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Lean Six Sigma: AN/ANS-146 Electronic Shelter Vans, Tobyhanna

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Abstract: This case study aims to investigate the application of Lean Six Sigma (LSS) methodology in reducing the Repair Cycle Time (RCT) for the AN/ANS-146 Electronic Shelter Vans (ESV) at Tobyhanna Army Depot (TYAD). This paper outlines the methodology of LSS through DMAIC (Define, Measure, Analyze, Improve, Control). The contribution of this research is valuable because it provides insight to how the DMAIC methodology and other LSS tools can be used to improve process efficiency at TYAD and beyond. The team worked to reduce RCT for the 146 ESVs to allow TYAD to produce more products effectively and handle increased demands.

Keywords: DMAIC, TYAD, RCT, Lean Six Sigma (LSS)

1. Introduction

Tobyhanna Army Depot provides support across the Department of Defense (DoD). The ESV process has encountered several challenges such as moving into a new building, supply chain issues of parts, and having insufficient power supply. These issues generate inefficiencies in the ESV process, making it difficult to meet demand. Clients of the TYAD ESV process send their ESVs to be refurbished and expect a timely turnaround. Due to the increased demand and existing inefficiencies, TYAD is falling behind on the refurbishing of the 146-ESV orders. The goal of this project was to decrease the RCT of the 146 Electronic Shelter line to combat the increase in orders at Tobyhanna Army Depot.

2. Literature Review

2.1 Define

The define phase is the first step of the DMAIC methodology. In this phase, it is critical to understand why there is a problem, before investing time and money into the project (Brook, 2020, p. 14). It is important for both sides to focus on reaching an agreement on problem definition and the scope of the project (George et al., 2005, p. 4). Key deliverables of this phase include scope, creation of the problem and goal statement, project charter, supplier inputs process outputs and customers (SIPOC) map, voice of customer (VOC) and voice of business (VOB), business impact, communication plan, and the creation of a process map. All the deliverables in this phase are critical to the success of the project because they provide a clear understanding of the process and glidepath for the remainder of the project. Scope provides focus on what the project will and will not address (Lynch, 2003). The goal statement is nested within the scope and explains the key aim of the project. The project charter is a combination of several deliverables which summarize the findings within the define phase; allowing the stakeholders to review the project and commit to supporting it (Brook, 2020, p. 32). The SIPOC map graphically displays the key elements of a process and provides space for the VOC and VOB to be shared. The business impact allows the team to look back at previous fiscal years by observing data. Lastly, the process map allows the team to work together to create a collective understanding of the process and how it works (Ufer, 2021). These deliverables will create a visual depiction of the process and problem throughout the DMAIC methodology.

2.2 Measure

In the measure phase, critical data is acquired to identify problems in the process. Data is either provided by the stakeholder or generated by the team through a data collection plan. It is important to ask questions such as type of data is available, how is the data presented, and relevance of the sample population (Hessing). Once the data is obtained, a distribution type must be identified to run the proper statistical tests to see which factors are affecting the process the most. Collecting data often highlights issues in the process, leading the team to either broaden or zoom in scope. The next step is to collect baseline statistics on the data such as the mean and standard deviation. Creating visuals like an individuals-moving range chart (I-MR) and a capability histogram help show stakeholders the current state of their process and test the effectiveness of future solutions (Hessing). Data cleaning highlights issues or immediate correlations that the stakeholders may not have seen before, so it is important to present this data in a neutral way to the stakeholders. Quick wins, when they are available, provide immediate small fixes throughout the process. At the end of the measure phase, the ideal output is a cleaned set of data for handoff to the analyze phase.

