36,500), or $25,132 higher ($43,862 minus $18,730) once the effects of time are taken into account. Thus, the 'savings' from deferring maintenance are actually a false economy: the costs associated with increased reactive maintenance and earlier asset replacement outweigh the savings from deferring maintenance.

These then, are the figures the asset manager would be armed with to take to decision-makers in Finance or the Executive Budget Committee.

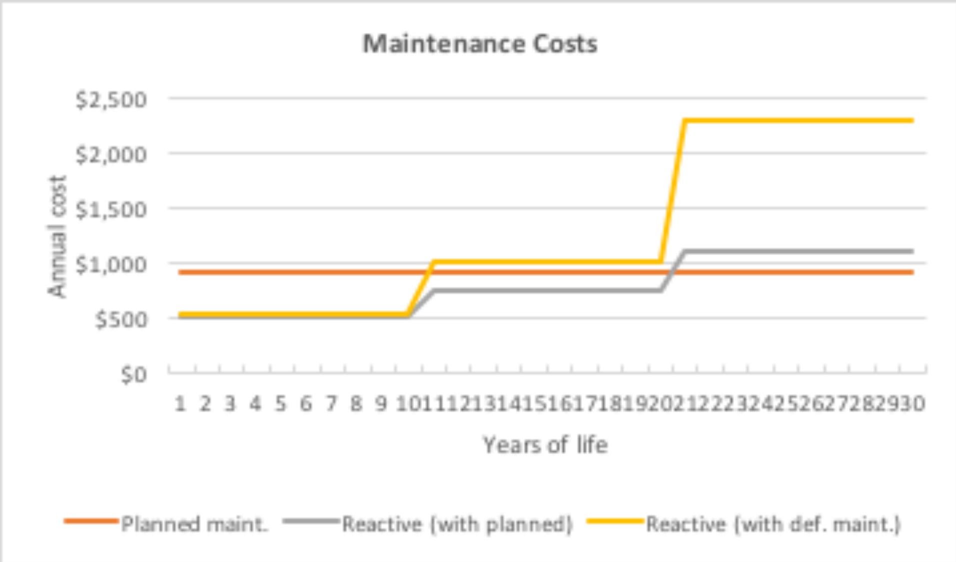

Figure 3: Annual Planned and Reactive Maintenance Costs

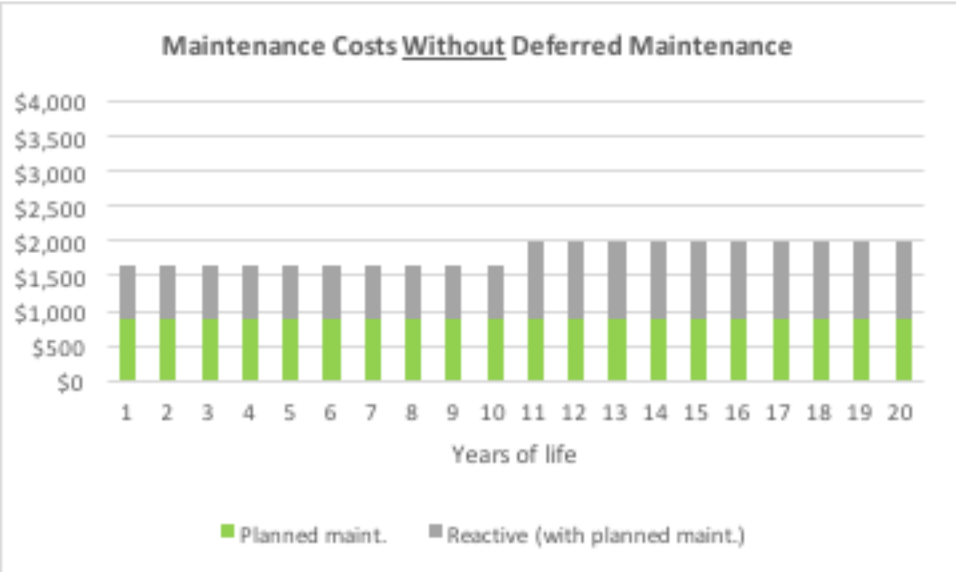

Figure 4: Maintenance Costs with Maintenance Not

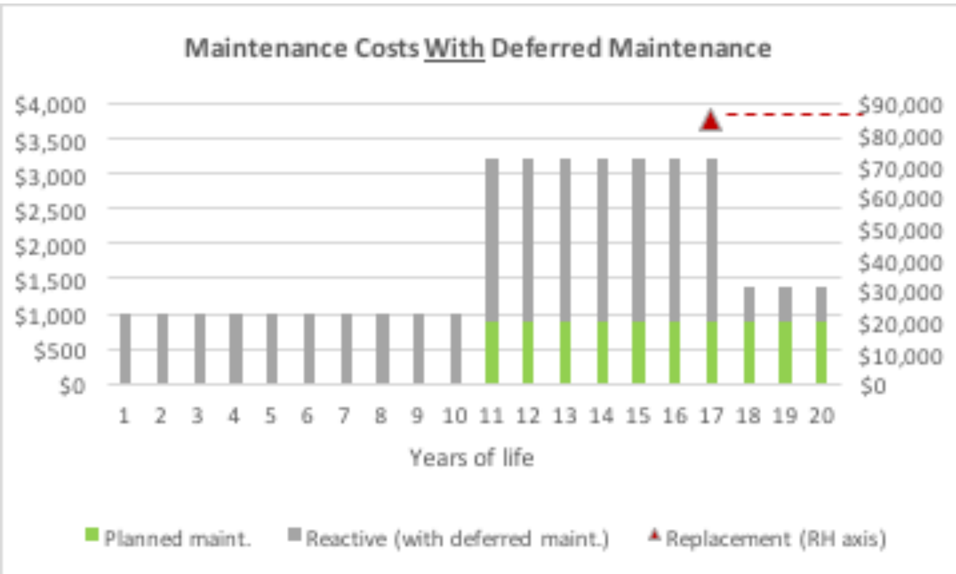

Figure 5: Maintenance Costs With Deferred Maintenance

WHERE DO THE NUMBERS COME FROM?

As we've seen, making the case to stop maintenance being deferred relies on putting together several key data items: where are the data for these items sourced from?

Expected useful life of an asset would be known from manufacturer's specifications or engineering experience. Replacement cost would be ascertained from market data or commercially available cost guides. Data on the cost of planned maintenance would be gathered from the organisation's historical financial data. Data on the relationship between reactive and planned maintenance costs, and on the degradation of expected useful asset life in the absence of planned maintenance, are critical to quantifying the impact of deferred maintenance. There are two main ways to derive these data items.

One way is to gather information from industry experts, trade associations or academic studies. These might be in the form of specific dollar values for reactive maintenance compared with planned maintenance, or a degradation factor which is applied to reactive maintenance costs and expected useful life.

The other way is to undertake (or commission) analysis and calculate these values from the organisation's own operating history. Plotting reactive maintenance costs against planned maintenance costs and using regression analysis to establish the relationship between them (refer Figure 6 below: again the data here is hypothetical for illustrative purposes only) is a powerful application of analytics and one that is at the heart of evidence-based asset management.

Of course, this line will also partially reflect the age of the asset: cross-referencing data on maintenance cost with that on asset age allows further regression analysis which 'unpacks' the cost impact of a certain amount of maintenance spend at a particular stage of asset life.

As we've noted, all this data collection and analysis requires commitment; it can seem like a major effort.

However, as with asset maintenance itself, the return is well worth the investment.

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Figure 6: Plotting Planned and Reactive Maintenance Costs Against