Proceedings of the Annual General Donald R. Keith Memorial Conference
West Point, New York, USA
April 29, 2021
A Regional Conference of the Society for Industrial and Systems Engineering

Applying Lean Six Sigma to Reduce Overrun Hours at Tobyhanna Army Depot

Ryan Hetrick, Breana McDonald, Joshua Park, John Zimmerman, and Courtney Razon

United States Military Academy
Department of Systems Engineering
West Point, NY

Corresponding author's Email: John.Zimmerman@westpoint.edu

Author Note: Ryan Hetrick, Joshua Park, Breana McDonald, and John Zimmerman are First Class (senior) cadets at the United States Military Academy at West Point. MAJ Courtney Razon serves as their advisor. The authors would like to express gratitude to the TUP team and Tobyhanna Army Depot Process Improvement Division for supporting this project.

Abstract: This report details ongoing efforts in a yearlong project to improve the touch up paint work center (TUP) at the Tobyhanna Army Depot (TYAD). Current overrun hours consistently exceed the standard of 148 hours per month, and recently have been averaging upwards of 197 hours per month. Additionally, TYAD is experiencing a repair cycle time (RCT) of 14.2 days, which is 12 days over their standard RCT of 2.2 days. By applying the Lean Six Sigma (LSS) methodology, the team identified the Satellite Communication Subsystem (AN/TSC-185B) as an item with the highest overrun hours. Applying the Define, Measure, Analyze, Improve, and Control (DMAIC) process improvement steps the team evaluated critical steps within the AN/TSC-185B, identified which steps contribute to overrun hours, and provided efficient solutions to optimize the process and reduce overrun hours to an acceptable level. Upon completion of this project, the client expects an annual savings of $203,895 and a 25% reduction in monthly overrun hours.

Keywords: Lean Six Sigma, Tobyhanna Army Depot, DMAIC, Process Improvement

1. Introduction

Tobyhanna Army Depot (TYAD), located in Tobyhanna, PA, supports the Department of Defense communications and electronics industry through retail and wholesale distribution support. TYAD is a world-class logistics support for command, communications, computers, cyber, intelligence, surveillance, and reconnaissance systems for the United States Department of Defense (C5ISR Mission, 2020). The touch up paint work center, otherwise known as Touch Up Paint (TUP) at Tobyhanna specializes in masking, painting, and stenciling U.S. Army equipment. The TUP team at Tobyhanna receives thousands of different parts from the Department of Defense that require painting and unmasking before returning to their functioning form. The TUP work center is comprised of multiple work centers such as Building 9 and Building 1C4 for unclassified assets and Building 73 for classified assets. For the scope of this project, the capstone team will focus on the unclassified assets within TUP.

2. Literature Review

Lean Six Sigma (LSS) is a framework for process improvement that combines the six-sigma process and the lean philosophy. LSS serves as a leading technique for organizations to maximize efficiency and maintain control in either manufacturing or service processes (George, Rowlands, Price, & Maxey, 2005). The Define, Measure, Analyze, Improve, and Control (DMAIC) methodology is an incremental effort and six sigma tool used to improve, optimize, and control current products and processes in an efficient manner (Alblooshi & Shamsuzzaman, 2020). The DMAIC methodology has five phases that serve as a roadmap for process improvement; these phases include: Define, Measure, Analyze, Improve, and Control. LSS is best used for eliminating wastes, reducing variation and costs, decreasing defects, and maximizing quality level and value (Alblooshi & Shamsuzzaman, 2020). Wastes are inherent in every process, however LSS attempts to mitigate its effects. LSS helps reduce service lead time, improve on-time delivery performance, and reduce cost and variation. The LSS framework will be key for decreasing overrun hours in the TUP process at TYAD.

3. Define

The define phase sets the path of the project by requiring the LSS team and its sponsor to agree on the scope, goals, and performance targets for the project. The primary focus of this phase is to identify the project problems and its subsequent needs through stakeholder analysis. During the define phase, the team must accomplish four tasks: develop a problem and goal statements, develop a process map, define customer requirements and create a communication plan (George, 2017). These tasks will guide the project's direction and manage expectations for both parties. By the end of this phase, the financial benefits, scope, communication plan should be validated (George, 2017).