2.3 Analyze

The purpose of the analyze phase is to find the causes affecting key inputs and outputs that affect the project goals (George, 2005). The data collected in the measure step is used in the analyze phase to gain insight into the root causes of the problems (Villanova University, 2020). To complete the analyze phase, the following steps need to be completed: analyze the process flow, analyze data collected in measure, generate theories to explain potential causes, narrow the search, and collect additional data to verify root causes (George, 2005). To accomplish these steps, several deliverables such as a cause-and-effect diagram, failure modes and effect analysis (FMEA), Pareto charts, and prioritized root causes matrix must be completed. The fishbone diagram assigns causes with an effect as it pertains to the process. Although simple, the fishbone diagram is an appropriate technique to graphically represent the potential root causes of problems that occur in the process (Coccia, 2018). The FMEA is a critical tool to determine the reasons for failure in the process. The FMEA is a risk management tool that prevents potential failures in a system by identifying and assessing the cause and effects (Lee, 2017). The Pareto chart transitions from receiving input from the process owner towards the data that was collected in the measure phase. After collecting data, a Pareto chart illustrates the defects in a process through a bar graph that exposes parts of the process with high defect numbers. These Lean Six Sigma tools concludes the analyze phase with a consolidated list of root causes with recommendations of which should be prioritized in the Improve phase.

2.4 Improve

The improve phase is where the work of prior phases culminates into an implemented solution. It is vital that the analysis done before the improve phase is the driving force behind creating possible solutions. Within this phase, solution development, selection, simulation, and implementation occur. Solution development relies heavily on idea generation to identify viable solutions. Solutions must include lean six sigma principles such as kaizen, single minute exchange of die, and visualizations to name a few. Solutions must be selected based on quantifiable methods such as FMEA, benefit vs. effort matrixes, cost benefit analysis (CBA), and/or value modeling. CBA pushes decision makers to choose the option with the most utility and the least cost through use of the four stages: identification, measurement, comparison, and selection (Nas, 2016). Value modeling occurs through development of value measures through understanding of stakeholder needs, wants, and desires, which is then formulated into a value score (Mittal et al., 2017). Value scores are then modeled through a cost versus value graph which provides a quantifiable deliverable for a stakeholder to decide on an option. Simulation is a powerful tool that helps predict outcomes of solutions without using too many resources and can be used before piloting a solution. Simulation is broken down into three main fields: system dynamics, agent-based, and discrete events (Ahmed, 2020). Each type of simulation aims to predict reality as accurately as possible but does so through various methods. Before fully implementing a solution, the lean six sigma team pilots a solution to ensure that it addresses the root causes and fixes any flaws in the new process. During the pilot, data is collected to inform and validate the solutions implemented achieve the desire effect. After the pilot, it is critical that the data is assessed, and improvements are made to the solution as needed before implementation. For the implementation aspect of this phase, it is key that all people who play some role in the process are informed of the changes and are trained to carry out the new process. The end state of the improve phase is a solution that has been measured, simulated, and ready to be handed off to the stakeholders for the control phase.

2.5 Control

The control phase is the final stage which provides stakeholders with an improved process and measurement system to ensure that the newfound success is maintained (George et. al, 2005). Helpful tools in the control phase consist of controls charts, out of control action plans (OCAP), and operating rhythm charts. These tools help managers and workers tell whether a process is in control or not and the steps needed to get a process "humming" again. Control charts map out the performance and variation in a process. Different processes have different quotas for what constitutes being out of control. For example, if a process is supposed to operate at a three-sigma level, variation outside of three sigma means that the process is out of control. It is important to ensure that the new process stays under control so that it produces consistent and reliable results. The governing rules considering control charts are the Western Electric Rules. The four Western Electric Rules provide guidelines to whether a process is in control (*Western Electric Rules*, 2014). It is equally important for the process to have an OCAP for when the processes do fall out of control. These plans provide a systematic way of turning the process back to normal as fast as possible. For the improved process to be maintained properly, it is vital that transition plans, documents, process maps, etc. are easy to read, understand, and use for the workers in the future. Standard operating procedures (SOPs) should be created at all levels of the process because they decrease variability by creating commonality within a system. Before the lean six sigma team hands the project completely over to the key stakeholders, project savings must be calculated to display how much the updated process will save the company in the future. Savings can come in the form of costs, quality, and/or time. The DMAIC process officially ends when the green or black belt hands the project off to the company for their use.

3. Methods and Results

The main goal of the define phase was to create a relationship between the West Point and TYAD teams to generate a collective understanding of the issue at hand. The scope was widest at the beginning, but it began to narrow as the phase continued. Narrowing down the scope resulted from understanding the process of how the shelters are refurbished, how Tobyhanna works, and becoming comfortable within the new team setting.

