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Cable Fabrication Process Improvement at Tobyhanna Army Depot

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Abstract: Tobyhanna Army depot (TYAD) is a Department of Defense Logistics Center situated in Pennsylvania. The depot specializes in cables production for use in Army equipment. As of August 2018, the Cable Fabrication process was experiencing overruns which threatened to cost the depot over $1 million per fiscal year. Utilizing Lean Six Sigma (LSS) Methodology, the USMA LSS Capstone Team aimed to improve the Cable Fabrication Process at TYAD. The team utilized the Define, Measure, Analyze, Improve, Control (DMAIC) process to methodically improve the process.

1. Introduction

Lean Six Sigma (LSS) is a combination of two separate business practices that can help an organization improve their work processes. A lean organization is dedicated to removing waste and non-value added steps in a process ("What is Six Lean?", 2019). The six sigma approach focuses on reducing variability in a process. Eliminating process defects is a hallmark of Six Sigma ("What is Six Sigma?", 2019). Therefore, LSS combines the separate methodologies of Lean and Six Sigma into one practice that eliminates waste and variability. Making a process lean and in control is important because a company can save costs. However, it also can have negative impacts on a company because processes can lack adaptation. A large number of issues in the 2008 financial crisis were the result of lean practices creating unadaptable processes (Blome & Schoenherr, 2011). This highlights the fact that while making a process lean and in control is a priority to cut costs and improve efficiency, too much of it can cost a company a lot of money and time if something goes wrong. Also, another negative example of LSS is when Nokia and Ericsson used the same supplier for their products. Nokia had multiple suppliers while Ericson only had one. It cost Nokia more time and money to have these suppliers but once a fire broke out in the shared factory, Nokia was able to adjust while Ericsson had to pay $400 million to adapt to the issue (Chopra & Sodhi, 2004).

Tobyhanna Army Depot is the Army's primary depot level maintenance and fabrication facility for all Command, Control, Computer, and Intelligence, Surveillance, and Reconnaissance assets. At Tobyhanna, three cost centers, 5M610, 5M620, and 5M650, were experiencing overruns in costs by $1 million per year. The three cost centers make their own unique cables, using their own internal process on fabricating the cables along with buyer requirements. Generally, cable parts are brought together from the supplier. The parts are then braided into a rough cable. Depending on the cable, it will go into the oven multiple times along with multiple in process inspections to make sure that the cable is up to the client's standards. Technicians must test cables to make sure they work properly and then finally, they will be sealed and ready to ship at the end of the process. This adds complications to the LSS process because each process is not standardized. Making a Blue Force Tracker cable in one of the cost centers has different personnel, time, and equipment requirements than an Abrams Tank Harness. The LSS process will look at these three cost centers to see if there are any underlying issues that can be fixed.

2. Literature Review

The Define-Measure-Analyze-Improve-Control process, DMAIC, is a problem-solving method used in Lean Six Sigma improvement processes. It consists of five phases which are completed consecutively. In order to use DMAIC, the basics surroundings a process must be preserved; DMAIC is used to improve a process, not completely overwrite it. The Define phase is used to develop an understanding between team and sponsor over what the scope id and agree on desired outcomes for the project. The Measure phase is used to understand a process prior to making any changes. Data is collected to give the project

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team a snapshot of the "before" state of a process. Following this is the Analyze phase, which is used to understand the data collected in the Measure phase. Analysis is conducted to find the key variables affecting process output. The Improve phase is where efforts to increase process outputs actually begin. Solutions are implemented to make the process more efficient. The final phase, Control, is the transition of the improved process from the project team back to the process owner. Standard operating procedures must be emplaced in order to maintain improvements made (George, Maxey, Price, & Rowlands, 2005).

2.1 Define

The Define phase is characterized by the review of a process and performance problems. A critical piece of this overview is the Project Charter. First, a problem statement and goal statement are created. A problem statement defines an issue or shortcoming of a process in objective terms, drawing attention to why it must be fixed. The goal statement, conversely, defines the desired outcome at the end of the process (George, 2004). Concurrently, the project scope is defined. A project's scope is the boundaries of operation within a project. Tasks and entities that are in scope can be changed through a project, however tasks and entities that are Out of Scope must be left alone.

