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Effectively Using Lean Six Sigma and the DMAIC Methodology for Process/System Improvement for Tobyhanna's Joint Node Network

Rylie Fry, Daniel Haider, Kraig Hamilton, Carter Macias, Jalen Moy, and James Enos

Department of Systems Engineering
United States Military Academy
West Point, NY 10996

Corresponding author's Email: rylie.fry@westpoint.edu

Authors Note: Cadet Rylie Fry, Cadet Daniel Haider, Cadet Kraig Hamilton, Cadet Carter Macias, and Cadet Jalen Moy are currently Firstie (Senior) Cadets at the United States Military Academy (USMA) at West Point. A thank you to Colonel James Enos in the Department of Systems Engineering and the team at Tobyhanna Army Depot (TYAD) for their guidance.

Abstract: In today's fast-paced corporate world, there is nothing more detrimental to a company's operations more than inefficient processes or systems. It is these inefficient processes and systems that can cause a business or company to lose money, time, and numerous other valuable resources. Lean Six Sigma and the DMAIC methodology are key tools that businesses and companies can leverage to improve their processes/systems to become a more efficient enterprise and gain a competitive advantage in today's world. All phases (Define, Measure, Analyze, Improve, and Control) are critical to the success of the process improvement program that is Lean Six Sigma and, subsequently, the DMAIC methodology.

Keywords: Lean Six Sigma, DMAIC

1. Introduction

Lean Six Sigma (LSS) and the DMAIC methodology are powerful tools used by businesses and companies around the world to improve inefficient or wasteful processes. By using these tools to their advantage, businesses and companies can better use their resources to become more efficient and therefore more productive, allowing them to thrive in today's competitive corporate world. The DMAIC process is comprised of five individual phases, each to be completed in order. The first is the Define phase, where the problem is identified, and the scope of the issue is determined. The second is the Measure phases, where key metrics are measured, and the business or company can get a better feel for the magnitude of the potential problem. The third is the Analyze phase, where the previously mentioned key metrics are analyzed and root causes are determined. The fourth is the Improve phase, where candidate solutions are developed and subsequently the best solutions are implemented. The fifth is the Control phase, where ways to sustain the implemented solutions are developed and subsequently implemented into the enterprise's course of action.

Tobyhanna first served the country as a field artillery camp, which later transitioned over to a prisoner of war camp in World War 2 (Tobyhanna Army Depot In-depth Overview, 2022). Tobyhanna Army Depot (TYAD) is the leader of the Department of Defense's full-service electronics system. The mission "is total sustainment, including design, manufacture, repair and overhaul of hundreds of electronic systems" (Tobyhanna Army Depot In-depth Overview, 2022). Tobyhanna has a process that includes receiving, repairing, and then returning the poor parts. One of the processes includes the workings of the Joint Network Node. The Joint Network Node system is a communications system for remote, satellite-based communication. For the Joint Network Node (JNN) process, Tobyhanna receives damaged JNNs where the company will first disassemble, inventory, and evaluate the JNNs. After, the engineers will work on the LRU processing, the wire check, rack mechanical, and software. Once the JNN passes the quality control for LRU processing, it does a final testing before it is returned to the owner.

2. Literature Review

As previously mentioned, Lean Six Sigma is an incredibly powerful tool that businesses and companies use to improve any process that is not operating as efficiently as it could be. Throughout the Lean Six Sigma process, effective communication is critical to the success of the process improvement program. Any Lean Six Sigma program is reliant on the effective communication between team members and the business or company that the team members are supporting. If there is a lack of communication during any point of the process, inefficiencies may be overlooked and therefore not fixed during the Improve phase. In an increasingly "transactional" corporate world, maximizing efficiency and communication within the Lean Six Sigma program is critical to the success of the program (Antony, Bhuller, Kumar, Mendibil, & Montgomery, 2012). Without a plan in place to effectively implement the Lean Six Sigma program, there will be little chance of success to improve the process or system that needs remediation.

2.1 Define Phase

The first phase of the DMAIC process is the define phase. The define phase, arguably the most important phase, sets up the project for success. If the define phase is worked through incorrectly, there is a chance that the incorrect work may jeopardize the future success of the project. Momentous steps in the define phase include communicating with stakeholders, identifying the problem and writing down goals, and cultivating an environment that enables development and growth (George, Rowlands, Price, & Maxey, 2005). These steps, along with others, are the foundation of a successful project because without correct information and the proper prioritization of time spent on the necessary resources, the project may develop inconsistencies that could leak over to the following four phases due to a lack of communication. Ensuring that the project team has properly identified the problem with the problem statement and developed SMART (smart, measurable, attainable, realistic, and timely) goals to solve those problems is crucial for the foundation of the project because it gives the project team a mission. Some other key steps in the define phase include developing a SIPOC (suppliers, Inputs, Process, Outputs, and Customers), flow chart, and fishbone diagram. Ultimately, the stakeholders, charts, and diagrams in the define phase sets up the project for success.

