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Lean Six Sigma Cable Fabrication Tobyhanna

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Abstract: Tobyhanna Army Depot produces military equipment to sustain the warfighter on the modern battlefield. 5M680 fabricates the first articles and engineering design models of cables entering full production. Our team was tasked with decreasing overruns within 5M680 by 30%. Using the Lean Six Sigma DMAIC process, our team was able to define the problem, analytically prove the problem exists, analyze what is causing the problem, implement an improvement process, and finally maintain a solution and hand over the project back to the client. In addition to process solutions, several quick wins were identified, with a combined projected cost savings of over $500,000.00 annually.

Keywords: Tobyhanna 5M680, Lean Six Sigma, DMAIC, Cable Fabrication

1. Introduction

Lean Six Sigma (LSS) is a team-focused managerial approach that seeks to improve company performance by eliminating waste and defects (Kenton, 2023). The LSS process is driven by data and facts to detect defects within a process. The term “Six Sigma” is a reference to the various tools that can be used to improve the manufacturing process by identifying waste (Kenton, 2023). Originally, Toyota created lean methodology in the 1940’s to remove non-value-adding activities from their production process (Kenton, 2023). It was then reestablished in the 1980s by Motorola, who modernized the process in U.S. industry and factories. The ultimate goal of “Six Sigma” is to identify and reduce the number of defects in any given production process (Kenton, 2023). In the present, “six sigma” has combined with the term “lean,” as a reference to the idea that true efficiency means continual improvement through the tools of defect identification and reduction. Presently, “Lean Six Sigma” is the wholistic methodology that is used by countless industries and organizations to make their processes efficient and effective. Tobyhanna Army Depot of Pennsylvania is one such organization that embraces LSS practices.

1.1 Background

Tobyhanna Army Depot is one the largest industrial installations in Pennsylvania (Boucher, 2020). More so, it is the largest electronics maintenance facility in the entire Department of Defense (Military Installations, 2023). The depot’s mission is “total sustainment, including design, manufacture, repair, and overhaul of hundreds of electronic systems” (Military Installations, 2023). Their area of expertise includes automated test equipment, systems integration, downsizing of electronics systems, electronics, radar, and missile guidance/control.

Tobyhanna Army Depot opened on February 1, 1953, and has been in service for over 60 years. The US Army first took an active role in Tobyhanna in 1912 when it was used as a field artillery training camp (Military Installations, 2023). Tobyhanna also had a critical role in hosting artillery training for the Civilian Conservation Corps (CCC) and West Point Cadets. In WWII, Tobyhanna served as a storage point for gliders that were used in the D-Day landings at Normandy in 1944. Following WWII, Tobyhanna’s command was switched from U.S. Army Industrial Operations Command to U.S. Army Communications-Electronics Command, which is still the case today (Tobyhanna Army Depot, 2023). Throughout history, Tobyhanna has played a critical role in developing technology and software capabilities for the Army. They continue to have this role today, with new developments and capabilities emerging yearly.

2. Literature Review

The DMAIC process is a Lean Six Sigma data driven improvement process based around six steps. These steps are Define, Measure, Analyze, improve, and control. DMAIC was invented in the 1950s by W. Edwards Deming and is now used by hundreds of Fortune 500 companies ("What Is DMAIC?," 2018) The purpose of the DMAIC process is to improve the efficiency and overall effectiveness of a companies already existing process (What Is DMAIC?, n.d.). The key to this process is that each phase is data driven to solve the problem at hand. Quality data makes the process accurate and precise so the company can make improvements to their companies. This process will improve the quality of their products along with driving the cost down to increase the company's overall profitability. The main purpose of the DMAIC process is to remove the waste or non-value-added parts of the process (Liu, 2020). The customer is now getting a more quality product with less defects and the company is becoming more efficient.

2.1 Define Phase

The Define phase is the first step in the DMAIC process. This phase is looked at as the most important phase of the process as it allows the company to understand why there is a problem, before investing time and money into the project (Brook, 2022, p.14). The purpose of this phase is to have the team and its sponsors reach an agreement in the scope, goals and financial targets of the project at hand (George et al., 2005, p. 4). Within the define phase there are seven key steps, review project charter, validate problem statement and goals, validate financial benefits, create/validate process map and scope, create a communication plan, develop projects plans (schedule, budget, milestones) and complete the define gate review (George et al., 2005, p. 4). In the define phase you are solely looking at what problem and not looking for a solution as they come later on in the process. If team members start looking at the solution, the project leader needs to turn the project back to being 'problem-oriented' (Brooks, 2022, p. 14).