Following the definition of project scope, the team created a SIPOC Map. This is a technique used to understand a process by defining its Suppliers, Inputs, Process, Outputs, and Customers. This provides a summary of the key components necessary to understand a process (SIPOC Diagram isixsigma.com, 2019). Finally, our team took a Gemba walk in order to identify Potential Areas of Opportunity. A Gemba walk allows project managers to observe the process in its natural state (Gemba Walk: Where the Real Work Happens, 2019).

2.2 Measure

The Measure phase is characterized by studying the process of the cable fabrication, eliminating data collection errors and identifying the level of improvements needed. A critical part of this section is the Data Collection plan. First, the team identified inputs, process variables and outputs relevant to the project. The Data Collection plan will not only identify how we collect data, but also identify possible errors that could influence it to become non- realistic (George, 2004). Next, we created operational definitions for parts of the cable fabrication process we were measuring in order to get whether or not that part is holding up the production. For Example,

$$Cost\ Performance\ Index\ (CPI) = \frac{Standard\ Task\ Time}{Actual\ Task\ Time} \quad (1)$$

After the Data Collection Plan help decide on how much data for each of our measuring points would be collected and how. Next was the measurement analysis which corrects bias or measurement errors and which considers how the project will approach them with such things as performance dashboard and technicians conducting oversight. Finally, we did risk analysis and mitigation to watch for what factors could possibly ruin our project overall. For example in our Gemba walk one problem we identified was The Hawthorne Effect, which is when subjects change behavior when they know they are being observed. In our case the floor workers are more effective when we are collecting the data.

After the Measure phase, there was a roadmap and plan of action that was put in place so that we knew how to collect the data necessary to get our statistics about the process. Collecting data from the cable fabrication process allows Lean Six Sigma to begin to identify the efficiency of production and if it meets the needs of the clientele.

2.3 Analyze

The analyze phase is the next step and uses the data to find the causes of cost, excess time, or any other factor being out of control. The analyze phase has many different tools that can approach this root cause analysis such as pareto charts, I-MR charts, ANOVA, and other statistical tests (George, 2004). These tests are all used to break apart the data into palatable chunks that can be interpreted. Charts like a pareto chart clearly show what subproject is overrun as compared to the other projects. Fishbone diagrams can help create a list of issues with a project that have to deal with man, machine, mother nature, method, material, and measurement. Taking feedback from the teams that are fabricating the cables allows a focusing of these efforts but some caution needs to be taken with this approach. The teams might not see that some of the processes are ineffective according to data. All of these devices are used to help create a finalized list of issues that the improve phase should focus on.

After the Measure phase, there was a lot of data collected that needed to be broken down into something that would allow us to find root causes of the process. Finding root causes allows the Lean Six Sigma team to start making changes in the Improve phase and codify them into a new standard in the Control phase.

2.4 Improve

The next step is the improve phase. After identifying the root causes in the analyze phase, the first step is to generate potential solutions that could resolve the issues. Some tools and methods include brainstorming, negative brainstorming, and benchmarking (Brook, 2017). After collaborating on potential solutions, the next step is to select the best solution or solutions. The purpose is to narrow the list of solutions in order to pick the most feasible one. Using an assessment criteria, pugh matrix, or solution screening helps visibly seeing which solution is the best. Next is to determine the risks of implementing the solution.

The best tools to use are fishbone diagram or FMEA. These give a layed out indication of the inherent risk that pose issues in implementing the solutions. Once the risks are mitigated, the next step is to pilot and implement the solutions. Some methods include conducting a pilot study or visual management. These help determine when, where, and how the solutions will be implemented (Brook, 2017).

2.5 Control

At the time of submission, the control phase had not begun. After the improve phase is completed, tools including control plans, statistical process control charts and visual management boards will likely be implemented. “For each process step, a control plan defines the characteristics that are measured, their specification, historical capability, measurement method used and a response plan if out of specification” (Brook, 2017). Within the control plan, is another plan known as the “response plan”. This part of the document details containment and adjustment- making sure defects do not reach the customer and ensuring the flawed process steps are fixed to prevent future defects (Brook, 2017). TYAD already has standard operating procedures (SOPs) for their cable manufacturing process. In order to decrease overruns, the SOPs will be reviewed and adjusted as necessary. Reviewing the process standards will provide the employees with clear guidance on the fabrication process. Successful methods implemented in the improve phase must be documented and disseminated to the workforce to ensure that old, inefficient ways are not reverted back to.