Two key deliverables produced in the define phase were the SIPOC map, which is a specialized process map, and the creation of the goal statement. These deliverables give a broad understanding of the problem at hand for the team. The goal statement was to improve the ESV process by reducing the RCT to combat the increased workload. Overall, reducing the overrun from X to 0 hours and improving the repair cycle time at Building 3. This was determined by stakeholders at TYAD. Through developing key deliverables and outlining goals throughout the define phase, the project team developed a broad understanding of the issue at hand, positioning the team well for the succeeding phases of the project.

The measure phase began with scraping and cleaning the data given by the TYAD team. The data provided information on 34 completed ESVs from 2019 to 2022. The group analyzed the RCT, overrun hours, and total hours worked within the data. Once conducting measurement system analysis, the data was deemed valid and usable for the project after looking for errors such as bias, variation, and stability. After running baseline statistics on each improvement goal, the team decided that RCT was the most effective way to improve the process. TYAD's goal for the project was to decrease the RCT to 90 days. Baseline statistics revealed a current average RCT of 136 days with a standard deviation of 30 days. This data shows that the operating RCT is well over a month longer than the goal of 90 days. As shown in figure 1, a key point that the data showed was there was a stark difference in RCT in the new building versus the old building RCT. The data shows that the mean RCT in the old building was around 131 days and out of control while the new building mean was 151 days and in control. This shows that the process became worse after the process moved buildings. Using this new building data, we ran a capability test to determine if the process was within the boundaries of the 90-day goal and if the process was centered. Using the software Minitab, a Cp value of .85 was calculated, indicating that the data was not within the boundaries of a 90-day RCT. A Cpk value of -0.01was calculated, indicating the process was not centered and exceeds the upper limit of the 90-day goal. Next, the new building sigma level and defects parts per million (PPM) for the process was calculated yielding a sigma level of 1.5 and the PPM of 508,820. The 1.5 sigma level proves the process in inefficient and with a PPM that high it demonstrates that the process was not in control.

