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Lean Six Sigma: Reduction of Backlog Hours within the Equipage Division

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Abstract: Tobyhanna has a significant backlog of work orders throughout the FABAPP01 Division. The delays in service to other work centers impact Tobyhanna's ability to complete contracted work within the agreed-upon time frame. The team applies methods of Lean Six Sigma to approach this problem. Using raw data analysis as the primary tool for problem definition, process capability. This thesis attempts to examine the inefficiencies in the work system that gives rise to the major delays within the equipage division and to reduce the backlog to two-hundred hours. Through understanding of the existing processes within the Tobyhanna Army Depot, as well as the analyzation of data provided by Tobyhanna, we aim to reduce the amount of backlog hours and apply Lean Six Sigma tools to eliminate non-efficient process steps as well as provide efficient solutions to optimize the processes used by the FAPAPP01 Division. These solutions will reduce backlog hours and save Tobyhanna business costs as well as improve working standards.

Keywords: Lean Six Sigma, Process Engineering, Industrial Engineering, Process Improvement, Lean

1. Background of Tobyhanna Army Depot

Tobyhanna Army Depot is a logistics center for the United States Department of Defense, specializing in primarily electronic systems. It employs 3,388 people and is a primary resourcing center for the United States Military. Tobyhanna Army Depot partnered with an LSS team from the United States Military Academy to apply the Lean Six Sigma Define, Measure Analyze, Improve and Control (DMAIC) process on the backlog within the Fabric Application Branch. Because there is a significant backlog in work hours, about 922 backlog hours per week on average, many leaders within the Equipage branch have allocated their time to solving this problem. The LSS team from USMA is assigned to the Fabric Application Branch Work Center of Tobyhanna Army Depot's Equipage division for the entire year to solve this problem. There has been a team at Tobyhanna that has assisted in providing resources and knowledge to the Cadet LSS team so that they can complete the DMAIC process and improve the system.

2. Introduction to Lean Six Sigma

In the past 100 years, companies have been moving towards new business strategies that produce more profit for the organization, while providing customers with satisfactory services (GoLeanSixSigma.com, 2019). Many organizations have implemented the Lean Six Sigma process for process improvements within their system (GoLeanSixSigma.com, 2019). Lean is the process of reducing waste to produce more value for customers (Ibid.). Six Sigma is the process of reducing defects and solving problems in the production process for service (Ibid.). By integrating these two improvement processes, companies have learned to solve problems while improving the efficiency and speed at which these products hit the market (Ibid.). Today companies among the automotive, education and food services use Lean Six Sigma, such as 3M, Toyota, General Electric, and Xerox (The History of 3M | Form Humble beginnings to Fortune 500, nd).

The foundations of Six Sigma start with the German mathematician Carl Friedrich Gauss in the 1800s ("Carl Friedrich Gauss |Biography, Discoveries, & Facts," n.d.), who developed the concepts behind the normal curve within probability and statistics ("The History of Six Sigma; 2010). However, the trademark "Six Sigma," was not established till the 1980's in which the Motorola corporation guided by Bill Smith, established that the standard defect should be six sigma (6σ) away from the central process in their business strategy (Ibid.).

Lean utilizes the use of tools to eliminate waste from an organization process and is vital to the Lean six sigma method (GoLeanSixSigma.com, 2019). The concept follows the idea that waste is broken down into seven sources, with the goal to reduce each waste to a minimum. The seven wastes are transportation, inventory, movement, waiting, overproduction, over-processing, and defective products (Kettering, 2016). These wastes can be eliminated through several techniques that remove non-value-added time from a process. Implementing methods such as layout improvement, defect elimination and the 5S's are critical in supporting the optimal use of people, space, equipment, and supplies.