2.2 Measure Phase

The second phase of the DMAIC process is the Measure phase. In this phase, the project team quantifies how the process or system they are investigating is currently performing. Additionally, the magnitude of the problem is addressed. The Measurement phase is critical to the DMAIC process, but the measurement itself throughout the entire project is key because it gives the project team a good idea of where issues are taking place and the overall health of the process. Especially in this phase, the project team has the critical task of determining the quality level the customers or stakeholders are getting from the process or system now. The project team establishes what they have measured and indicates the baseline/current performance of the process before moving on to the Analyze phase (Roth & Franchetti, 2010).

The purpose of the Measure phase is to thoroughly understand the current state of the process or system that is being investigated and collect relevant data on the current process/system speed, quality, and costs. These key metrics will be used to expose the underlying causes of the inefficiencies/issues/problems that the process or system is experiencing (George, Rowlands, Price, & Maxey, 2005).

The utilized deliverables for this phase were a fully developed current-state Value Stream Map (VSM); reliable data on critical inputs (Xs) and critical outputs (Ys) to be used for analyzing defects, variation, process/system flow, and speed; baseline measures of process/system capability, including process/system Sigma quality level and lead time; and a capable measurement system.

2.3 Analyze Phase

The third phase of Six Sigma DMAIC is the analyze phase. While the define phase states the problem, the measure phase collates data and uses it to measure performance of the process, the analyze phase begins the statistical study of data variation. (Six Sigma DMAIC - Analyze Phase, 2021) After completing the measure phase of the DMAIC process, project teams will have a clear idea of the project statement. We use this project statement to initialize the next phase of the DMAIC process: the analyze phase. Within this phase we are aiming to identify the potential root causes of the problem and arrive at the actual root cause of the project's issues. Completing the measure phase is the first step to having a successful analyze phase because we are going to use the data from the measure phase to identify the probable causes of the problem.

Some goals of the analyze phase are to identify the actual root cause using many techniques, find the critical root cause that has the highest impact on the process, and to verify the root causes using appropriate statistical tools and techniques, for example hypothesis testing. This phase can also review variation to determine which are significant contributors to the output. (Analyze, 2021)

2.4 Improve Phase

The purpose of the improve is "to learn from pilots of the selected solutions and execute full scale implementation."(Drohomeretski, 2014) According to the Lean Six Sigma Pocket Tool Book , the steps for the improve phase are " generate potential solutions, select and prioritize solutions, access the risks , and pilot and implement." (George, 2005).

Like the measure and the analysis phase, the improve phase is centered around the statistics of the project. The aspect that distinguishes the improve phase is that it involves the generation and implementation of a solution. The common pitfall individuals fall in is that they view their success in the improve phase on how well they implemented the solution. Although this is not what should be valued, the improvement of the process measurements is the success metric of the improve phase.

2.5 Control Phase

The control phase is where the sustenance of the gains from the previous phases is achieved through statistical, analytical, and engineering techniques. The most necessary tool used in this phase is the control chart (Goh & Xie, 2003). Ultimately, this phase's purpose is to complete the project and hand off the improved process to the owner of the process, with standardized procedures for maintaining gains (Saravanan, Mahadevan, Suratkar, & Gijo, 2012)

The first step in this phase is documenting the improvements that were made from the improve phase. This comes from an updated process map, a user guide to accompany that process map that explains the steps and rationale of new process, and finally, ensuring that everyone involved in the new process receives proper training on it (DMAIC, 2015). The gate review checklist contains three things that signify success. One, full scale implementation of the project; data charts and other before/after visuals are in line with project charter. Two, documentation of the measures and procedures. Three, the project has been effectively handed over with all actions done accordingly, summary of lessons learned throughout the project, list of issues/opportunities for future projects, and lastly, celebrating the hard work of the team.

3. Methods/Results

3.1. Define

In the Define Phase, using the information provided by Tobyhanna, the process was outlined, and the scope of the problem was limited to JNNs. The SIPOC map,

Figure 1, explicitly illustrates the characteristics of the process as well as the metrics that the project team will use for the rest of the methodology. The main parts of the SIPOC map are the metrics and voice of the customer and voice of the business. The goal of the project is to reduce the scheduled repair cycle time (RCT) and the planned labor hours. The metrics for repair cycle time and planned labor hours are days and hours respectively. Because satisfying customers is the goal for any business, some factors regarding customers included funding decisions, long lead time, and providing TYAD work. Tobyhanna was far over the desired RCT and planned labor hours of 150 days and 43 hours respectively. There were also external factors such as CHS, which forced Tobyhanna to wait before continuing work on relevant LRUs.