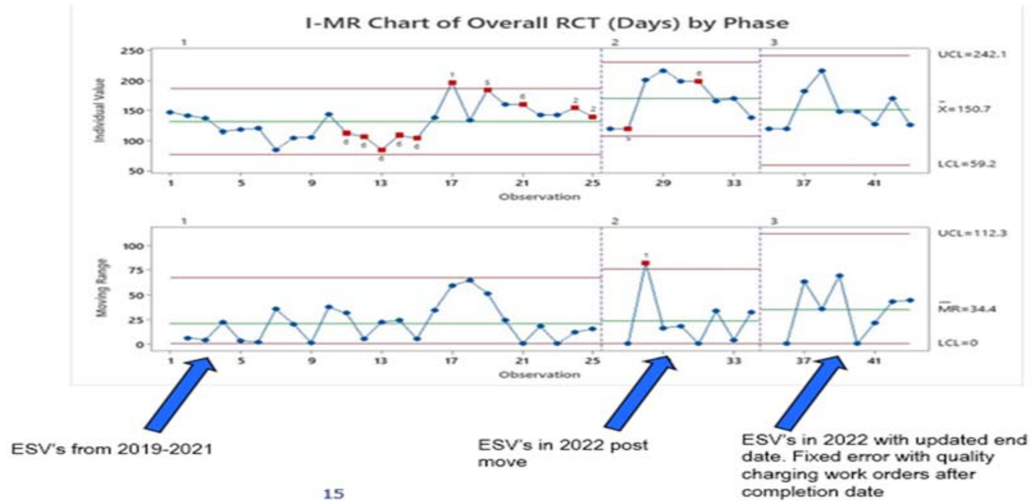

Figure 1. IMR of New and Old Building RCT

After the measure phase, it was important that the team looked further into the data and allowed it to guide in finding the root causes. To aid in this analysis, the cadet team worked closely with TYAD to develop a FMEA to understand potential problems in the process. Through multiple brainstorming sessions, the teams developed a list of problems and were able to associate severity, occurrence, and detection scores to assign a risk priority number (RPN) to each issue. This RPN allowed the team to perceive the largest problems within the process. Additionally, further analysis of the data generated by Pareto charts was done to depict potential problems within the process in a statistical manner. Slack time and hold reasons were areas of concern as they extend the RCT. Figure 2 depicts a Pareto chart which illustrates that slack time occurred the most during phases 0010-0030. Regarding hold reasons, data revealed that parts and arrival delays account for 80% of why an asset was held. This data exposed potential problems in the earlier phases of the ESV's production. The FMEA and Pareto charts provided guidance to where the team concentrated focus on improvements. These tools support the prioritized root causes of movement of ESVs, communication between TYAD and DLA, and delays in sole source items.

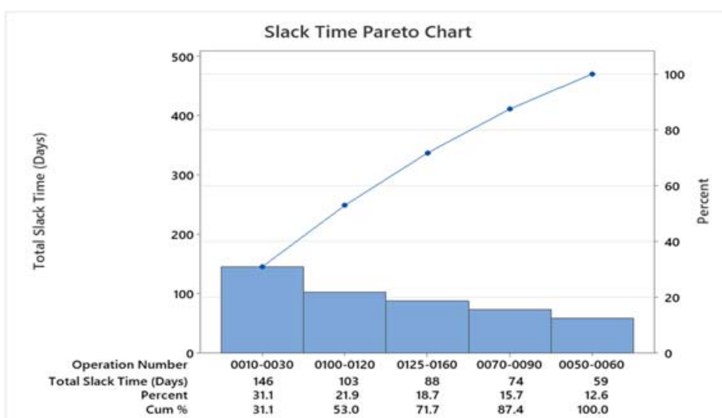

Figure 2. Pareto Charts

Solution	Method	Effect
Improve Forecasting and Communication	Flattened BOM	Identify high risk materials
	Supply Supportability Analysis	
	Quarterly SSA Meetings	Reduce restock wait time (reduce slack time)
	Obsolete List	
60 Amp Hawk	Install extra power source on column in process line	Increases throughput and capability (# of ESVs worked on at one time) which will decrease RCT
Standardize Kit Setup	Install layout pictures on cage	Streamline process of identifying parts, reduce learning curve, increase efficiency of workers
	Label with part numbers	
	Standardize across production line	
Improve awareness of material location through DLA (The U)	Hire new U Manager	Reduce slack time and holds for missing asset
	Increase communication between the U and TYAD	

Figure 3. Solutions Matrix

The group scoped in on the most prevalent issues which were determined by the highest RPNs. Solution development focused on generating solutions to address these issues of concern. With TYAD members, the LSS team formed solutions through the Delphi technique and brainstorming meetings. These idea generation techniques allowed a plethora of possible solutions to be created for each issue. After solutions were developed, each solution was placed on a Benefit vs. Effort matrix. Solutions that yield high benefit and low effort were deemed as the most favorable. A second way solutions were screened was through a ranking matrix which addressed several categories such as time to implement/install time, resourcing, meeting customer requirements, and level of coordination. Candidate solutions with the highest rank across these categories were prioritized. After solution screening, the group identified four solutions to address the top issues highlighted in the FMEA.

Figure 3 displays each solution, how it will be achieved, and the projected effect it will have on the ESV process. Supply supportability analysis (SSA) is a product produced by TYAD which categorizes materials/supplies for the ESVs into bins based on availability. SSA allows TYAD to identify current supply chain issues and forecast future ones. The LSS team identified that many key people within the ESV line were not fully aware of these issues, so quarterly SSA debriefs will bridge this gap of information. The 60 Amp Hawk opens up another power supply on the ESV line which greatly increases their process's ability to work on multiple shelters thus increasing throughput. The increased throughput results from transitioning the serial process into a parallel one. Standardizing kit setup allows for anyone, regardless of experience level, to be able to work on the ESVs and improve efficiency. Since ESVs and parts were being held or not received for a variety of reasons, the TYAD team hired a new "U" manager, who tracks assets across the process, to better manage the critical supplier (DLA). This new position prevents ESVs and parts from being not received.