3. DMAIC Process

Before the process improvement, the first step in the DMAIC methodology is the Define phase. In this phase, the project team, the sponsors, and the stakeholders create the goals, targets, and finances for the project. A project team and sponsor select a project based on certain needs. (George, 2017) The team gathers the background information of the project and analyzes the original project charter to define the scope of the new project. (Ibid.) A key aspect of this phase is resource allocation. Allocation of resources are critical to the phase because this information creates the initial schedule and budget that the project must-have. Once this is complete the project team will meet with the sponsors and stakeholders to validate the scope of the project concerning the voice of the customer (VOC) (Ibid.). It is essential that once the define phase is complete, the project team, stakeholders and sponsors review the define phase to validate its completion. The document that certifies the completion of the define phase, is called the Tollgate review, which is a checklist that identifies that every requirement during the define phase has been completed. Within this checklist, the project charter is officiated which will set the precedent for the rest of the project.

The Measure phase aims to set a stake in the ground in terms of process performance (a baseline) through the development of clear and meaningful measurement systems. (Brooks, 2017). The flow through the measure phase is to develop a process measures, collect process data, check the quality of data, understand the process behavior, and establish the baseline of the processes' capability and potential. The goal of the analysis phase is to derive causes of the flaw in the process as well as utilize tools and methodologies to support findings. These include time analysis, value-added analysis, value stream mapping, charts (histograms, Pareto charts, box plots), cause and effect diagrams, and thorough root cause analysis. (George, 2017).

The Cause and Effect Diagrams, also known as a fishbone or Ishikawa diagrams provide multiple purposes to LSS teams. Their purpose is to help teams push beyond symptoms or distractions to uncover potential root causes as well as provide structure to cause identification effort. Cause and Effect diagrams can also be used as a cause-prevention tool by brainstorming

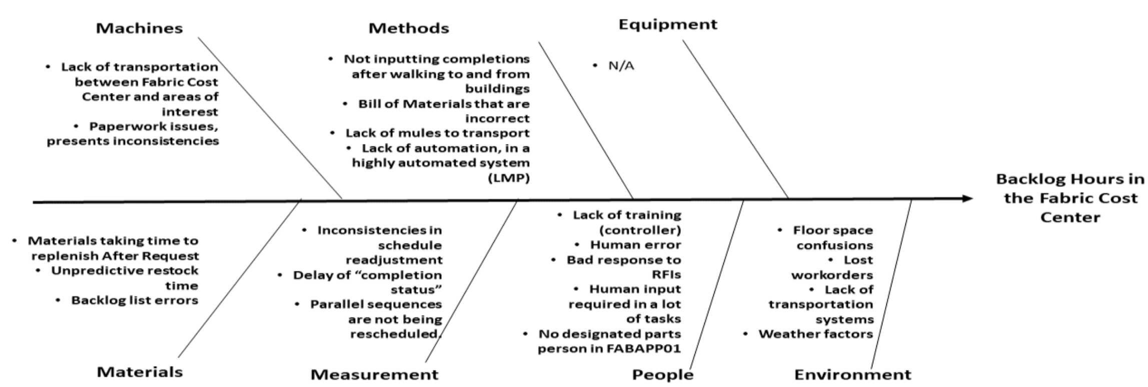

Figure 1. Cause and Effect Diagram

ways to maintain or prevent future problems (during planning efforts in improvement or Control) (George 2005). Figure 1 presents the cause and effect diagram for the Fabric Application Branch backlog.

The improve phase aims to develop, select and implement the best solutions, with controlled risks (Brooks, 2017). The effects of the solutions are then measured with KPI's developed during the measure phase (Brooks, 2017). The objectives of the improve phase are to generate potential solutions, select the best option, assess the risks associated with the option, and implement the plan. The success of the improve phase is not based upon the successful implementation of the selected solutions, but instead when the process measurements have improved and been validated with appropriate statistical techniques (Brooks, 2017). Lastly, the control phase aims to ensure that the solutions that have been implemented become embedded into the process, so that the improvements will be sustained after the project has been closed (Brooks, 2017). The process of this phase consists of implementing ongoing measurements, standardizing solutions, quantifying improvements and closing the project.

