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Enhancing Soldier Equipment Readiness: Boosting Production Order Accuracy with Lean Six Sigma

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Author Note: Cadets Chitty, Farris, Hardy, McMickens, and Tomeo are seniors at the United States Military Academy at West Point, studying systems engineering. These Cadets are pursuing their Lean Six Sigma Green Belt Certification. This group is working with Tobyhanna Army Depot (TYAD) scoped into buildings 9 and 30 in their refabrication and overhaul departments. Additionally, we would like to thank Ramona Cost, the lead black belt representative from TYAD, Sergeant Major Schlegel, for mentoring us and teaching us the Lean Six Sigma process, and Colonel Enos for facilitating the LSS projects. This paper's views and opinions are ours and separate from the United States Military Academy and the Department of Defense.

Abstract: TYAD's mission is to produce military equipment for the warfighters on the battlefield. Buildings 9 and 30 specialize in the refabrication and overhaul of large objects. Our team was tasked with lowering the number of items in these buildings that were put on hold, specifically regarding unclear traveler instructions. A traveler is a comprehensive work instruction packet that accompanies an item throughout its production process. A hold pauses the production process and prevents the item from moving forward. Our team used the DMAIC process to identify inefficiencies in the traveler process and derive and implement improvements to the process. Throughout this process, we were able to not only save TYAD money but also make the jobs of the workers at the depot easier.

Keywords: Lean Six Sigma, DMAIC

1. Introduction

Lean is concerned with efficiency and "focuses on how operational processes are designed and managed to minimize inefficiencies attributed to delays, errors, and waste" (Shore, n.d.). The lean principles have been widely adopted in manufacturing and various industries, including healthcare and software development. The "goal of lean is to create more value for customers with fewer resources and less waste, leading to increased efficiency, improved quality, and higher customer satisfaction" (Shore, n.d.). On the other hand, Six Sigma is a data-driven approach that focuses on eliminating defects in a process. Six Sigma can "improve the quality and consistency of products and services. It does this by identifying and removing the root causes of defects and ensuring the lowest amount of variability in a process" (Shore, n.d.). Consistency involves delivering products and services day after day to meet quality standards. Combining Lean and Six Sigma creates a powerful approach to enhancing the process. The methodology merges the strengths of both Lean and Six Sigma to develop a comprehensive framework that addresses efficiency, quality, and customer satisfaction. The five principles in Lean Six Sigma are defined as **D**efine, **M**easure, **A**nalyze, **I**mprove, and **C**ontrol.

This paper will describe the foundations of Lean Six Sigma methodology as it applies to Tobyhanna Army Depot, how our team executed the DMAIC process, and the results of our work.

2. LSS Literature Review

DMAIC is a problem-solving approach comprised of five phases. It is used for variation reduction, quality improvement, and cost reduction (de Mast, 2021). Typically, a problem with a process is identified before the beginning of a project. After this problem is found, the DMAIC approach can be used. The first phase of DMAIC is the Define phase. The Define Phase identifies the problems within the process (Rodriguez Delgadillo, 2022). The project charter is also finalized in this phase. In the Measure Phase, the focus is on the data. This phase involves target-oriented analysis (Rodriguez Delgadillo, 2022). This means the data is selected based on the project goals. Following the Measure Phase is the Analyze Phase. In this phase, the team identifies key causes and process determinants (Sokovic, 2010). Following the Analyze Phase is the Improvement Phase. During the Improvement Phase, the team will brainstorm, plan out, and implement improvement ideas. The final phase is the Control Phase. This phase is where the team creates standard operating procedures to ensure the changes made are continued once their project is complete. This ensures that the gains and improvements made from the project are sustained. DMAIC provides a structured, systematic approach to problem-solving that drives both immediate improvements and long-term results. By ensuring each phase is completed thoroughly, DMAIC helps organizations achieve sustained enhancements in quality, efficiency, and cost-effectiveness.