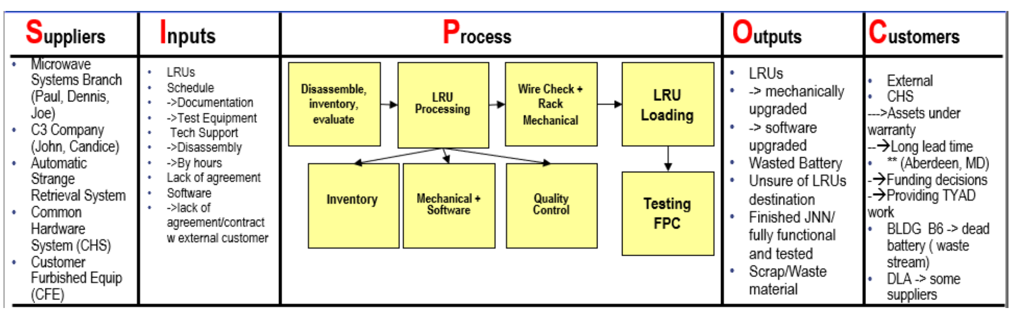

Figure 1. SIPOC Map

The LRU process had four major distinct areas: Disassemble, inventory, and evaluate; LRU processing; and Testing. When LRUs arrive at Tobyhanna, they first are disassembled, inventoried, and evaluated. Then, the LRU moves to LRU processing, where wire check and rack mechanical occurs. In this part of the process, sometimes batteries and other parts must be exchanged. If the batteries are damaged and not under warranty, then the LRU will be sent to CHS. If the parts are not under warranty, then it is up to the customer to decide the fate of the LRU. If all parts are properly working, then the LRU is sent to software checks to ensure the software is up to date. If not up to date, then Tobyhanna must call IT to fix the software issues for the LRU. After software is up to date, then the LRU proceeds to quality control where if it passes, then it moves to testing the LRU. Testing the LRUs either works, or it does not. If it fails, then the LRU is sent to LRU processing to proceed with the same steps. If it passes, the LRU is discharged to the customer.

3.2 Measure

The Value Stream Map (VSM) shows the average standard Direct Labor Hours (DLH), average actual DLH, average actual Repair Cycle Time (RCT), and average wait time for each major component of the process. The bottom line is that the process is currently operating at 39.20% efficiency, which is less than acceptable for Tobyhanna.

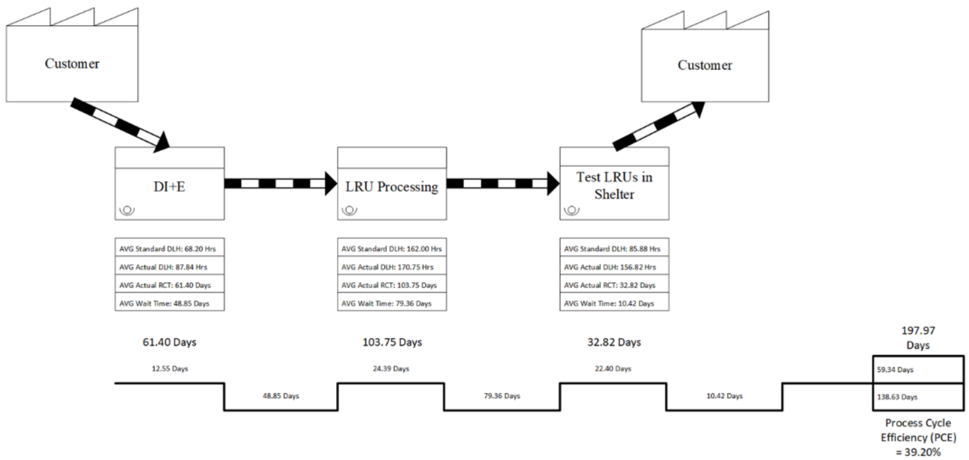

Figure 2. Value Stream Map

The Process Capability Report for overrun hours (bottom left) shows that the process is not capable, as the mean of overrun hours is above the upper spec limit. Specifically, we set an upper spec limit of 24 overrun hours, which is a reduction of 50% from the current median value of 48 hours. The Process Capability Report for RCT percentage (bottom right) shows that the process does not follow a normal distribution. A distribution identification test determined that the overrun hours followed an exponential distribution and the RCT percentage followed a lognormal distribution. RCT percentage is defined as the actual RCT divided by the standard RCT (in days) for each major component in the process, as derived from the VSM. The current process has a lognormal distribution with a p-value less than 0.05. The range for RCT percentage is 7,869.75%. The median RCT percentage per system is 258.12%. This is greater than the Customer Target of 230%. 230% equates to 150 workdays.