Visual management is another tool frequently used in LSS projects. Easily accessible, real-time updates improve control and increase quality (Brook, 2017). A visual management system could possibly be implemented at TYAD to provide the floor with timely updates on their progress and identify areas of friction. Real time updates could reduce overruns by allowing the floor manager to adjust processes during the workday rather than waiting until close of business to analyze the statistics of that day’s work. These tools will ensure that project success is sustained well into the future.

3. Analysis and Findings

This section presents the team’s analysis and findings from the phases of the DMAIC process. During the define phase, an essential element is building the SIPOC map to identify key inputs, outputs, and customers for the process. The measure phase determine if there is a problem with the process in the current state. The analysis from the Analyze phase determine what is causing the problems in the cable fabrication process. Finally, the improve phase develops and implements potential solutions to correct the problem.

3.1 Defining the Problem with Cable Fabrication

Prior to the beginning of this project, the Cable Fabrication process at TYAD cost centers was consistently experiencing overruns of over 1000 hours of Direct Labor Hour overruns every month. These overruns equated to a loss averaging over $120,000 per month. The goal of this project was to reduce monthly overruns by 25% by project completion. For this project, cost centers 5M610, 5M620, and 5M650 were In Scope cost centers, as they were the cable fabrication effort.

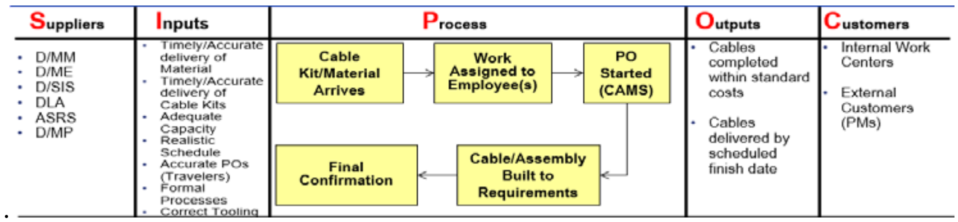

Figure 1: SIPOC Map

Shown in Figure 1 is a SIPOC Map for the Cable Fabrication Process. This Map shows the key components of the process. Along with the SIPOC Map, the team defined the Voice of the Business as well as the Voice of the Customer based on three metrics: Input Metrics, Process Metrics, Output Metrics. Relevant to the team from the VOC: Key Customer Issues included inaccuracies in information, inaccuracies in the actual cable kit, or a process rework requirement. From the VOB: Key issues included inaccuracies mentioned above.

The team observed that the cable fabrication workforce was in flux potentially due to continuously changing workload requirements. The result of this was a learning curve which potentially contributed to overruns. Furthermore, cable drawings had more than one cable associated with the drawing. There also seemed to be a lack of visual cues which contributed to fabricating incorrect cable and increased rework and overruns. The master routes for various cable needed to be reviewed due to inaccuracies which potentially contributed to increases in rework and time spent finding correct information.

3.2 Measuring the Cable Fabrication Process

For the measure phase of the project, the team collected data to understand the current state of the cable fabrication process and identify problems in the process regarding inputs, process variables, and outputs. Inputs are the materials needed for the cables, their arrival time, and the types of cable orders that come to TYAD. Process variables are the different workers, each type of the cable process based on the order, and design of new cables based on needs. The outputs are the fabricated cables. The team created a data collection plan outlining the process for collecting data for each type of cable produced at TYAD. The CPI equation outlined in section 2.2 was used to measure productivity.

The next step was determining what type of measurement errors would occur while collecting data and how the team would mitigate them. The stability of the data will be affected by bias over time which will be mitigated by a performance dashboard that is updated daily. After this the team collected the data and established baselines.

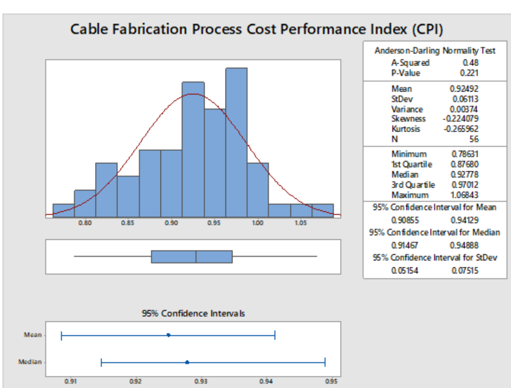

Figure 2. Cost Performance Index (Minitab)

