How Lean is Your Six Sigma Program?

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Introduction

Combining Lean and Six Sigma has become extremely popular. Everywhere I turn, Six Sigma programs have morphed into Lean Six Sigma. Lean Six Sigma is intended to combine business improvement methodologies to improve quality *and* efficiency. Lean production emphasizes the elimination of waste; Six Sigma strives for improvement in process performance. Lean programs can certainly be enhanced through better problem solving for process improvement, and while Six Sigma has frequently been put to this use, the question remains: Are Six Sigma projects themselves Lean?

I have heard many manufacturing company executives complain that Six Sigma projects often take too long, use too many resources and don't always deliver the expected benefits to the bottom line. Such concerns would appear to indicate that many improvement processes contain waste of their own in the form of surplus effort and underwhelming results. The essence of lean, according to one Toyota Production System authority, is its emphasis on discovering waste in order to eliminate it. Since it seems that many improvement processes are not very lean, let's see what can be done to reveal and eliminate the waste in their problem-solving methods.

A Case of Failed Problem Solving

Consider a real-life problem faced by a manufacturer of automotive air-conditioners: compressors used in a number of automotive models were failing in vehicles driven more than 20,000 miles. The problem persisted for more than seven years, despite the efforts of four separate teams of air-conditioner engineers to solve it. Examination of returned parts revealed that one component within the compressor failed under fatigue. The manufacturer made fourteen different changes to the component design and the manufacturing process, with no impact on the failure rate. (The engineers responsible contended that production failed to execute their changes properly.)

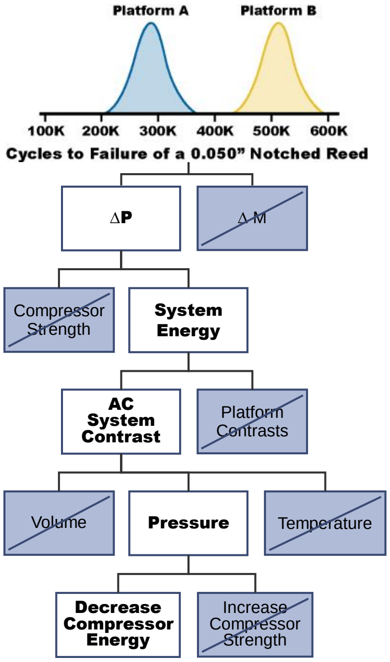
Implementing ineffective solutions, as in the case above, may produce the greatest amount of problem-solving waste. In this case, the waste included millions in warranty costs as air-conditioners continued to fail year after year, the time and resources expended by four problem-solving teams that failed to solve the problem, and the cost of implementing each unsuccessful alteration. Add to these tangible losses the future sales lost to customer dissatisfaction, and the cost of wasteful problem-solving becomes evident.

A Lean Approach to Problem Solving

In the end, the air-conditioner case was solved using an evidence-based approach we call Shainin® Red X®. Teams of engineers deployed to solve technical problems typically employ what we might call an engineering design approach: using their expertise with the systems that have failed to suggest possible causes based on visible failure symptoms. Thus the engineer easily identifies ways the system *could* be failing. But the actual cause of failure may not be among the listed causes!

The evidence-based approach is rooted in both engineering and statistics, but it’s most fundamental principle is that the parts themselves can be coaxed to reveal the cause of their failure. Rather than relying on our preconceptions and existing knowledge to brainstorm possible causes, the evidence-based approach studies the distinctions between parts performing at opposite extremes for clues to the probable causes of failure.

Data revealed that identical components had vastly dissimilar failure rates when installed in different vehicle models. Working with the client’s engineers, we developed an accelerated test that produced failures in less than 24 hours, which allowed us to investigate the differences between the best and worst models. We converged on the source of the differences through a process of elimination. In rapid succession, the team eliminated the measurement technique, the compressors and the vehicles; leaving only the air-conditioning system. Concentrating on differences in the air-conditioner designs, the client’s engineers discovered a physical reaction in the higher failure rate system that surprised them. With this discovery, the team was able to develop a lab test that recreated the field failures and confirmed that the Red X® cause was an interactive effect among environmental factors, operating system factors and a compressor component material property. An inexpensive design change made the system robust to the environmental and operating condition factors. The evidence-based problem solving team used two cars, several compressors, and a few engineers,



Rationale:

- Pass stage 0 of Component Search.
- No “smart” compressors.
- Swap systems. Problem follows the AC system, not the platform.
- Group comparison.
- Strategy choice based on physics of failure. Lowest risk and lowest cost along with the fastest timing.
- B vs C test.

test track time and lab time to solve a seven year old problem. The team required five months, which is longer than we'd like. However, the returns from solving the problem made the investment worthwhile. In addition to solving the problem, the client used the insights gained and the new lab test to ensure future designs were resistant to these failures.

The DMAIC Approach

So far, we have looked at two approaches to solving this problem. Engineering redesign, which failed and evidence-based problem-solving that succeeded. There is a third approach which relies on statistical tools only. Since this approach was not used, we will have to speculate on how the investigation might have transpired.