2.1 Define

The Define Phase begins with project selection, a critical step in DMAIC that lays the foundation for success. Lean Six Sigma often employs a top-down approach, where higher management identifies key business goals, analyzes performance data, and prioritizes the most impactful project (Ray, 2010). This method ensures alignment with business objectives, customer needs, and internal process improvements. Once the project is selected, the team develops a project charter, defines the scope, creates a SIPOC diagram and process map, formulates a communication plan, and outlines the overall project plan (George, 2005). A well-structured selection process sets the stage for meaningful improvements by providing a clear direction. Establishing a shared understanding between the team and stakeholders further ensures a seamless transition into the Measure Phase, where data collection and analysis begin.

2.2 Measure

The objective of the measurement phase is to thoroughly understand the current state of the process and collect reliable data on process speed, quality, and costs that will be used to expose the underlying causes of problems (George, Rowlands, Price, & Maxey, 2005). The key step to the measure begins with creating and validating a value stream map to confirm the current process flow. The value stream will identify the outputs, inputs, and process variables that are relevant to the project. After confirming the inputs and outputs, the project team will create a data collection and data analysis plan. Then, the project team begins collecting data to establish baselines and update the value stream map with data to perform process capability evaluations and calculate lead time (George, Rowlands, Price, & Maxey, 2005). The project team can make small improvements and move into the next phase of the DMAIC methodology.

2.3 Analyze

The Analyze phase is used to diagnose the root causes affecting inputs and outputs relating to the project. One could break up the Analyze phase into two major components. Identifying the root causes and then analyzing and validating the root causes. The resulting product of the Analyze phase is a list of prioritized root causes which are dug into during the Improve phase. Begin with analyzing the data collected in the measure phase. Creating Pareto charts and other analytical graphics is an effective method of visualizing data to hone in on potential root causes and uncover unseen ones. Concurrently, work with process leaders and workers to uncover other unseen potential root causes. With the potential root causes identified, conduct root cause analysis to find the true root causes. With these new root causes, identify failure modes, failure effects, potential causes, and current controls of how the root cause relates to the process. Using these metrics one can derive a risk priority number which is used to prioritize root causes in the Improve phase.

2.4 Improve

In the Improve phase, the team “develops potential solutions from the Analyze phase to identify a wide range of solutions by altering and developing criteria” (George et al., 2005, p. 15). Some key steps to improve are developing potential solutions, evaluating the best solutions, developing a value stream map, developing pilot solutions, confirming the attainment of the project goal, developing a full-scale implementation plan, and preparing for an improved gate review. A stakeholder analysis ensures the group is ready to promote and encourage change.

2.5 Control

The Control Phase is the first step that requires exploring data and what is happening in the process. This phase ensures the sustainability of process improvements by maintaining consistency and preventing deviations. Key components include the Control Plan, which documents methods to monitor and maintain process standards, and Standard Operating Procedures (SOPs) that provide clear instructions for routine tasks. Statistical Process Control (SPC) employs tools like control charts to track process stability over time, identifying variations early. Failure Modes and Effects Analysis (FMEA) assesses risks and develops mitigation strategies for potential issues. The handover to the process owner formalizes responsibility for ongoing monitoring, while process capability analysis evaluates whether the process consistently meets requirements, ensuring long-term success.

3. Methodology/Results

3.1 Define

The project charter's goal was to improve the accuracy and reduce delays of the TYAD traveler documents. The Define Phase began with a problem statement on production order traveler accuracy, followed by data confirming the need for a Lean Six Sigma project. The project scope focused on traveler instructions, Gatekeeper validation, and assets in the Support Operations and C4ISR Finishing Divisions, specifically for 1600 (fabrication) and 1800 (overhaul) production order numbers. A SIPOC Map clarifies the process by defining suppliers, inputs, outputs, and customers, while a process map details each role and step in the traveler process, identifying tasks, decision points, and errors. Figure 1 shows the process map outlining the traveler process. The Voice of the Customer emphasized meeting delivery dates and reducing rework, while the Voice of the Business focused on cost efficiency and minimizing delays. Together, these tools ensured alignment between customer satisfaction and operational efficiency.