4. Methodology and Results

4.1 Define Phase

The purpose of the define phase is to have the team and its sponsor reaches an agreement on the scope, goals, and the financial and performance targets for the project (George, 2017). The Lean Six Sigma team has documented that the problem statement for this project is that the Equipage Division has a significant backlog of service requests due to process inefficiencies. The delay in service to other work centers impacts Tobyhanna's ability to complete contracted work within the agreed-upon time frames. From June 23rd, 2019 to August 4th, 2019, the average existing backlog per week was 922 hours. The problem statement identifies what the problem is, the frequency of the problem and the impact of the problem. The purpose of the goal statement is to identify the key output metrics that need to be improved in the process (George, 2017). The goal of this project is to reduce the backlog, or overflow hours, of the Equipage Division to 50 hours by 1 Mar 20. The average size of the Equipage branch is 8 personnel. Each person works 7.1 hours per day. Thus, 50 hours is equivalent to one day of full productivity in the Equipage Branch. The scope of this project is the working system at the fabric application branch (FABAPP01) facility and ends when the workers on the floor submit that the job is complete. Due to the changes that will be made, the business impact that the LSS team plans to have on Tobyhanna is a decrease in manhours devoted to prioritizing work within the list of work orders, the reduction of division overtime payment, and the reduction of non-productive tasks.

The Define phase outlines the problem between the LSS team and the partnering team in order to develop a plan of action to solve the problem. Thus, the problem statement is that the Equipage Division has a significant backlog of service requests due to process errors in logging backlog hours. The delay in service to other work centers impacts Tobyhanna's ability to complete contracted work within the agreed-upon time frames. The goal is to reduce the backlog of the Equipage Division to 50 hours by 1 Mar 20, which would have a business impact of decreasing the overtime pay and reducing the non-value-added work within the system.

4.2 Measure Phase

The measure phase focused on identifying performance criteria (KPI's) and reaching a quantifiable measure plan for the process. The key performance indicators we identified are as follows: Work Hours Assigned, Work Hours Completed, Work Hours Available, Non-Scheduled Work Hours, Backlog Hours and Time spent traveling to Work Centers. Once we compiled and reviewed these parameters, our group began developing a measure plan. Our measure plan focused primarily on the data extrapolation from the Tobyhanna Scheduling program (LMP). The LMP scheduling datasheet contains information for all our KPI's except for travel time, which relied on employee feedback and recording of travel times to various workstations. Based on our evaluation of the process, our key performance indicators were the focus of our statistical analysis regarding the capability and performance of the Tobyhanna Army Depot Equipage Division.

Using the LMP, over a 12-week time period, our team assembled a core group of results. Figures 2 and 3 highlights three aspects of work produced within the Equipage division: Work Hours Completed, Work Hours Available and the number of workers. In evaluating efficiency, it was important for our team to identify the factors influencing the output of the process. The LMP, which serves as the master schedule for the division, is the coordinating source for asset work. The LMP indicates the following important information: Work Hours available, Work Hours assigned, Number of Workers, Work orders completed, and work orders assigned. Analyzing that data, over a twelve-week window, allowed us to compile performance trends, which are illustrated in these figures. Figure 2 highlights the inconsistency in output over the time horizon, which is indicated by the vast range in work hours completed each week. Important to note for this analysis is the number of workdays

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and workers available, which fluctuate depending on the week. Figure 3 highlights the discrepancy in works hours completed versus the work hours available.

