Golf and Six Sigma

Use Six Sigma metrics to drive proper process behavior

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Measurements affect behavior. Accordingly, the leaders of many respected companies are now paying the price for creating an environment in which measurements did not accurately reflect what was occurring in their organizations. They created an environment where it was common practice to play games with the numbers and make short-term numbers look good at the expense of long-term performance for stockholders and employees. They did not track high level business measurements as a process, create a meaningful strategic plan and then align process improvement and reengineering projects to this plan.

Some measurements from Six Sigma can be similarly deceiving. When creating a Six Sigma infrastructure, you need to be careful with the metrics and their interpretation. Otherwise, practitioners may feel pressured to play games with the numbers. The measurements used in a Six Sigma infrastructure need to drive the right behavior for all processes, not just manufacturing.

Taking a closer look at the sport of golf is one way to illustrate Six Sigma measurement alternatives and the confusion that can result. Pretend you played two 18-hole rounds of golf and ended up with the following scores (see Table 1). Think of these scores as a sequence of products produced or transactions executed over two days.

How should these metrics be reported? Within a Six Sigma infrastructure we encounter process capability/performance indexes, such as C_p, C_{pk}, P_p, and P_{pk} (see “Glossary”). We also encounter defects per million opportunities (DPMO) and sigma quality level metrics. These metrics are to help quantify how well a process or product is doing relative to a criterion.

How to define a defect

Let's say you are a Six Sigma Black Belt and your employer wants you to report these units for all projects. How should you make these calculations? In this article I will focus on the sigma quality level.

You could define an opportunity for defect at the golf stroke level. That is, you would say a stroke has a defect when the ball is not hit properly. However, this approach can force you to play games with the numbers because this definition for a defect includes various levels of goodness and does not necessarily relate to your overall score.

Another approach would be to define a defective event as when you exceeded par on a hole. Using this definition for your two days of golf, you could count 25 defective holes out of 36 holes, noting that a birdie counted the same as a par hole. This translates to a defective rate of 0.694444 (25/36) or a parts per million (ppm) defective rate of 694,444. This ppm rate approximately equates to a sigma quality level of 1.0.[1]

So how well does the sigma quality level metric describe your golf game? If you reported a one sigma quality metric to a friend, would it be clear to him how well you are doing in golf? Do you understand how your golf game is progressing over time? Do you have a strategy that naturally leads you to quantify the source of variability within your golf game? Do you have a measurement strategy that will ask you questions on what you might do differently to improve? The answer is no. This same confusion can occur when using the C_p, C_{pk}, P_p and P_{pk} metrics.[2]

The problems with this golf illustration relative to the understanding of someone's golf score performance are not unlike the reporting of the Y output or key process output variable of many Six Sigma projects and other metrics within an organization. Also, the implication of sample size and of how samples are taken is often not addressed in these metrics.

An alternative approach

There is an alternative to reporting your golf metrics. This strategy starts with a high level view of your golfing process. In this approach, a 30,000-foot level metric is created using what I call infrequent subgrouping/sampling. With this strategy, you can create a sampling plan that considers operator-to-operator, machine-to-machine, raw material lot-to-lot and shift-to-shift factors as noise to the overall output.

This strategy is in alignment with W. Edwards Deming's belief that if performance is poor, 94% of the time the system must be modified for improvements to occur. If you agree with this categorization of these variables as common cause noise variables, you can see that many standard control charting procedures can lead to the wrong activity. That is, many current control charting procedures compel practitioners to fire fight common cause variability, such as day-to-day raw material differences, as though it were a special cause.[3]

If you collected data on 20 rounds of golf and plotted the average number of shots above par in an XmR control chart, you would come up with a 30,000-foot level view of your golf game (see Figure 1). I chose this procedure of reporting, as opposed to plotting the number of shots above par for a golf course, because I wanted to be able to describe process/capability at the golf-hole level, as well as the overall course level.