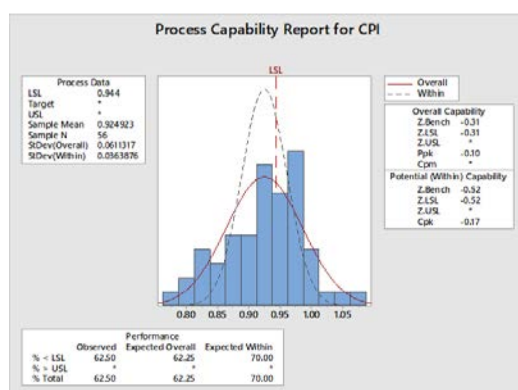

Figure 3. Capability Report for CPI (Minitab)

Finally, the process capability evaluation was executed, and it gave the team the following results, shown in Figures 2 and 3. The reason why only a lower specification limit is used is because if the process goes below .94, the process is worse off than when the LSS team took on the project. Going above .94 is great for the project and part of the goal to limit overruns. The current Cpk at the time of measurement is -.17, which means that the team is currently not capable of meeting our customer's requirements. The sigma quality level was 1.19. The goal for an ideal Lean Six Sigma is 6 sigma. This shows that the project has more defects to fix in the process.

3.3 Analyzing the Problem

The first thing the team did was create a swim lane diagram. This diagram showed each step in the process as value added, non-value added but required, and non-value added. This allows us to focus on things that might be able to change in the process. For our project, the team looked at the cost performance index (CPI) for the process in the measure phase and the analyze phase. Both CPIs were normally distributed which will allow for certain tests to be performed that the team otherwise could not if they were not normal. I-MR charts were used to look at the data and see if the data is out of control (See Figure 4). After seeing if the process was in control, the team did a pareto chart on each cost center to see what areas to focus on. When looking at 5M610, the Abrams tank harness and ADL tank harness were the highest overrun projects with about 1000 hours each.

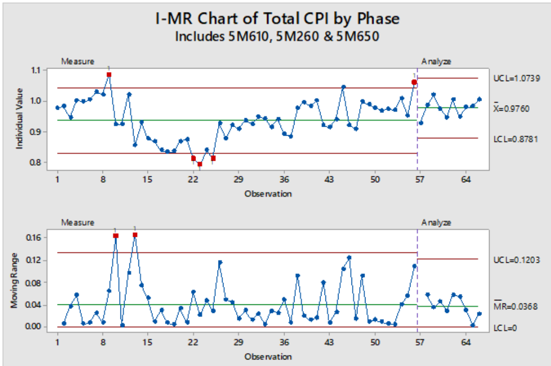

Figure 4. I-MR Chart by Phase (Minitab)

Within those subprojects, the largest use of time came from the task "assemble connectors". This task takes up most of the workers time. For 5M620, the largest overruns came from Installation and EQ which has to do with the Blue force tracker (BFT). This project is overrun by 4000 hours and is a consistent workload in the cost center. By breaking down the BFT and another project called the Common Remotely Operated Weapon Station (CROWS), the largest overruns came in the fabrication of the cables. Once looking at an I-MR chart for the BFT, the process has a much tighter spread after 2018-36 but there is still one point that is out of control. For 5M650, the RIC cable had the largest overruns but it a very inconsistent workload. The focus in this cost center will be the Nett Warrior program which still accounts for 20% of the overruns in 5M650.

The LSS team used a multi-voting system that got sent out to the fabrication teams involved in the process. This looked at factors from the cause and effect diagram that had an impact on the process and there was a factor of control associated with it (Figure 5). By analyzing the results from the survey, the research team identified 5 common issues. This led directly to the failure modes effect analysis (FMEA) that expanded upon the focus areas that the team will look at. The FMEA shows each failure mode as a value of the product of severity, occurrences, and detection. This product is the risk priority number (RPN). The higher the RPN, the more of an important issue it is to address. These root causes are ordered as follows: (1) Material does not meet specifications, (2) Inaccurate pre-production planning, (3) Improperly trained employees, (4) Not following the first article process, (5) Different working rates between employees, (6) Lack of visual management. These six root causes are being pursued in the improve phase.