The team defined the problem statement as: the TUP work center has experienced a steady increase in overrun hours from Jun 2019 to May 2020. At the beginning of the project, TUP had an average of 197 overrun hours per month which is 25% above the expectation of 148 overrun hours per month. The goal of the LSS is to reduce the TUP average monthly overrun hours from 197 to 148 hours by 30 April 2021, and to reduce the average Actual Repair Cycle Time (RCT) for operations within TUP by 12 days to a total of 2.2 days by 30 April 2021. The RCT is defined as everything that happens in the entire process from the start to finish of touch-up paint (both value-add and non-value-add steps). Figure 1 below illustrates the Supplier-Input-Process-Outputs-Customer (SIPOC) map for the touchup process map. The SIPOC Map serves as a process overview to assist analysis of all information critical to the process. The SIPOC map also helped the team understand the core processes at Tobyhanna. The scope of the project will cover assets that go through Building 9, Building 1C4, and Building 10. Although the assets go through the prime shop and trailer shop, these locations are out of the project scope. The customer requirements are to complete assets on schedule with minimal overrun hours. The communication plan serves as a plan for keeping parties informed on the status of the project and collaborate through the phases. There are four audiences for the TYAD Touch-Up project: the project sponsor, the project team, the resource manager, and the Master Black Belt Mentor, who the cadet team will communicate with bi-weekly or as needed.

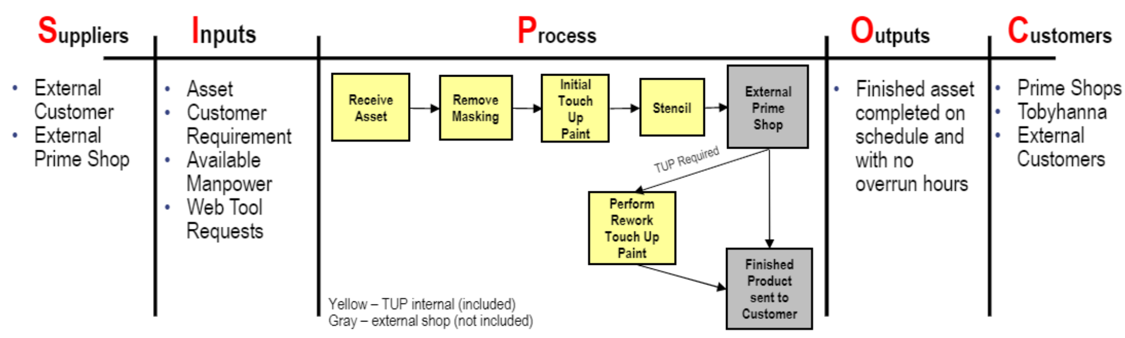

Figure 1. SIPOC Map

4. Measure

The measure phase of the DMAIC process allows the LSS team to investigate the process at its current operating capacity. The measure phase serves as a benchmark for the entirety of the project and allows the team to eventually compare the process after the teams implement LSS tools to the process at the beginning of the project. To properly measure a process, the team must understand the process in depth. To accomplish this, the LSS team used the swim lane diagram and the value stream map. The swim lane diagram allows the LSS team to map how assets flow through a process, and who is responsible for certain steps in the process. Additionally, the value stream map helps the team understand steps that add value for the customer or provide no additional value at all. Combining these two mapping techniques provides the team with a holistic approach to understanding the process. With a better process understanding, the next step is to develop a data collection plan to collect baseline statistics on the process. Next, the priority becomes validating the measurement system and conducting baseline process capability reports. These two steps are heavily reliant on each other and validating the measurement system is potentially the most important step in the DMAIC process. Validating the measurement system is important because it allows the LSS team to make data driven decisions throughout the project. Finally, process capability analysis is necessary to determine if a process is capable of meeting customer and business demands at its' current capability. This step allows the LSS team to create a benchmark to compare to once improvements have been implemented within the process. A thorough measure phase is paramount to the success of the following analyze, improve, and control phases.

ISBN: 97819384962-0-2

After completing the Define phase, the LSS team met with the Tobyhanna team to map the process in both the swim lane diagram and the value stream map format. An important lesson when creating mapping diagrams is the importance of iteration on previous designs. The team faced a challenge to reach a thorough understanding of the process as COVID restrictions prohibited the team from visiting TYAD throughout the duration of the project. The swim lane diagram located below in Figure 2, is iteration seven of the swim lane diagram for the Tobyhanna process.