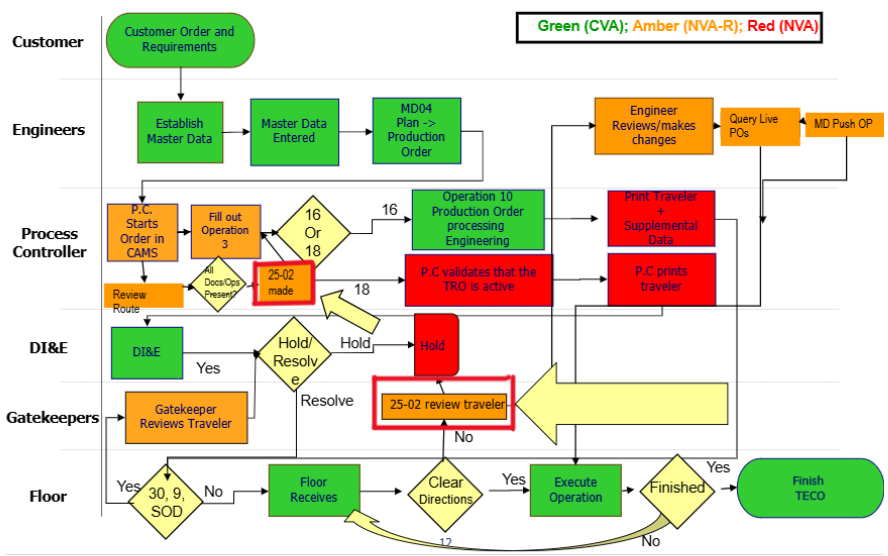

Figure 1: Process Map

Figure 1: Depicts the revised process map for how a traveler moves across the depot. The traveler starts out with the customer order/inputs. The engineers and controllers then create the traveler in Master Data. By the time the traveler reaches the finish at TECO. The addition of the 2502 was necessary to allow controllers and engineers to add needed time and corrections to the traveler that is live. This 2502 just added time on a traveler if it was falling behind in the process.

3.2 Measure

During the measure phase, data was collected to run a baseline process performance and capability test for the TYAD traveler documents. The data was collected by pulling a list of all traveler holds and refining to only those within scope of the project. A total of 35 data points were gathered between September and October 2024 to analyze the traveler holds and their impact on production. The results in Figure 3 indicated a mean hold time of 8,394 minutes (148.9 hours) with a standard deviation of 10,585 minutes (176.4 hours). These results demonstrated significant variability in processing time. The hold time data also exhibited a left skew, indicating that a large portion of traveler holds fall in a shorter hold time range whereas a smaller portion has hold times greater than the mean. The process capability for the hold travelers in Figure 2 has an overall rate of 571,479 defects per million opportunities (DPMO), corresponding to a Sigma Quality Level of 1.32 (SQL), which is an accuracy rate of approximately 43%. The findings from the Process Capability Figure confirm substantial inefficiencies in the current process and highlight the need for targeted improvements to traveler document accuracy and validation procedures.