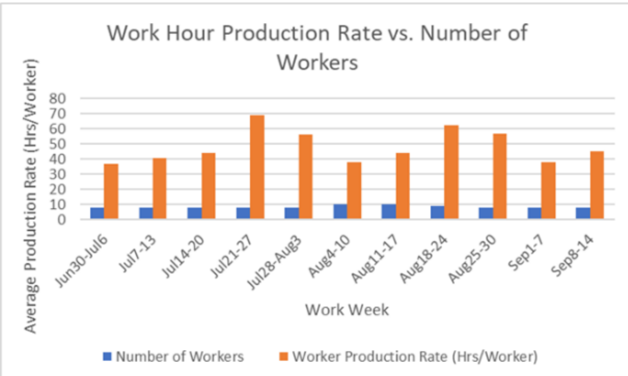

Figure 2. Work Production

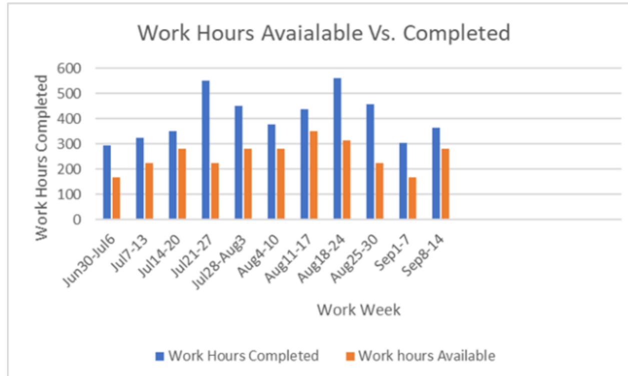

Figure 3. Work Completed

Our analysis showed that the scheduling constraints, based on the estimated time for each work order, force the FABAPP01 Division to exceed their projected weekly available work hours. The gap in completion hours and available hours is largely due to the inclusion of Non-Scheduled work hours, which is defined as work completed that is not on the weekly schedule. Meeting with the Tobyhanna team, the presence of Non-Scheduled work is acknowledged and accepted, but there is no system to monitor the status of Non-Scheduled work if it is not on the weekly schedule. Figures 2 and 3 highlights the worker production rate, which is derived from the work hours completed and the number of workers available. Based on this graph, the worker production rate fluctuates on a weekly basis. Potential root causes for this inconsistency are travel and material aspects that limit the production within FABAPP01. Workers within FABAPP01 travel to various work centers throughout TYAD to complete fabrication work orders, decreasing their value-added time completing work orders. Often times, workers spend time making unnecessary trips to retrieve materials, as the on-site locations of the asset do not have the necessary material to complete the work orders.

The overall performance assessment of the FABAPP01 process highlighted several factors that identify as root causes for inefficiency. The LMP scheduling system does not actively track the progress of scheduled assets, limiting the availability for workers to execute the assigned work order. Also, there is no system to monitor non-scheduled work, creating a large gap in assigned hours versus completed hours. Lastly, the travel time associated with traveling to various work centers and material resupplies introduces a large portion of nonvalue-added time into the process, decreasing worker efficiency. Based on the measurements of the process, over a twelve-week time horizon, the team's focus for the analyze phase will focus on worker travel time, individual work order efficiency, categorized by material, and assessing strategies to track and update the LMP for asset availability and non-scheduled work.

4.3 Analyze Phase

The purpose of the Analyze phase is to pinpoint and verify causes affecting the key input and output variables tied to project goals (George 2005). This process occurs after the measure phase has been completed as well as a successful tollgate. The analysis phase aims to identify critical factors of a 'good' product or service and the root causes of 'defects' (Brook 2017). After meeting with key stakeholders at Tobyhanna, interviews were conducted to determine root causes of the process error, and prioritization were derived from a multi-vote system. This allowed voters to determine the severity and detectability for the defined causes. Table 1 displays the major root causes for the process inefficiencies creating the backlog hours. For the Tobyhanna Army Depot Division, our primary form of quantitative data derives from their LMP macro-enabled excel sheets that help track work order status. Information includes work order assigned/completion dates, asset type, and latest finish date.

