Size Maintenance Craft Capacity on Forecasts, Not Backlog

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Get maintenance craft capacity right and many things get right. So it is no small thing that the wide range of insight given by data analytics enable maintenance operations to find and stay on the sweet spot.

The consensus amongst maintenance practices professionals has been that the best way to size a plant's craft capacity is upon the recent history of weeks of craft backlog, and direction and rate of change. The new-age alternative is to use the plant's troves of data to size the craft capacity upon statistically forecasted workload.

The statistical forecast of workload is inherent to workload-based budgeting in which it is also inherent to statistically determine the number and mixture of crafts to execute the workload. The necessity for adjustment is confirmed through variance analysis against the budget rather than attempting to interpret changes in craft backlog. The larger two-dimensional system to make this possible is explained the article, "The Secret is to Budget and Control Maintenance Opex Dimensionally."

This article will introduce, summarize and compare the effectiveness of the approaches. It will also make clear why business losses are inevitable to the backlog-based approach while the forecast-based approach steps over them.

The Backlog-Based Approach

Weeks of craft backlog is computed as follows:

$$\text{Craft backlog (Weeks)} = \frac{\text{Work in backlog (Hours)}}{\text{Craft capacity per week (Hours)}}$$

The equation is applied to each craft type associated with a given work type. Most practitioners include all known work as "work in backlog." The calculation is typically limited to corrective work. In turn, "craft capacity per week" in the calculation is limited to the craft hours available to do the corrective work.

The calculation can be expanded to include proactive work, but is usually not. Instead, the craft force is sized for corrective work and adjusted by some factor to account for craft capacity to be engaged in proactive work.

The result is craft backlog in weeks for each craft. The operational principle is to periodically evaluate if current craft capacity is showing to still be appropriate or needs to be adjusted. The signals are the direction and rate of change relative to weeks as upper and lower limits. The typically recommended range is two to four weeks.

There is a red flag in the description. As an analytic, the process is evaluating a series of current and recent snapshots of backlog. It is not evaluating the snapshots in the context of the budget year's forecasted occurring work.

The Forecast-Based Approach

The engine of the forecast-based approach is shown in Figure 1. The figure shows the forecast of work to occur as the year unfolds. The horizontal plot is the average of the forecast. The broken line is actual occurring work; which in this case is continuing to show a good fit.

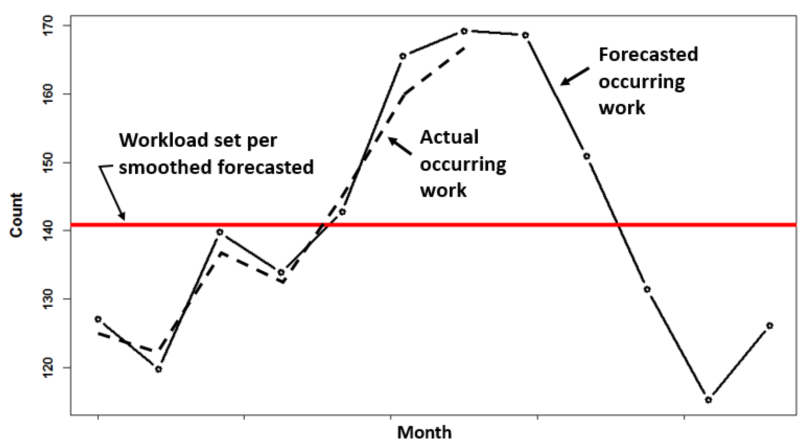

Figure 1: Forecasted and actual workload with smoothed workload as an average of forecast.

The forecast is modeled using as shown in the article, "[Setting the Budget for Maintenance Workload](#)." Time series analysis is explained in the article, "[Explore What and Did Happen With Time Series Questions of Operations](#)."

The statistical analytic decomposes the past many years of history into two constituent series. They are trend or level and recurring cycles such as season or calendar.

If we are comfortable with assuming that the characteristics of the past for each component will continue into the budget year, we will accept the modeled forecast. Otherwise we will adjust the component forecasts to fit revised assumptions.

The plot would also be the case for proactive work. The time series of occurring work is the timing at which the orders will appear in the maintenance system to be scheduled. Just as for corrective work, the smoothed workload is the average of the series profile.

The budgeting process attaches craft resources to the smoothed workload. In turn, the findings for craft resources are translated to size the cross-plant craft capacity to deliver the smoothed workload.

There is another important departure. The budgeting process determines workload and craft resources for every homogenous workload group, within each cost center, and for corrective and proactive workload.

Inclusiveness has important Lean-type ramifications. It allows the maintenance operation to function around a smoothed work flow with a constant mixture. This, in turn, allows the cross-plant craft force to be more sharply optimized, while allowing other plant operations to sharpen their effectiveness.

How They Play Out

Figure 2 shows the outcomes of the respective approaches. The plots show the weeks of craft backlog at the end of each month for the same workload group. Both are shown to begin at a backlog that has been set with regard to business risk and process efficiency.

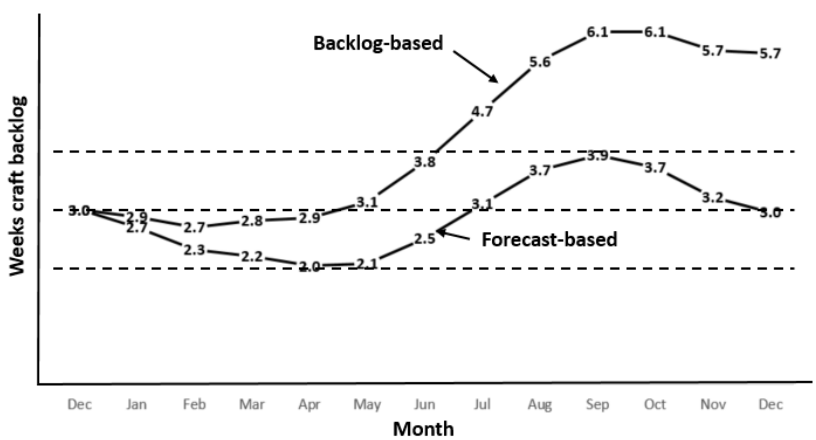

Figure 2: Backlog driven by forecast-based craft capacity compared to backlog-based craft capacity.