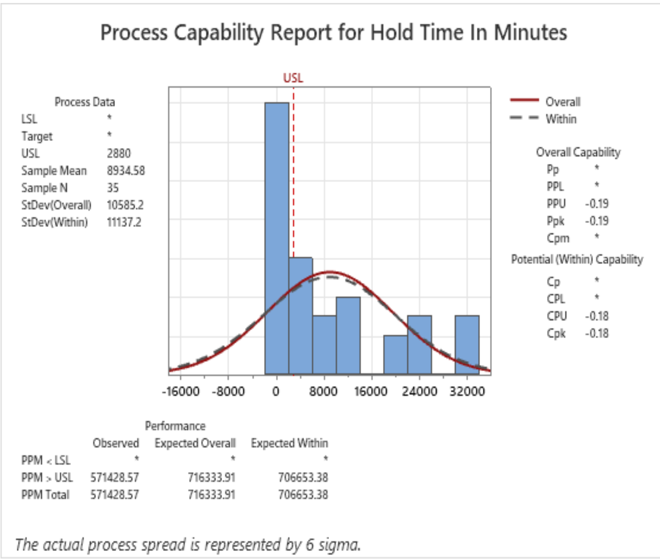

Figure 21: Process Capability Report

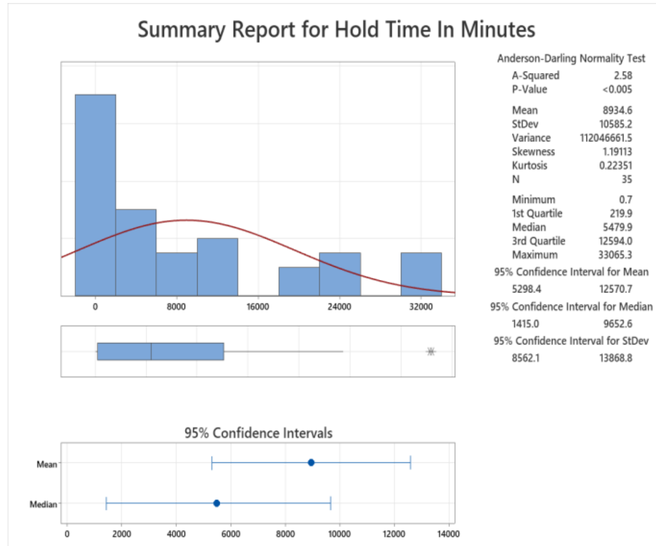

Figure 32: Summary report for Hold Time In Minutes

3.3 Analyze

Utilizing the data collected in the Measure phase, our team created a Pareto chart of defects. This chart identified our three major bins of traveler defects that resulted in holds. The three bins were missing or unclear masking documents, missing operations, and incorrect routes. We brought these results to our TYAD team to flesh out potential root causes and conduct a root cause analysis. Some of the identified root causes were that work instructions are not standardized, no tracking of changes in routes when holds occur, there is no review of routes before implementation, and engineer training. From there, we created a Failure Mode and Effects Analysis (FMEA) chart to identify failure modes, potential failure effects, potential causes, and current controls. Working with our TYAD team, we assigned weight values to each metric, which were used to calculate a risk priority number. The risk priority number allowed us to identify the top root causes to validate and focus on in the improve phase.

3.4 Improve

In the Analyze phase, the team looked at the root causes that were affecting the traveler process. The team developed a cause-and-effect diagram and a root-cause analysis. The prioritized root causes from the Analyze were that work instructions are not standardized, tracking changes in routes when holds occur, and review of route before implementation. As we moved into the Improve phase, we were able to narrow down the main focus from the Analyze phase. The critical X's were narrowed down to tracking changes in routes when holds occur, unclear work instructions, and review of routes before implementation. We developed these potential solutions: master data push operations, 2502 document revision, and order maintenance training with the controllers.