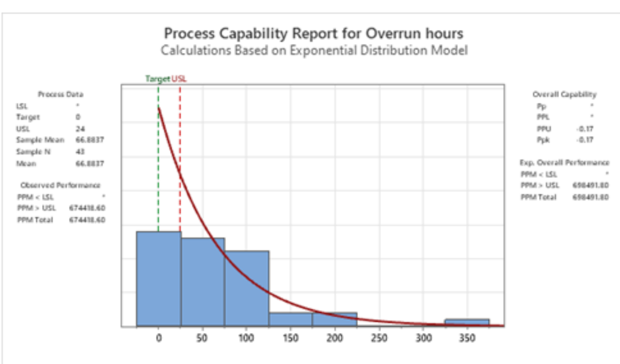

Figure 3. Process Capability Report - Overrun Hours

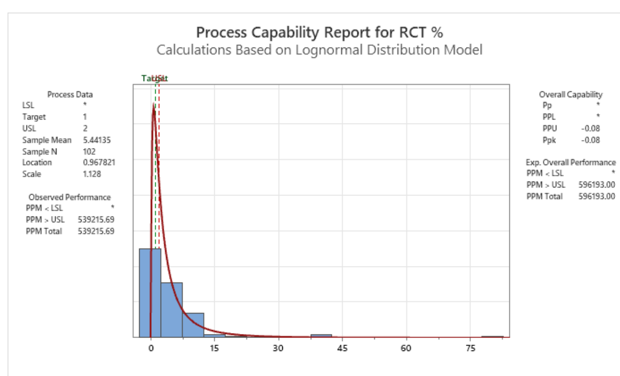

Figure 4. Process Capability Report - RCT %

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3.3 Analyze

The fishbone diagram is a cause-and-effect tool that begins with a problem statement at the "head" of the fish. Building off the head are "bones" that indicate possible causes of the issues. These possible causes are divided into six different categories known as the 6Ms: manpower, method, machine, material, measure, and mother nature. The fishbone diagram will identify the main focuses for the process. They are numbered within the fishbone diagram and will be the key tasks to change.

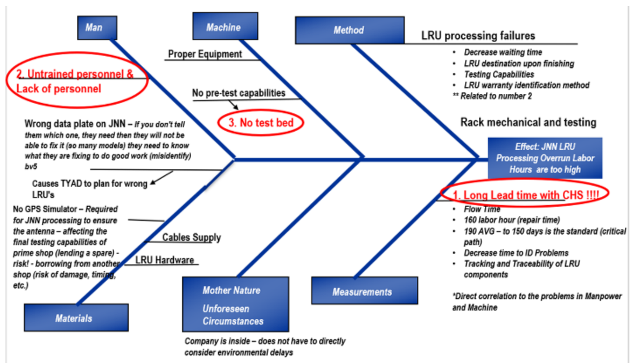

Figure 5. Fishbone Diagram

Graphical analysis is one way used during the analyze phase of Six Sigma DMAIC. It is effective in visualizing data patterns and providing key insights into the variation and distributions of the data. In most projects, teams deal with large amounts of data that cannot easily convey the desired information. It is recommended that data is broken down, grouped, and placed into visual plots to easily convey the information to the stakeholders of the project. (Taghizadegan, 2006) One example used in our project is a pareto chart that directly compares different aspects causing issues in the process.

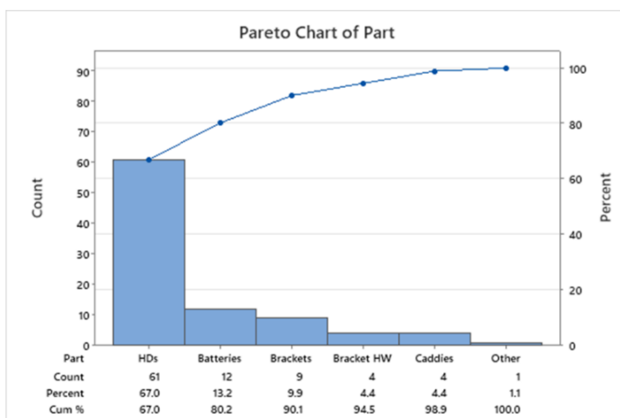

Figure 6. Pareto Chart of Part

3.4 Improve

The FMEA is conducted by first identifying potential failures and effects, this is used to analyze functional requirements and their effects to identify all failure modes. The FMEA lists all failure modes per function in technical terms, considering the ultimate effect of each failure. The next step is to determine the severity of each project step and the failure modes that are associated with it. Severity is the seriousness of failure consequences of failure effects. Usual severity is measured on a scale from one (lowest) to ten (highest). (Software, 2016) Our FMEA calculates a value, the risk priority number (RPN), that will rank the process steps in order of importance.