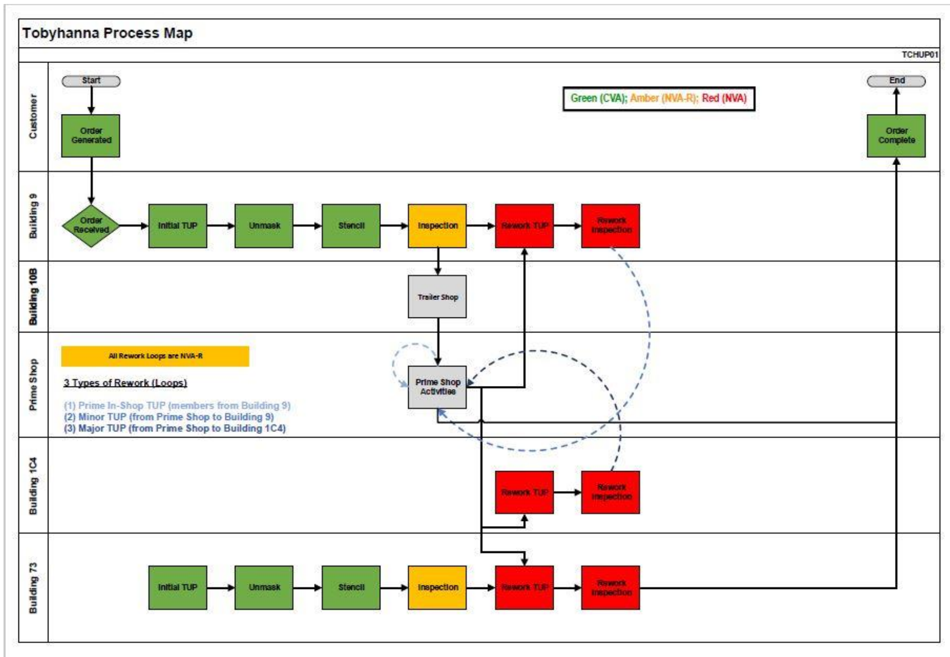

Figure 2. Swim Lane Diagram

With a better understanding of the process, the LSS team then created a data collection plan. This was a unique challenge as TYAD initially provided a great deal of data that had to be analyzed before decided what additional data was needed. After analyzing the initial data, the LSS team realized that much of the data received was not useful, and that more data would be needed to properly analyze the process. In the Tobyhanna project, the LSS team recognized that 5 of 80 assets accounted for over 50% of the overrun hours. Therefore, the LSS created a specific data collection sheet that allowed additional data collection on the Satellite Communication Subsystem asset (AN/TSC-185B), which was one of the largest overrun hour contributors. The next step was to validate the measurement system used to collect data. Validating a measurement system requires analysis of that measurement system's resolution, bias, stability, repeatability, reproducibility, and variation. Tobyhanna uses a Logistics Modernization Program (LMP). The LMP system is highly reliable compared to conventional methods, so the LSS team validated the measurement system. Finally, the LSS team conducted process capability analysis to determine if the TUP process was meeting business and customer demands at its' current capability. Using Minitab software to produce control charts, process capability reports, and baseline statistics of the process, the LSS team determined that the TUP process was not capable of meeting business or customer requirements at its' current operating capability. In fact, initial analysis of the TUP process resulted in a process performance of 0.61, which falls far below the expected threshold of 1.33. In conclusion, the LSS team determined that the process was out of control, the LSS team could implement strategies to increase the process capability throughout the project, and continue to the analyze phase.

5. Analyze

The main purpose of the Analyze phase is to determine and confirm the root causes of variance within a system that the LSS process is targeting (Montgomery, 2008). During this phase, the focus is on conducting data analysis and data interpretation, where the designated team will identify key input variables in a system and explore its relationship to the key output variable confirming the nature of the relationship. To explore the relationship between input and output variables, the LSS team used hypothesis testing, regression analysis, failure mode and effects analysis, and process control plans (Montgomery, 2008). At the conclusion of the Analyze phase, the data analysis will have guided the LSS team on where to focus their efforts for the improve phase.