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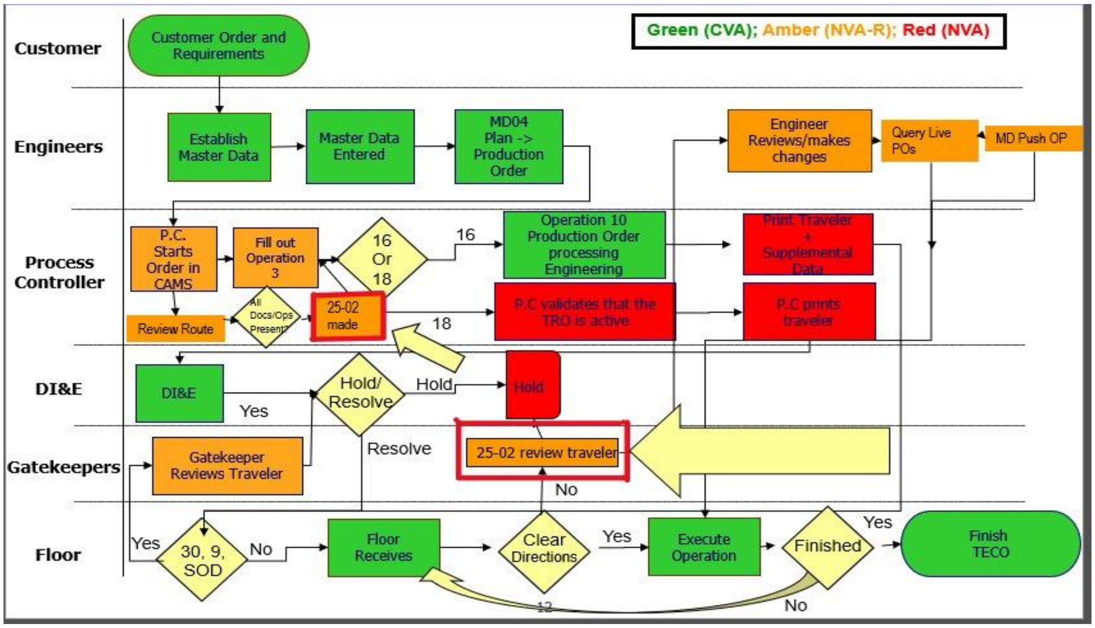

Figure 43: To-Be Process Map

The above To-Be Process Map in Figure 4 shows some of the changes that a revised 2502 introduces to the overall production of an order. The revised 2502 implementation will be accessible at the controller level to make changes. The engineers have access to any updates that are made on the 2502. The To-Be Process Map shows the order of the path of a production order. The team is currently in the process of conducting the pilot plan for the potential solutions that were identified. Once the results are received, the team will analyze the data to see if the implemented changes have an effect upstream in the process of a production order. In the future, after analyzing the pilot plan, the team will choose the best potential solution and start heading into the Control phase of the DMAIC.

4. Conclusion

Buildings 9 and 30 have seen an increase in travelers on hold for years, having been deeply rooted in many issues throughout the master data and route maintenance processes. Our team determined that these holds are mainly binned into three main issues: masking, missing operations, and master data. Overall, we believe our research can make an immediate impact on the TYAD traveler process today, as well as set up upcoming groups for the future.

The common issues we identified in the Measure Phase directly contribute to the inefficiencies not only in the traveler process but in TYAD's production as a whole. By continuing to follow the DMAIC framework, we have been able to collect meaningful data, identify root causes, and propose potential solutions, including master data operations, a revised 25-02, and enhanced order maintenance training. These conclusions are designed not only to reduce traveler holds but to reduce rework and make a more efficient production order traveler process. Looking ahead, the Control Phase aims to solidify these gains. This phase outlines a clean handoff to the process owner with implementations to the traveler process that will drive long-term operational improvement. This project has not only delivered a measurable impact but also valuable data and models that can contribute to future projects across the depot.

4.1 Future Work (Control)

This phase consists of three major deliverables. SOPs, control tools, and financial operation benefits. SOPs are essential in maintaining the changes and solutions that were established in the prior phases. To create these SOPs, we will look back at the high RPNs found in the FMEA created in the Analyze portion. By looking at these RPNs, we can identify detection methods to reduce risk and ensure that the new process that is being pushed out is more likely to be followed in the future when our project has been completed. In addition, a transition plan is pivotal to ensuring a clean, full-scale implementation of the changes created in this project. Control tools assist in maintaining the improvements that were created and pushed out in the Improve phase. We plan to create a control tool that will monitor the number of travelers on hold associated with the 3 largest bins of hold reasons established in the Measure phase, along with any traveler in our scope that exceeds 24 hours on hold. Lastly, we will create a financial operational benefit chart that will outline the defects identified before and after the implementation to quantify how productive our changes are.

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