The center line of this plot is a best estimate for the mean response of the golfing process. Since the process is in control, it is predictable. You can expect to shoot on average about 1.2 strokes per hole above par for 18 holes of golf, unless something different occurs. The normal probability plot shown in Figure 2 describes what you can expect 80% of the time when you play 18-holes of golf. This probability plot is a best estimate that considers the variability between courses, course conditions and your golf swing consistency.

You could also describe an estimated process capability/performance of your golf game as an 80% occurrence rate. An 80% interval could be expressed as either:

- 0.92 – 1.47 average per hole strokes above par for an 18-hole course.

- (0.92 x 18) + 72 = 89 strokes to (1.47 x 18) + 72 = 98 strokes for an 18-hole, 72-par course

I think these metrics provide a more understandable description of your golfing capability/performance than the sigma quality level and other Six Sigma metrics described earlier.

The 30,000-foot level view of your golf game provides a good baseline from which you can build strategies on how to improve your game. For example, you can build a Pareto chart that shows the distribution of long shots, short shots and putts. The chart will indicate where you should focus your practice efforts.

Business application

On a larger scale, when companies are implementing Six Sigma, they need to align their measurements and improvement activities with the overall needs of the business. Organizations need to create a set of balanced, cascading measurements that leads to meaningful activities, which can get them out of firefighting mode. With this strategy, we are pulling (to use a lean term) for the creation of Six Sigma/lean projects when the process does not have a satisfactory level of capability/performance.[4,5] I wonder how many of the companies currently having financial problems would still be profitable if they had followed this basic strategy instead of playing games with the numbers.

Text References

1. Forrest W. Breyfogle III, *Implementing Six Sigma*, John Wiley and Sons, 1999, Table S.
2. Forrest W. Breyfogle III, "Golf Scores and Six Sigma Metrics: Confusion and Resolution, part 2," www.smartersolutions.com/html/golf_and_six_sigma_part_2.htm.
3. Breyfogle, *Implementing Six Sigma*, see reference 1.
4. Forrest W. Breyfogle III, James M. Cupello and Becki Meadows, *Managing Six Sigma*, John Wiley and Sons, 2000.

5. Forrest W. Breyfogle III, David Enck, Phil Flories and Tom Pearson, *Wisdom on the Green: Smarter Six Sigma Business Solutions*, Smarter Solutions Inc., 2001.

Glossary

Birdie: A hole completed in one shot under par.

DPMO: When using the nonconformance rate calculation of defects per million opportunities (DPMO), one needs first to describe what the opportunities for defects are in the process. Next, periodically divide the number of defects by the number of opportunities to determine the DPMO rate.

Par: The regulation number of strokes set for a hole played perfectly, determined by yardage and design of the hole.

Process capability indexes (C_p and C_{pk}): C_p is a measurement of the allowable tolerance spread divided by the actual six sigma data spread (six times standard deviation). C_{pk} has a similar ratio to that of C_p except this ratio considers the shift of the mean relative to the central specification target.

Process capability: According to the Automotive Industry Action Group (AIAG), it's the six sigma range of a process's inherent variation for statistically stable processes, where standard deviation is usually estimated as $\overline{R}/d_2$ [$\overline{R}$ is the average within subgroup range from an $\overline{x}$ and R control chart and d_2 is a constant]. For the attribute data case, process capability is usually defined as the average proportion or rate of defects or defectives, such as the center of an attribute control chart.[1]

Process performance: According to the AIAG, it's the six sigma range of a process's total variation, where sigma is usually estimated by s, the sample standard deviation.[2]

Sigma level or sigma quality level: A quality calculated by some to describe the capability of a process to meet specification. A six sigma quality level is said to have a 3.4 ppm rate.

Glossary References

1. Chrysler Corp., Ford Motor Co. and General Motors Corp., *Statistical Process Control (SPC) Reference Manual*, Automotive Industry Action Group, 1995.
2. Ibid.

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