2.2 Measure Phase

The measure phase is the second phase in the DMAIC process. The purpose of this phase is to understand the current state of the process and collect reliable data on the process speed, quality, and costs that you will use to expose the underlying causes of the problems (George et al., 2005, p. 8). Within the measure phase, there are a couple of deliverables that need to be created, which include a fully developed current-state value stream map, reliable data on critical points (Xs) and critical outputs (Ys), and a refined definition of improvement goals (George et al., 2005, p. 8). As before in the define phase, the measure has key steps as well. The steps are create/validate a value stream map to confirm current process flow, identify the outputs, inputs, and process variables relevant to your project, create a data collection plan including operational definitions for all measures, create a data analysis plan, use measurement system analysis and gage R&R, collect data to establish baselines, update value stream map with data, use Little's Law to calculate lead time, perform process capability evaluations, make quick-hit improvements, and prepare for measure gate review (George et al., 2005, p. 8-9).

2.3 Analyze Phase

The analyze phase's primary purpose is to determine the root causes of waste in the system. It takes the data from the measure phase that conveys to the client an issue with the process and tries pinpointing the exact cause (Hessing, 2023). Mainly focusing on the input and outputs tied to the project goal and identifying any issue that may be happening to them (George et al., 2005). Many tools are utilized in this phase to help find the root issue, such as the bone diagram, the five whys, and a process map (Jameslopresti, 2020). Many calculations and analyses happen during this phase, such as the root cause, failure mode, and effects analysis (George et al., 2005, p. 8-9). The system's processing time and flow are considered add-value or non-value-adding. In this phase, something to be careful of is to "avoid paralysis by analysis" and be honest with the entire process, not trying to force an analysis but instead being meticulous in finding an actual issue with the system (George et al., 2005). Reviewing the project goals and requirements guarantees they are still being met.

2.4 Improve Phase

The improve phase is the fourth phase of the DMAIC process. Its purpose is to identify solutions for the problems identified in the other DMAIC phases. The main focus of this phase is to "focus on eliminating root causes and implementing the improvements (Hessing, 2020). A lean Six Sigma team will "develop solutions, pilot the process changes, and implement their ideas and collect data to confirm that they made a measurable difference" ("Improve- Phase 4 (of 5) of Lean Six Sigma," 2023). The ultimate goal is to implement changes that eliminate root causes. This step enables the Lean team to move onto the final phase, "control," in which the team measures the results of their solution and ensures it will last in the long term.

The main goals of the improve phase include the following: Identifying feasible solutions for the identified root causes, selecting the best solution using statistical tools, performing a cost-benefit analysis, testing the solution, and assessing the effectiveness of the solution (Hessing, 2020). All of these goals seek to redesign an aspect of a process in order to improve overall process functionality and capability ("Improve," 2023). In other words, successfully completing the improve phase can lead to better working conditions for employees, better customer service, and an overall better business.

2.5 Control Phase

The Control phase is the final of the five phases in the DMAIC process. The goal of the control phase is to ensure that any improvements implemented are working and keeping the process under control while also handing the project over to the client for them to continue operation at a higher efficiency and less wasteful. The Control phase begins with creating control charts to ensure the process is under control. The next step is creating standard operating procedures (SOPs) and process control plans. The final step is to hand the project over to the client.

3. Methods and Results

3.1 Define Phase

The define phase establishes the problem statement and goals of the project. The phase also establishes the project scope and resources needed to be successful. The problem statement is: During the 3rd and 4th quarters of FY23, the Production and Development Branch scheduling variances ranged from 1 to 709 days (average 52 days), and the cost variance during the same timeframe ranged from 0.9 to 21.25 times the hours given (average 4.265). There are three goal statements: 1. Reduce the overall cost and schedule impact of 5M680 on the organization by 30% by 01 May 2024. 2. Increase the workload throughput within the Preproduction and Development Branch by 01 May 2024. 3. Define clear roles of responsibility for all parties involved within 5M680 by 01 May 2024.

3.2 Measure Phase

The Process Map of a process map for business to improve their efficiency by looking deeper into each task. As seen in the figure below there are 15 steps within 5M680 pre-production fabrication assembly. This is how they complete cables from start to finish, starting with picking up the traveler to transitioning the work to full rate production. Within each step of the process, we looked at if the step was critical value-added, non-value-added required, or non-value-added. This determined what needs to stay in the system and what can be removed or changed in order to make the system more efficient and remove waste. We have five critical value-added steps, seven non-value-added required steps, and three non-value-added steps within the process. We are currently working on removing the non-value-added steps in the process to make it more efficient.