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FMEA was first developed during the analysis phase where the process was evaluated which determined the processes that needed the most attention. Once we established the three areas (no test bed, wrong data plate on JNN, and LRU processing failures) we were going to address, we addressed the actions recommend handling the problems, the individual/s responsible for the improvement, and solution implemented. Once the solution is implemented the severity, occurrence, and action taken are all assessed again and a new RPN is given. In our project, we were able to lower the RPN of three of our problems to under 30.

Process Step / Input What is the process step and input under investigation?	Potential Failure Mode In what ways does the Key Input go wrong?	Potential Failure Effects What is the impact on the Key Output Variables (Customer Requirements)?	SEVERITY	Potential Causes What causes the Key Input to go wrong?	OCCURRENCE	Current Controls What are the existing controls and procedures (inspection and test) that prevent either the cause or the Failure Mode?	DETECTION	RPN	Actions Recommended What are the actions for reducing the occurrence of the cause, or improving detection?	Resp. Who is responsible for the actions taken	Actions Taken What are the completed actions taken with the recalculated RPN?	SEVERITY	OCCURRENCE	DETECTION	RPN
Long Lead Time with CHS	LRUs that need to be fixed are not returned quickly	Excessive time to return the LRU (160 labor hours and 190 day average)	8	Out of warranty items (requiring repair capabilities), issues with warranty identification, a 160 labor hour repair time, a 190 day critical path	7	There is not a sufficient warranty identification for the LRUs or the personnel to prevent the excessive labor time	8	448	Work with program office to provide line repair capbilites and line replaceable units	Production management	N/A	8	7	8	448
Untrained Personnel & Lack of Personnel	Cannot train the personnel correctly, but there aren't enough people to train	Correlates to the long labor repair times and long wait times	7	Workers are not getting proper training and there are not enough workers	7	Tests are completed to ensure personnel is trained, but this is a time consuming process and there are not enough workers to ensure a continuous system	2	98	Hire more people and have more annual training	Work supervisor	N/A	7	7	2	98
No Test Bed	Failure to identify issues in the process	Lack of identification in processing failures causes future problems in the rack mechanical and testing	7	No Pretesting Capabilities so issues are not identified	7	There are no existing controls on the procedure	8	392	Develop testing capabilites by creating SIPR and TIRP test beds	Work Center	Aquire the test material	7	2	2	28
Wrong Data Plate on JNN	Misidentification of plate	Misidentifying the LRUs and returning the wrong software in upgrades	6	Improper communication regarding JNN models	6	There are no existing controls on the procedure other than correct communication	5	180	Verify the data plate	Engineers	Engineers verfies model of JNN during DI&E	6	1	1	6
LRU Processing Failures	LRUs placed in the system are failing at critical testing times, no pretesting capabilities prevents identification during uprading	Failure in the Rack Mechanical/Testing and an increase in waiting time	6	No pretesting capabilities and the lack of trained personnel	6	No existing controls for LRU testing failure	10	360	Create a testing bed for the LRUs	Work Center	Developed a test bed	6	1	2	12

Figure 7. Failure Mode and Effects Analysis (FMEA) Chart

4. Conclusion

Lean Six Sigma and the DMAIC methodology are incredibly effective process/system improvement tools that businesses and companies can use to identify inefficiencies within the organization make said processes/systems better. Once these inefficiencies are uncovered, a business or company is then able to fix the inefficiencies, therefore improving the process or system that had the problems (50MINUTES, 2015). Once a business or company recognizes how effective a process improvement program like Lean Six Sigma can be, it leaves them longing for more. As it stands to reason, Lean Six Sigma has been a critical part of today's corporate world for many years (Taghizadegan, 2006).

Looking forward, the next phase we will execute the control phase of the project. In this phase we can expect to build a plan for the Tobyhanna group to carry forward the things we've put in place during the improve phase, as well as document and monitor the process. We will do so with control charts, SOP development, lessons learned, and a new/final process map. Visuals and training will also be recommended/carried out during this time to make sure everyone is on board with the new processes.

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