An Introduction to Process Control Charts

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What is a Process Control Chart?

Process control charts (or what Wheeler calls "process behavior charts") are graphs or charts that plot out process data or management data (outputs) in a time-ordered sequence. It's a specialized run chart. They typically include a center line, a 3-sigma upper control limit, and a 3-sigma lower control limit. There might be 1- or 2-sigma limits drawn in, as well. The center line represents the process mean or average (and sometimes the median).

The control limits represent the process variation and shows us what's typical or "common cause" variation. Based on the typical baseline period-to-period variation, those limits are calculated as to help us distinguish between "signal" and "noise." Again, these are calculated... they are part of "the voice of process" and you don't get to choose what the limits are. If you don't like the control limits or think they are too wide, you have to improve the process to reduce variation and noise, which is different than asking "what went wrong?" in any given time period.

As leaders, we want to make sure we aren't wasting our time (or our employees' time) by asking for explanations about the noise. If we're going to ask "what happened yesterday?," we want to make sure we are reacting to a statistically significant signal in the data. One of those signals is a data point outside of those 3-sigma control limits.

Again, control limits are usually set at three process standard deviations above and below the average. This is because in the early 20th century, when Walter Shewhart, one of the founders of the modern quality movement, formalized the ideas used in control charts, he determined that, if any single measurement falls within above or below those 3-sigma limits, it is considered “expected” behavior for the process (and Wheeler's modern-day writing explains why this is the case).

Variation

When a process is stable and in control, as in the above example, you see nothing but common cause variation. Common cause variation results from the normal operation of a process or system and it is expected due to the design of the process, routine activities, materials, and other factors.

When a single data point falls outside of the control limits, something unexpected has happened to the process. Something out of the unusual has caused the process to become out of control. This is one example special cause variation. It indicates that it's very unlikely that the data point is due to noise, randomness or chance.

It is important to note that process control charts can reveal problems even when all of the data points fall within the control limits. If the plot looks non-random, with the points exhibiting a form of systematic behavior, there may still be something wrong.

For example, if we have eight consecutive data points above or below the average, that's statistically unlikely to be due to chance. Statistical methods to detect sequences or nonrandom patterns can be applied to the interpretation of control charts. In control processes display random deviation within the control limits.

The "Western Electric Rules" give us additional guidelines for determining what is likely a special cause.

The 4 Process States

At any given time, each process falls into one of four states:

The ideal state occurs when a process is in statistical control and produces 100 percent conformance to specifications or goals. The process is predictable and produces expected results.

In the threshold state, the process is in statistical control but occasionally exhibits non-conformance at times.
The brink of chaos state refers to a process that is not in statistical control but is not producing defects. This is usually a precursor to the last state;
The process is out of control and is producing unpredictable non-conformance.

Each process fits into one of these states at a particular point in time, but will not stay in that state. All processes will move toward chaos of their own accord, over time, without due attention. Most companies only recognize the need for intervention and improvement when the process has moved to the out of control state. Control charts help organizations recognize process deterioration so that improvements can be applied to processes in the threshold or brink of chaos state.

Benefits of Process Control Charts
Organizations that practice continuous quality improvement use control charts to:

Provide a simple, common language for talking about process performance and behavior
Make informed decisions about which processes to leave alone and which to subject to an improvement cycle
Limit the need for inspection
Determine process capability based on past performance and trends
Predict future performance if the system is stable and in control
Assess the impact of process changes
Visualize the performance of the process over time
Create a baseline for future improvements
Communicate the performance of a process

Implementation

There are a few basic steps to implementing a control chart.

Step 1: Define what needs to be controlled or monitored

Step 2: Determine the measurement system that will supply the data

Step 3: Establish the control limits based on some baseline data

Step 4: Collect and chart the data

Step 5: Make decisions based on the correct interpretations control chart information.

Process control charts are popular with manufacturing organizations using the Lean or Six Sigma business methodology, but they can be of great value when applied to any process that has measurable outcomes that can be tracked over time. Businesses of all types can benefit from this simple, yet powerful way to visualize process performance.