3.4 Improving the Cable Fabrication Process

The fourth step is to generate ideas for improvements and implement them. The goal of the improve phase is to "develop, select and implement the best solutions, with controlled risks" (Brook, 2017). After implementation, the team then could compare the before and after performances of the process. The first step is to generate solutions. During one of the visits to Tobyhanna, the team gathered input from the workers on how to improve the process. The team also conducted a brainstorming session to generate solutions that could improve the roots causes. After the team created a list of possible solutions, they used a pugh matrix to select the best solution. The pugh matrix is a method for selecting a solution, but also

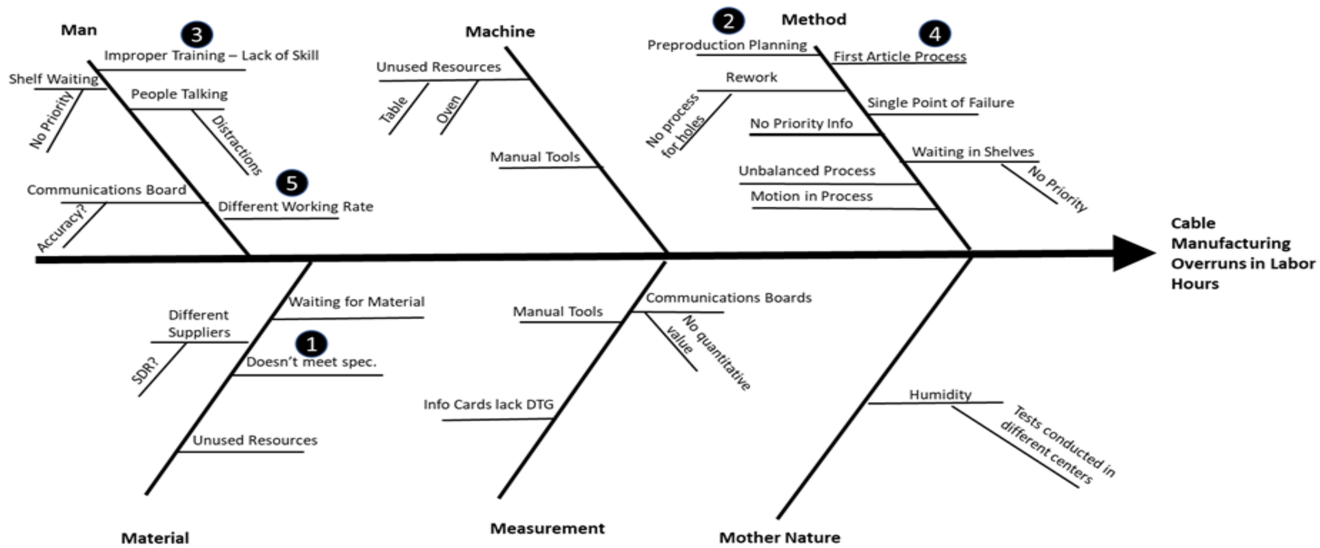

Figure 5. Fishbone diagram with multivoting feedback displaying top issues

further developing and refining the potential solution (Brook, 2017). The team listed the potential solutions from the brainstorming session and assigned a value against various weighted criterias. Each potential solution had a calculated score, ranking each one from the best to the worst. One of the solutions with a high score was to redesign the process layout. The team concluded that there was an enormous amount of product movement that affected the cable's cycle time. The team designed several layouts, one resembling a product layout and another that realigned the direction of the benches.

4. Conclusion

By working on the project, a few conclusions can be drawn. The first thing is that proper measurement of the process is key to discover root causes. If the data does not help paint a picture of the process, discovering root causes will be very tough. Another issue the team found is resistance to change in policy. When talking with workers on the line in each cost center, each person said that process was good and that there were no improvements needed. By looking at the data, this was obviously not the case. When working to find root causes, the team had the additional duty of trying to not make workers lose buy in. Some of the groups interactions with workers had them thinking that job cuts were happening. This could have resulted in certain things like the hawthorne effect. This might have resulted in the upward trend in CPI we can see in cost centers like 5M620. All tools utilized in the DMAIC process are useful, however without strong leadership, progress made from a LSS project is unlikely to endure. Project initiatives must be prioritized by TYAD leadership, and the project team must actively focus on emplacing systems to sustain momentum after the project has formally concluded. The first four phases of the process are important, however success or failure from the control phase onward will be known as the project's legacy. Currently the project is in the improve phase, therefore it is unclear if the project goal of 25% overrun reduction will be met.

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