For the Analyze phase for the TYAD project, the LSS team created a column that measured the number of total work hours in each step so that the data is interpretable and, most importantly, ready to use. The LSS team conducted data exploration on the TUP data and identified the steps with the largest number of overrun hours in the touch-up paint operation. After conducting data exploration and recording client feedback for qualitative analysis, the LSS were able to narrow down key process steps and assets to focus on. The LSS team verified these highest overrun steps by conducting hypothesis tests, pareto charts, and client confirmation to show the team at Tobyhanna what the data determined are greatest sources of overrun hours and repair cycle time.

From the pareto chart, the LSS team identified three main steps that spent the most time in operation which were and its codes final touch up (0160), touch up paint – CARC (0120), and touch up paint (0070). These steps were all related to the touch-up paint process whether it was the final or an asset specific step. After the findings from the pareto chart, the LSS team moved into statistical testing and analysis focusing on the operations identified from the pareto chart. The LSS team found that operation 0070 could be a systemic source of error while 0120 and 0160 could have been anomaly occurrences where the issue was the physical asset itself and not operations because operation 0070 had a high number of occurrences and operations 0120 and 0160 had a few occurrences but resulted in high number of hours.

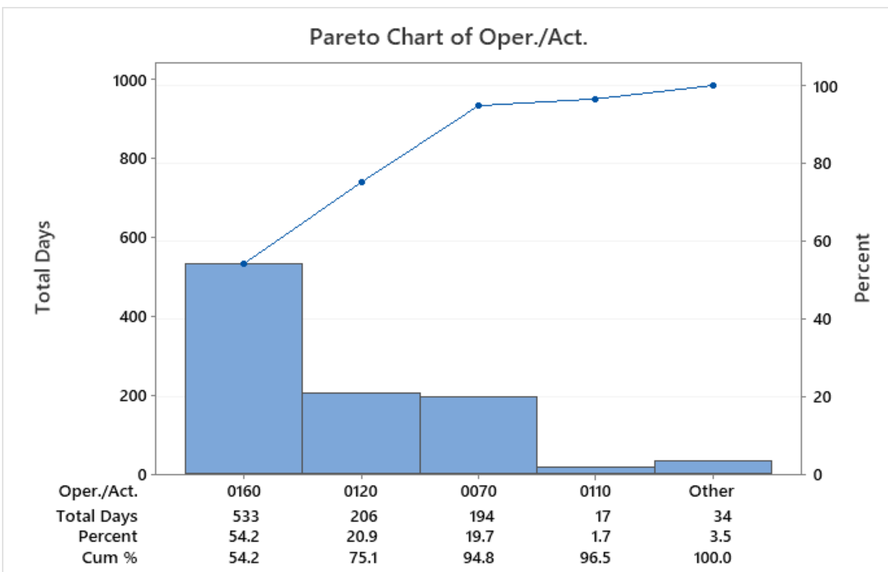

Figure 3. Pareto Chart

From the LSS team's analysis, the AN/TSC-185B's greatest source of overrun hours is rework specifically the touch-up step denoted as operation 0160. The damages to the asset that occur in the prime or trailer shop require frequent touch-up paint jobs that significantly increase the overrun hours. The Pareto chart illustrated in Figure 3 directed the LSS team to focus on the final touch up phase (Oper./Act 0160) because it contributes to almost 60% of the total hours in operation. By analyzing the relationship between total time in operation and overrun hours, the LSS team deduced that higher times in operation led to overrun hours which was confirmed by client feedback. Thus, the LSS team's priority became reducing overrun hours at operation 0160 because reducing overrun hours is the goal of the project. Moving forward, the team must be cognizant not to rearrange process steps so that the reduction in overrun hours in one operation transfers to another operational activity.

6. Improve

The purpose of the improve phase is to develop, select, and implement the best solutions, with controlled risks (Brook 2020). First, organizations must generate potential solutions through negative brainstorming, chain letters, billboards and other solution generating methods (Chen, 2009). Next, organizations and the LSS team must select the best solutions through a Pugh matrix and other assessment criteria. Following the selection criteria, organizations must assess the risk through a Failure Mode Effects Analysis (FMEA) table and other risk mitigation methods such as Pugh matrices and scoring charts (Alblooshi, et al 2016). The most important step of the improve phase is to develop a pilot plan after the team develops matrices and risk criteria. Lastly, the team must collect data after the piloted solutions were implemented. The LSS team would collect the data and analyze it to determine if the potential solutions made a statistically significant difference.