Table 1. Multi-vote Results

1.	Parallel Sequences are not being scheduled
2.	Lack of Training
3.	Not Inputting Completions after walking to and from buildings
4.	Bad response to requests for information regarding work orders
5.	BOMs (material requests) that are incorrect
6.	Inconsistencies in schedule readjustment

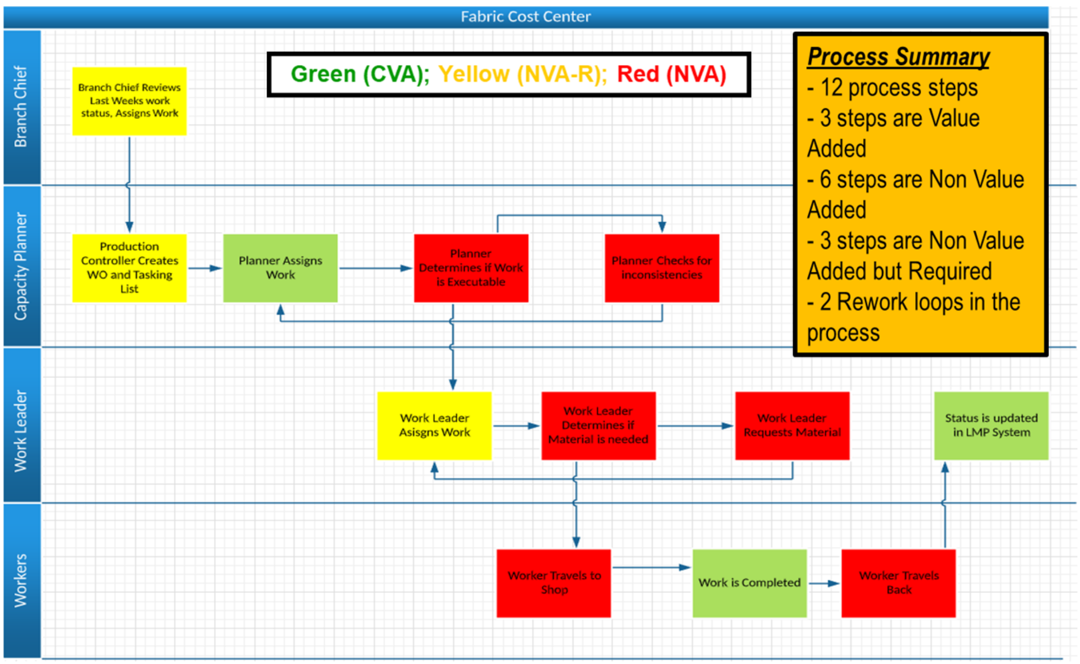

Figure 4. Process Map with Value-Add Analysis

Figure 4 depicts the starting and finish points of the process as well as the tasks along the process to identify areas for improvement in the process. This is crucial to the analysis phase as the diagram helps break down the process to determine which step adds value from the product of the fabric cost center. The process includes 12 process steps with 3 that added value, 6 steps that did not add value, and 3 steps that were required but did not add overall value to the process. Within the swim lane chart, there were 2 rework loops in the process that had to be repeated if it did not meet the conditions necessary for the process to continue. From here, specific points in the process determine can be identified that lead to backlog hour accumulation.

The statistical analysis of the root causes that are creating a backlog within the fabric application branch and taking into account that FABAPP01 maintained a procedure for working on backlog tasks through overtime used on Saturday; We included Saturdays in our analysis in order to determine how much overtime was used within a three-month period from our obtained LMP data. We determined that overtime hours are required in order to keep up with the growing list of backlog hours. We then aimed to look towards what was the cause of the backlog increase. Using the chi-squared statistical test, we saw that if work orders were started late, they were most likely going to be finished late and increase the number of backlog hours.

Figure 5 presents the Pareto analysis completed on the general tasks to see if there were specific general tasks that contributed to most of the late completions and backlogs in the Fabric Cost Center. The Pareto analysis determined that that the operations “apply foam”, “install gasket”, “anti-skid”, and “miscellaneous” contributed to 80% of the backlog. As the data was not normal, the Moods Median test checked the medians of each operation against one another to determine if one operation contributed more to the overall delay. The resulting p-value, 0.056, indicates that there is a statistical difference in operations. As a result, specific operations highlighted in the Pareto chart contributed to the backlog hours in comparison to others. Like the general operations analysis, Figure 6 displays the Pareto chart used to analyze the hypothesis that there is a difference for assets. The Pareto chart does not display convincing results and the Kruskal-Wallis test compares medians of the late days regarding each asset. The test resulted in a p-value greater than 0.05 which failed to reject the null hypothesis so there is no statistical difference of medians of days late with assets. As a result, we've analyzed that the backlog hours build up can be resolved by implementing solutions that assist workers in preventing scheduling errors and identifying what "backlog" represents.