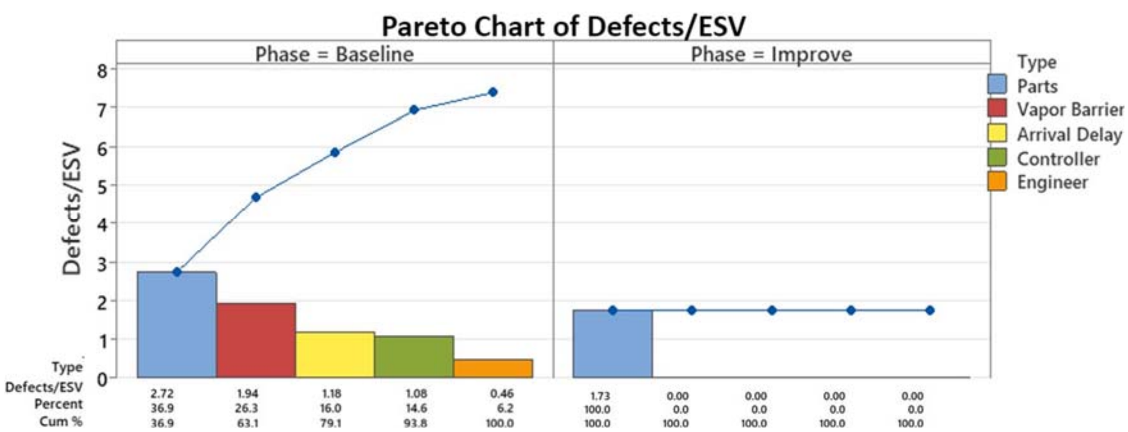

Figure 4. Baseline vs. Improve Hold Reason Pareto Chart

A major contributor to high RCT is when an ESV is held from moving onto the next phase of the process thus creating a delay. As shown in Figure 4, ESVs are held for a variety of reasons. The baseline phase represents hold reasons for 50 ESVs from 08/08/2022-02/17/2023. As predicted, due to supply change issues, parts yielded the most holds per ESV. The improve phase represents measurements over a month where the solutions from Figure 3 were implemented. Holds per ESV in all categories except parts dropped to zero, while parts dropped from 2.72 to 1.73 holds per ESV. Decreasing holds per ESV lowers delays which in turn shortens the RCT.

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During the control phase, the focus is to make a control plan and SOPs to sustain improvements. For the quarterly SSA meetings, the team will create a schedule as well as a required personnel roster. This will ensure that supply chain issues will continue to be talked about and that the right people are in the room to make a difference. Next, an updated process control board (PCB) must be made to determine whether the new RCT remains in control following the improvements. Analysis on this PCB will be done through control charts. Lastly, documentation must be created concerning those who are responsible for ensuring the improvements are continued in the future. Following the control phase, the project will be given to the TYAD team to run themselves.

4. Conclusion

The application of the LSS DMAIC methodology allowed the LSS team to evaluate and improve TYAD ESV line. The group defined the problem and had a goal of lowering RCT to meet demand. The measure phase provided necessary data to scope in on the true problem. Next, the data was analyzed to pinpoint root causes of the issue which were lack of power supply, missing parts for the ESV, management of where the ESV was located, and a lack of SOP for kit set up. Based on these issues, solution development occurred through brainstorming meetings, solutions were screened through a benefit effort matrix, and then solutions were implemented. The solutions were to install a 60-Amp Hawk for the electrical issue, quarterly SSA meetings to communicate part issues, standardize kit set up, hiring a U-Manager to locate and facilitate where the ESV is in the process. The next step is the control phase to effectively hand off the improvements by creating standard operating procedures (SOPs) and a control plan to ensure that the problems that arose will not happen again in the future.

There are several areas in which future work can be done. First, analysis on the effect of the 60-Amp Hawk may show large improvements on the RCT. Capturing this data may allow the TYAD team to push for additional power supply in the future. Another issue in this process is the rusting of the hand-cut raceways. Future work could involve automating the process of cutting the raceway. This would generate a smaller possibility of error thus leading to less defects.

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