The baseline statistics for 5M680 were broken into three distinct time bins. Bin one ranged from 0 to 5 hours, Bin two ranged from 5 to 10 hours, and bin three was any project over 10 hours. Projects were categorized by confirmed hours, which is the actual time the cable took to be fabricated, or standard hours, which is the estimated time the cable fabrication process should take.

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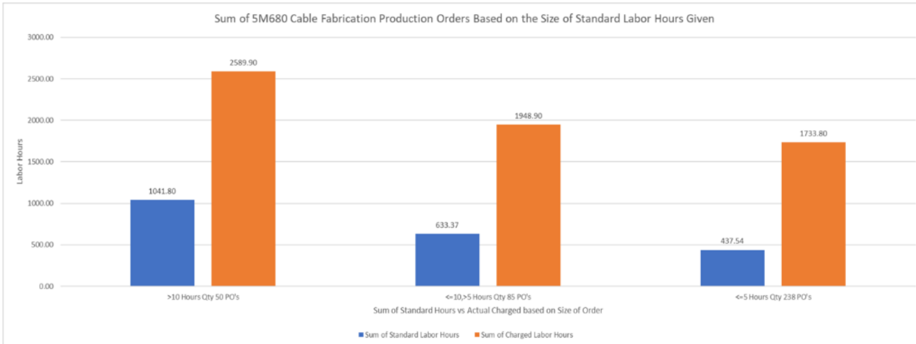


Figure 1: Sum of 5M680 Cable Fabrication Production Orders Based on the Size of Standard Labor Hours Given

From the graphic, it is easy to see that for each bin, 5M680 is not meeting expectations and has overrun in each bin. Conducting a capability analysis each cable fabrication bin is currently incapable of meeting process expectations.

3.3 Analyze Phase

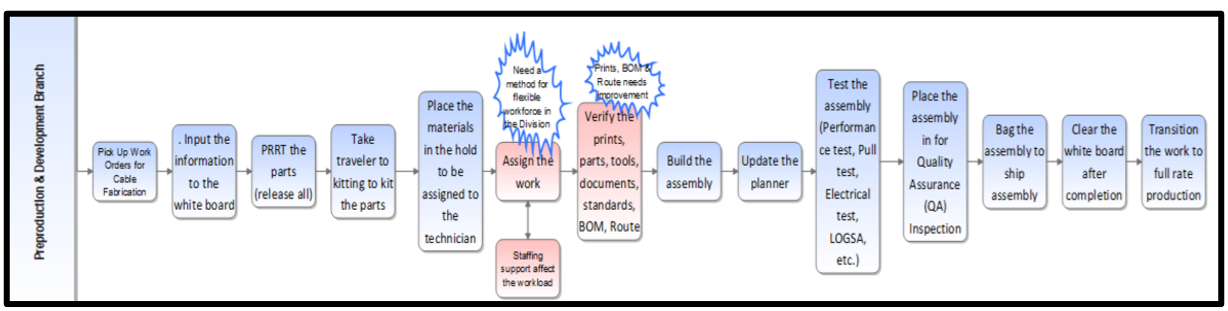
To understand what is causing the overruns at 5M680, we conducted a root cause analysis (Ishikawa). The team identified eleven issues affecting overruns, and of the eleven, four were considered critical to effecting overruns: no planning capacity, staffing, no 5M680 mission statement, and Engineering Design Model. These four causes were identified as most critical through a combined analysis between the Lean Six team and partners at Tobyhanna.

The FMEA was conducted with 5M680 based on our root cause analysis. These issues were identified and ranked based on severity, occurrence, and detection. We found that the most pressing problems directly correlated to the process map are the lack of knowledge of travelers, incorrect travelers, lack of input on the whiteboard, and manpower.