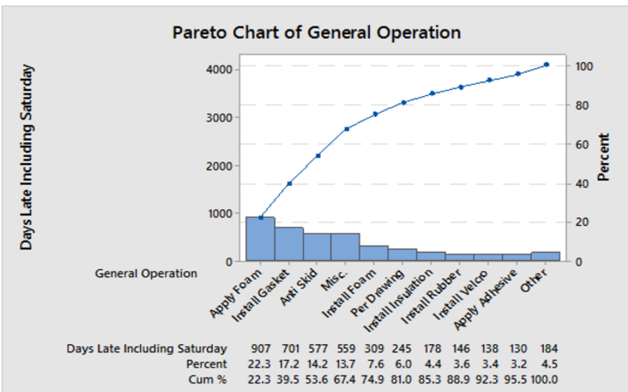

Figure 5. Pareto Chart of General Operations

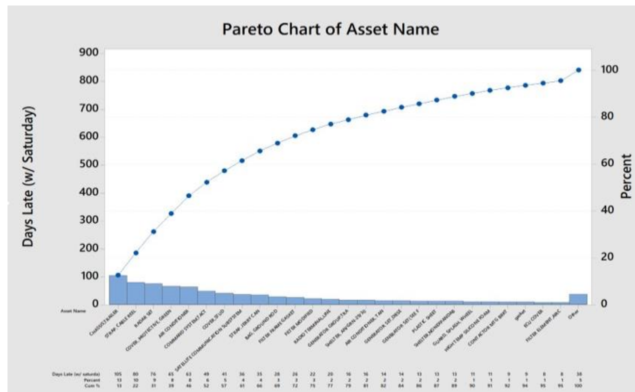

Figure 6. Pareto Chart of Assets Completed

5. Conclusion

Throughout the DMAIC process, the team was challenged with managing the improvement of Tobyhanna's Fabric Application Branch in a manner that allowed the reduction of backlog hours, as well as improved standardization and organization efforts for future reductions. The LSS team's application methods of Lean Six Sigma to approach this problem helped to discern the inefficiencies in the work system that gave rise to the major delays within the equipage division and to reduce the backlog within the equipage branch. In the Define phase the LSS team along with the sponsors, and the stakeholders created the goals, targets, and estimated finances for the project. The project team, stakeholders and sponsors reviewed the define phase to validate its scope and charter, setting the precedent for the rest of the project. Within the measure phase, the teams focused on identifying KPI's and reaching a quantifiable measure plan for the process. Once the KPI's were compiled and reviewed these parameters, The LSS team began to develop a measurement plan focused primarily on the data extrapolation from the Tobyhanna Scheduling program (LMP). Based on our evaluation of the process, our key performance indicators were the focus of our statistical analysis regarding the capability and performance of the Tobyhanna Army Depot Equipage Division. The Analysis analyzes the causes of the flaws in the process. Through time analysis, value-added analysis, value stream mapping, charts (histograms, Pareto charts, box plots), cause and effect diagrams, and root cause analysis, the LSS team was able to deduce all root causes.

The next step for the LSS team will be the implementation of the improve phase, to bring the LSS team along with project sponsors, and stakeholders, together to identify possible solutions that will answer the problem statement in the project charter. The main goal of the Improve phase is to develop, select and implement the best solutions while monitoring risks in a controlled manner. Initial estimates of the process indicate that the Fabric Application branch's backlog requires 20,576 hours of overtime to complete their assigned tasks. An anticipated 50% reduction in backlog will potentially save Tobyhanna $370,000 per year.

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