Notice that the backlog for the forecast approach centers around the set backlog. This is inevitable because craft capacity was determined on the forecast of occurring work smoothed as monthly workload.

Also note that weeks of backlog for the perfect case are always in flux. This is because actual occurring workload normally differs from the smoothed workload. The point is that direction and rate of change (occurring work minus craft capacity) never tells a story we should hang our hats on.

The upper plot of Figure 2 is one modeled with craft capacity which is approximately 93 percent of the smoothed forecasted workload. The big point is that backlog will always be headed toward bad and worse until craft capacity arrives at, by either design or trial and error, the capacity driving the lower plot. Furthermore, trial and error is an expensive way to find it.

Control on Variance

A primary measure of an operation's potential for excellence is the strength of its ability to control on variance against granularly budgeted activity times resources times cost. The large gap in the ability between the backlog- and forecast-based approaches can be seen in the formula that interrelates them.

$$\begin{matrix}\text{Ending} \\ \text{craft backlog} \\ \text{(Weeks)}\end{matrix} = \begin{matrix}\text{Beginning} \\ \text{craft backlog} \\ \text{(Weeks)}\end{matrix} + \frac{\begin{matrix}\text{Occurring work} \\ \text{(Hours)}\end{matrix} - \begin{matrix}\text{Completed work} \\ \text{(Hours)}\end{matrix}}{\begin{matrix}\text{Craft capacity per week} \\ \text{(Hours)}\end{matrix}}$$

What immediately jumps out is that ending craft backlog is the wagging tail on the dog of activity times resources. In contrast, occurring work, completed work and craft capacity are analytically derived elements of activity and resources. An effective operation will focus on their variances for control.

Upon the forecast approach, the questions of variance and control are no longer direction and rate of change of the ending backlog, and the almost unanswerable question whether the change is meaningful. Instead, variance and control questions laser in on the activity and resource elements of the formula.

The first essential question is whether or not the forecast of occurring workload is still a good fit to actual occurrences. Statistical methods allow us to meaningfully answer the question.

The second essential question is whether or not actual completed work matched the budget for completed work—the smoothed workload of Figure 1. Such a case is shown in Figure 3; the conceptual depiction of workload-based budget and variance and explained in the article, "The Secret is to Budget and Control Maintenance Opex Dimensionally." Actual completed work fell short of the budgeted workload.

The follow-on question to the revealed variance, is why? With respect to the craft force, the path of investigation is directly into the current version of analysis of craft hours per job and the optimizing construct of the plant-wide maintenance craft force.

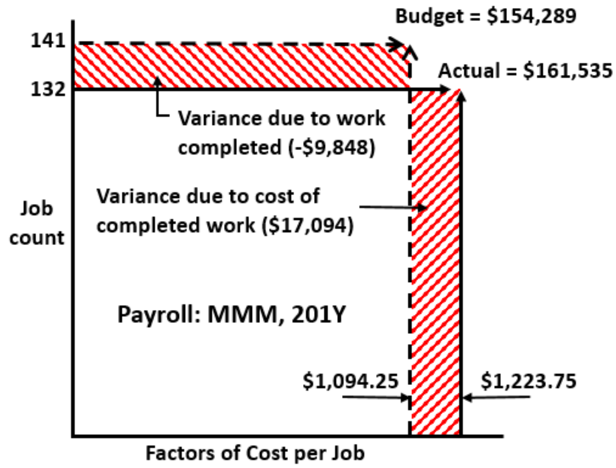

Figure 3: The concept of workload-based budget and variance.

The preliminary indication of Figure 3 is that the size of the craft force is not the cause of the work shortfall. Notice that there is an overrun variance in payroll cost per job. If upon tracing to direct hours, we find a systemic increase in hours per job (reduced productivity), then we are seeing that the craft force was not the entire bottleneck, if any at all.

It is noteworthy that the backlog-based approach cannot trace to these variances. This case demonstrates the importance of operational control upon activity and resource variances. The backlog approach could easily head-fake us into increasing the craft force rather than continuing on to find the organizational dynamics causing the shortfall.

It is also a validation of the forecast approach that at any point in time we can delineate for action the components of the current backlog. We can distinguish the change in craft hour backlog caused by variance from workload budget and take action to catch up. We can distinguish the change in backlog as actual work normally varies from smooth and know to not take an action. We can distinguish the proportion of backlog associated with a poor fit of statistically forecasted workload with actual workload and take action to settle the craft force on a revised equilibrium forecast.

Whenever the craft capacity is a poor match to actual workload, there will be consequences across the plant; pushing it into a continual state of gaming the system and damage control. Now that the organizational skills in data and analytic tools have come of age, it is time to add to the financials and cash flow the dividends of moving away from the past.

Sources for self-directed learning: Introductory Time Series with R, Cowperwait and Metcalf, 2009 | Event History Analytics with R, Bostrom, 2012

Related papers: ROACE: Financial North Star to Maintenance and Reliability Operations **|** The Secret Is to Budget and Control Maintenance Opex Dimensionally **|** Setting the Budget for Maintenance Workload