One approach would have used multivariate regression analysis to find suspect variables whose behavior correlated with the failed parts. Air-conditioning subject-matter experts would be asked to suggest variables to track. This step may involve brainstorming or the use of fishbone diagrams. Data would then be gathered over a period of time. Although multivariate regression analysis is a fine tool when data is available, in this case it would not have helped. The critical variables were not being tracked.

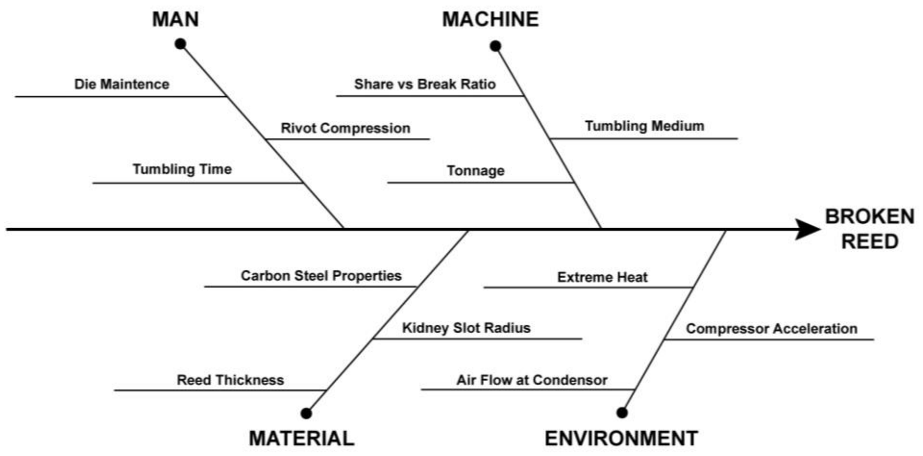
Another statistical tool is the designed experiment. Once again, air-conditioning subject-matter experts would be asked to propose input variables. A response variable would need to be selected. Test samples would be created with the levels of the input variables carefully controlled. Again, designed experiments can be highly effective. They are a good way to see interactions. However, since the Red X® cause turned out to be a complete surprised, it is unlikely that the critical variables would have need included in the experiment.

Even if regression analysis or a designed experiment had included the right variables, these techniques would have required more time, parts and resources than the evidence-based approach.

Types of Waste in Problem Solving

Lean experts have identified seven types of waste in manufacturing. Here are my candidates for types of waste in problem solving:

1. **Guessing at causes:** Guessing is often facilitated by brainstorming or fishbone diagrams. Of course, no one calls it guessing. It's called engineering judgment or relying on expert insight. Engineering judgment is guessing with a degree. When we are faced with something unknown, it is human nature to assign potential causes. We imagine all the things that can cause a phenomenon. This is a divergent activity. It expands in multiple directions. Lean problem solving converges on the true root cause. Guessing leads to one of the next two sources of problem solving waste.



2. **Lots of action:** Once a long list of possible causes has been developed, teams work in parallel to develop solutions for the causes that have been deemed most likely. Since the true root cause is often an interaction among independent variables, it doesn't make it onto the brainstormed list. Lots of action can result in no progress toward solving the problem. This was the situation with the failed air conditioning compressors. Even if the team is fortunate enough to touch the Red X cause and fix the problem, no one knows exactly which action made the difference. This means the problem may come back.

3. **Large experiments to screen variables:** A better approach than developing solutions for a large number of untested potential causes is to conduct designed experiments. Designed experiments are a valuable tool to confirm cause-effect relationships and to reveal interactions among independent variables. However, large experiments require lots of time and resources. To gain efficiency, most large experiments are fractional. These means that every cause-effect relationship is confounded with others and follow on experiments are required to resolve the confounding. A much leaner approach starts with evidence based tools to eliminate large groups of variables. Designed experiments with a small number of suspects are quicker, more manageable and yield the same understanding of critical relationships.

4. **Design changes in the absence of a demonstrated understanding of the physics:** As engineers, we were taught that we solve problems through invention and design. However, if the current design makes both good and bad parts, we can make them all good by discovering the Red X causing the difference. Once the Red X has been discovered and understood, a design change might be the best way to control it. We do not want to overlook opportunities to make things robust. Robust engineering activities are leaner once the Red X has been found and confirmed.

5. **Containment:** Containment is often necessary to protect the customer. It is a lesser waste than delivering bad product to the customer. Unfortunately, once containment is in place and the customers stop complaining; too many managers and executives stop trying to solve the problem. Containment should be a tourniquet: necessary for the short term to stop the bleeding, but dangerous and expensive when left in place too long.

Guidelines for Lean Problem Solving

The key to minimizing waste in the problem solving process is to learn to talk to the parts. The most important steps are statistical and engineering planning: identify families of variation and develop a response that provides insight into the physics of the problem. Talking to the parts is not an innate skill. It requires development and practice. The secret is to follow a convergent strategy that eliminates most possibilities in the first few steps using an evidence based strategy. Designed experiments when needed are used toward the end of the search when there are only a few suspects remaining. Before solutions are considered, the problem physics are demonstrated by turning the problem on and off with a designed experiment. Finally, in lean problem solving the results of each project are leveraged across the enterprise to deliver maximum value to customers and the bottom line.