3.4 Future Works

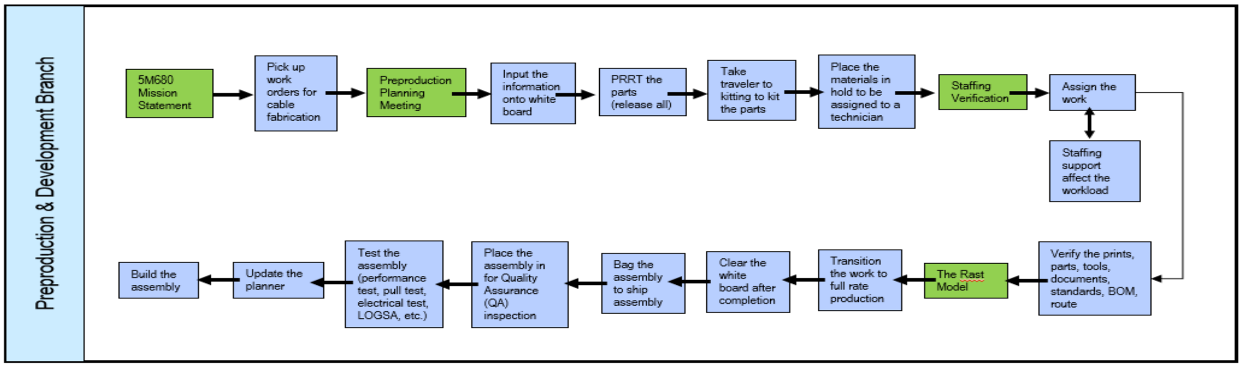
3.4.1 Improve Phase

The analyze phase provided our team with a baseline knowledge of critical problems and their roots. With these issues in mind, we moved into the improvement phase, where we sought solutions for these problems. The five main problems we identified include lack of planning capacity, staffing, EDM threshold, lack of mission statement, and incorrect travelers. These issues were identified within the main process line, which was originally structured as follows.



We determined the priority of effort and discussed our findings with the 5M680 team in order to gather their input on ways to address the identified issues. After this brainstorming process, we identified potential solutions and mapped them out in our FMEA chart to see their impact on overall RPN. Once we felt confident in our solutions and their ability to create positive change, we created our final prioritized list of solutions and began developing a pilot plan.

Our prioritized list of solutions includes the creation of a time prediction model, a WG-11 pilot program, pre-production planning meetings, and the implementation of an updated mission statement. Our pilot plan contains two parts: a waste observation model, completed with process observations, and a capacity planning model, which measures the success of our time prediction model. These pilot plans have begun during the improve phase and will continue on through the life of this project. With these models enacted, the improvement phase is complete, and the control phase will begin to utilize our findings. Our solutions have been implemented into the original process map, as shown below.



Our solutions are implemented into the production process as indicated by the green boxes. Now, we have several tools and mechanisms to aid the production process and avoid holdups that cause costly overrun hours. The green boxes should be kept in the process as permanent additions for long-term success.

3.4.2 Control Phase

The key deliverables of the control phase are standard operating procedures (SOPs), control tools, and transition plans. Standard operating procedures are key to maintaining the improvements and solutions implemented in the improvement phase. The SOPs created were the general shop floor procedures, which are based on the SOPs established before the start of the project. A key SOP created was a transition plan. The transition plan aids in moving the cable from fabrication to full-rate production. Control tools created to assist in maintaining the improvements captured in the improvement phase are process control tools. Our process control tool created two process outcomes that, when violated, trigger an action. The first of the two is when three or more work orders are placed on hold. This triggers a serious of events to communicate the issue on the floor to leadership and identify the root cause of the problem. The second is when a work order is on hold for more than 72 hours. The response is the same as the other process outcome.

3.5 Quick Wins

Quick wins are improvements recognized during the DMAIC process that can be quickly implemented with little effort and can help process efficiency or cost savings. In our project, we identified the printer as a major quick win. If they switch to Brady Label Machine, Tobyhanna could save over $500,000 annually by changing the paper to continuous. Alternatively, by maintaining the current printer system and moving to continuous paper, the projected savings are $340,000 annually.

4. Conclusion

4.1 Final Takeaways

5M680 has seen an unexpected increase in overrun hours despite their branch only being a few years old. Our team has determined that these trends are caused by a select group of issues that have broad impacts on the branch's production process. Overall, we see ways in which 5M680 can make immediate improvements to its current cable fabrication process.

The core issues we identified in the cable fabricating process include lack of planning capacity, staffing, EDM threshold, lack of mission statement, and incorrect travelers. Each of these issues directly contributes to inefficiencies in 5M680's manufacturing process. Upon the completion of our analysis and conversations with cable fabrication employees, we determined the following list of solutions: the creation of a time prediction model, a WG-11 pilot program, pre-production planning meetings, and the implementation of an updated mission statement.

Ultimately, our analysis has shown that the implementation of these solutions reduced the number of overrun hours in the 5M680 cable fabrication shop by 73%. This will directly increase total savings to around $690,000 and bring about other benefits, such as customer and employee satisfaction. The process capability of 5M680 drastically increased, with a 308% improvement in Cpk (short-term capability) and a 292% improvement in Ppk (long-term capability). Our pilot plan should be implemented and followed into the future to ensure that Tobyhanna fully benefits from our work and can find long-term success in 5M680.

5. Resources

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