After determining the steps that contributed the most overrun hours, the LSS team conducted root cause analysis. Through detailed analysis and discussion with the TYAD TUP team, the LSS team identified scuffed paint, improper colored part allocation, and reworking processes as the root causes of the overrun hours.

After identifying root causes, the LSS team and team at TYAD held a brainstorming session to develop possible solutions. After the two teams established the potential solutions, the LSS team used a Pugh matrix to determine the best solutions. The team created criteria to evaluate the solutions. The LSS team asked the TUP team to rank how well each criterion addressed each solution. Figure 4 below shows the Pugh matrix. The numbers in green correlate to the highest-ranking solutions.

Criteria		Easy to Implement	Cost Effective	Meet Project Goals	Easy to Maintain	Long Term System Quality	SCORES
Solutions	**Weight**	5	1	4	2	3	
Shoe Slip Covers	A	H	H	M	H		92
Waterproof Sheet Covers	B	M	M	L	H		52
Ladders	C	H	H	M	M		76
Safety Stock of Items	D	M	H	H	M	L	83
Rearrange rework process to have rework in a centralized location	E	L	M	H	M	H	83
6s Methodology to clean up work space	F	L	M	H	M	H	67
Protect asset with large tent	G	M	L		M	L	39
Standardize LMP system with Serial Number	H		L	H	M	H	74
Electronic Warboard	I		M	H	M	H	78
Numeric Values for Relevance Letters: Blank= 0; L = 1; M = 5; H = 9							

Figure 1. Pugh Matrix Depicting Scores for Each Potential Solution

Though interviews with the TYAD TUP team, the LSS team determined that the most important factor when evaluating solutions was “Easy to Implement.” As a result, the teams decided on three solutions to pilot: shoe slipcovers, safety stock of items, and rearranged the rework process solutions. Solutions from the improve phase will serve as preventive measures for mistake proofing the TUP process. Shoe covers prevent employees from scuffing the paint, and the pre-painted parts will prevent other buildings from placing incorrect colors on an asset. The safety stock of pre-painted parts and shoe covers will help prevent rework touchup from occurring. Next, the LSS team and TUP team met to discuss how to quickly implement the pilot solution plans.

7. Control

The control phase aims to ensure that the effective solutions that have been implemented become embedded in the process, so the improvements will be sustained after the project has been closed (Brook 2020). The most important part of this phase is to develop a standardized process plan moving forward. The project ends at the conclusion of the control phase; thus, it is important to have effective closing project methods to sustain the positive effects of LSS.

After implementing the pilot solutions, the LSS team determined that all three solutions contributed to decreasing overrun hours in the process. With this, the LSS team first coordinated with the TYAD TUP team to either create or update existing standards of operating procedures (SOPs) to reflect the implemented solutions. For this project, the SOPs focused on the AN/TSC-185B; however, similar solutions can be applied to other assets in the future. In addition, to help maintain the changes made throughout the DMAIC process, the LSS team assisted in creating an employee training program specific to the implemented solutions. Finally, the LSS team developed a process control plan to ensure the TUP process remains stable and will meet Tobyhanna's customer requirements. This plan will monitor the AN/TSC-185B and the upper and lower specifications for its overrun and touchup hours. The purpose is to assist with recognizing what and when corrective actions should be taken. Visual management techniques, such as Tobyhanna's primary method for collecting data (SIS Dashboard) will serve as a tool to sustain the gains.

The final step is creating a transition plan back to the process owner. This plan identifies which specific members of the TUP will be responsible, accountable, consulted and informed in a RACI chart. The project will close with a summary of the projects achievements which include the financial and operational benefits. The operation benefits include the DPMO (defects per part per million opportunities) which are drawn from the overrun hours and RCT to show the degree in which the goal was achieved. Figure 5 below depicts the Individual-Moving Range (I-MR) Chart, which serves as a visual depiction of the goal achievement of overrun hours improving through the LSS process. Due to time constraints, there were only two data points collected during the control phase and does not fully and accurately reflect the process improvement for the last phase of the project. The LSS team's primary goal was to reduce overrun hours by 25% from 197 to 148 for all of the Tobyhanna assets. The LSS was able to reduce the monthly overrun hours to 164, a 17% decrease. However, focusing on the STT AN/TSC-185B, the LSS team reduced the monthly overrun hours from 32 to 19 hours, a 40% decrease. Moving forward, TYAD should focus on reducing overrun hours for the receiver-transmitter and the transmitter radar assets.

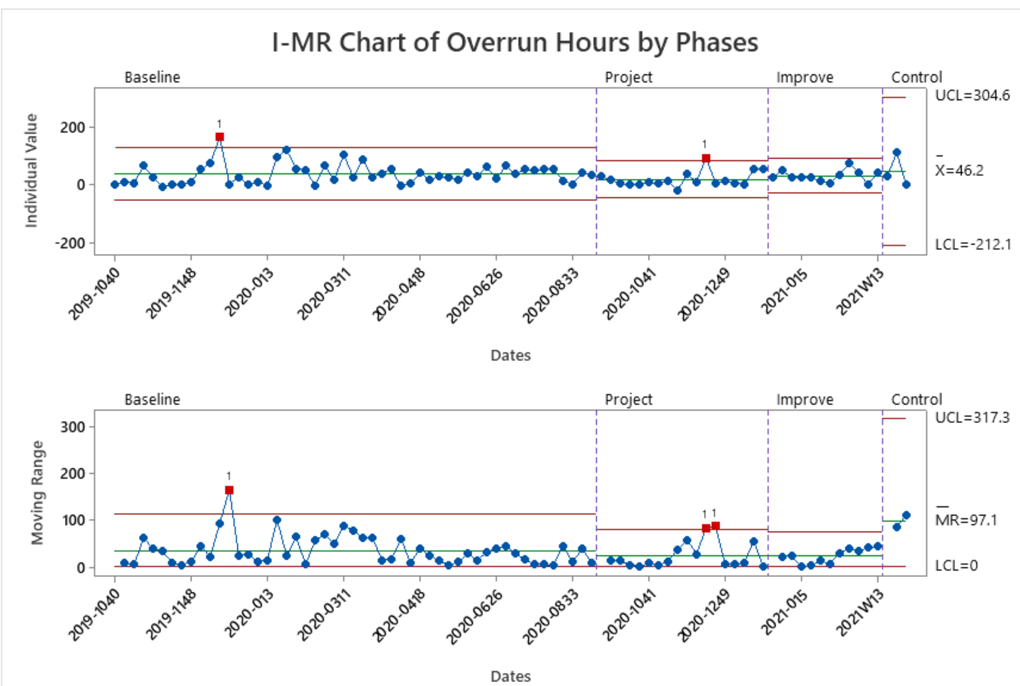

Figure 5. IMR Chart Depicting Overrun Hours

8. References

Alblooshi, M., & Shamsuzzaman, M. (2020). Investigating the Relationship Between Lean Six Sigma's Intangible Impacts and Organisational Innovation Climate Factors. *International Journal of Productivity and Performance Management*, *69*(6), 1247-1270. doi:10.1108/IJPPM-06-2019-0311

Brook, Q. (2020). Lean Six Sigma and MiniTab. *OPEX Resources LTD*, 1-286. 978-0-9957899-2-0. C5ISR MISSION. (2020). Tobyhanna Army Depot: Excellence in Electronics. https://www.tobyhanna.army.mil/Organization/Our-Mission/

C5ISR Mission. (2020). Tobyhanna Army Depot: Excellence in Electronics. https://www.tobyhanna.army.mil/Organization/Our-Mission/

Chen, M., & Lyu, J. (2009). A Lean Six-Sigma approach to touch panel quality improvement. *Production Planning & Control*, *20*(5), 445–454. https://doi.org/10.1080/09537280902946343

George, M., Maxey, J., Price, M & Rowland, D. Lean Six Sigma Pocket and Toolbook. *McGraw- Hill*, IBSN: 0-07-144119-0.

Montgomery, D. C., & Woodall, W. H. (2008). An Overview of Six Sigma. *International Statistical Review*, *76*(3), 329–346. https://doi.org/10.1111/j.1751-5823.2008.00061.x