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**Six Sigma Principles for Process Improvement – Technical
Report**

Quality & Business Improvement ACMA4004

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Table of Contents

1	Introduction	1
1.1	Aims	1
1.2	Objectives	1
2	Main Body	2
2.1	Define Phase	2
2.1.1	SIPOC Mapping	2
2.2	Measure Phase	3
2.2.1	Pareto Charts	4
2.3	Analyse Phase	5
2.3.1	Cause and Effects Diagram	5
2.3.2	The 5 Whys	6
2.4	Improve Phase	7
2.4.1	5S	7
2.4.2	Just In Time (JIT)	8
2.4.3	Poka-Yoke	8
2.5	Control Phase	9
2.5.1	Failure Modes and Effects Analysis (FMEA)	9
3	Conclusions and Final Recommendations	10
4	References	11
5	Appendices	Error! Bookmark not defined.

Figure 1 Example of SIPOC Diagram template (Stanke Bob, 2014)	3
Figure 2 Example of a Pareto Chart that PESC could use.	4
Figure 3 Example of a Cause and Effects Diagram (GoLeanSixSigma, 2012)	6
Figure 4 Poka-Yoke example clearly showing a user which way to insert a plug into a socket (Subhash Kumar, 2016).....	8
Figure 5 FMEA Column Titles produced by Diamond Centre of Wales Ltd CAD Department	9

1 Introduction

1.1 Aims

Precision Electronic Solutions Cymru (PESC) are a manufacturing company who supply electronic components to many large OEM companies. They are currently experiencing a high defect rate which has led to an increase in costs and customer complaints.

This technical report aims to give the reader knowledge of how the use of Six Sigma Principles, specifically the Define Measure Analyse Improve Control (DMAIC) framework, to improve the manufacturing process at PESC.

1.2 Objectives

The objectives of this report are to show the reader how DMAIC can significantly improve the manufacturing process at not just PESC, but all manufacturing companies.

The reader should be able to successfully implement DMAIC at their own place of work for the improvement of processes, applying a range of tools such as process control charts, root cause analysis etc.

2 Main Body

2.1 Define Phase

PESC use a batch processing methodology in the manufacturing of electronic components to supply to large OEM companies. The company has a high defect rate which has resulted in complaints from customers and an increase in costs. PESC uses a conventional production planning strategy which is based around monthly forecasting and weekly scheduling. They hold a significant number of raw materials, work-in-progress (WIP) and finished goods inventory to help cope with product demand. The company is forced to use compulsory overtime for employees and use sub-contractors to cope with the demand variation.

The above problem statement clearly identifies that PESC should examine their process to define why they are receiving customer complaints and suffering from an increase in costs. They need to examine their products from a customer's perspective. There are plenty of tools in the DMAIC framework that could help them to define the problems which are arising, such as SIPOC Mapping, Kano Model, Project Charter, CQT Trees and Process Flow Charts.

2.1.1 SIPOC Mapping

SIPOC Mapping is a tool used by Six Sigma Practitioners which provides a high-level view of a process within a company. It stands for Suppliers, Inputs, Process, Outputs and Customers. SIPOC diagrams are key for improving processes with some benefits including that they provide a simple explanation of how a process works, keeps staff on the same page and provides clarity. **(Asana, 2022)**

The Suppliers column of a SIPOC diagram is where PESC would identify the suppliers of inputs to their process for the manufacturing of the electronic components. The Inputs column is where the inputs provided by the suppliers is examined for quality, quantity and characteristics to highlight their significance in the process. The Process, which is the core element of SIPOC, lists the tasks and interactions which help to create outputs for customers from the inputs. The Outputs are the final product created in the process. Lastly, the Customers are the beneficiaries of the outputs. In this section, the needs and expectations of the customers need to be highlighted as they form the main focus of what the process is trying to achieve. **(Ogunkoya Oluwatosin, 2023)**

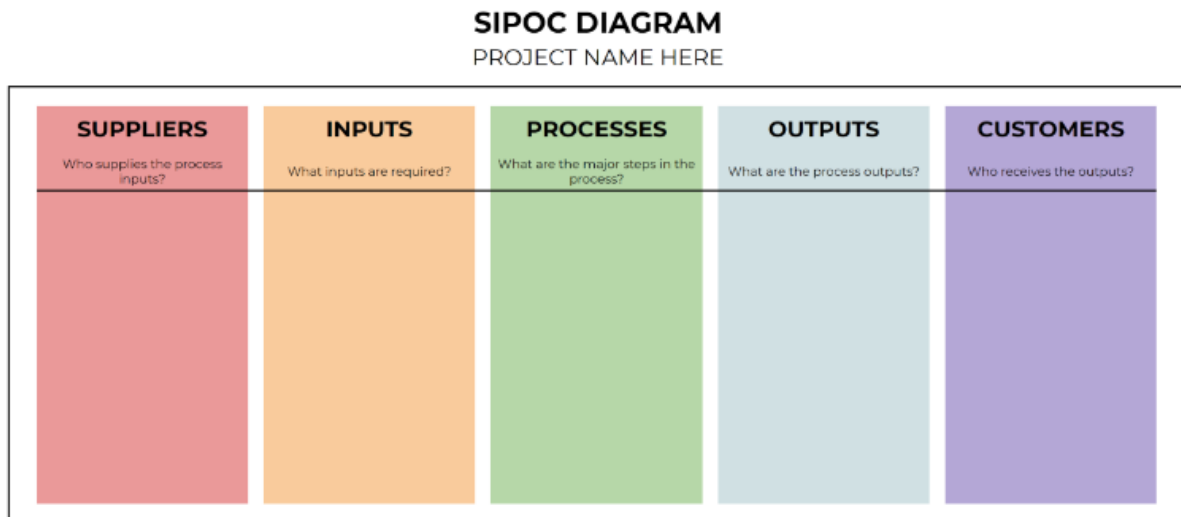


Figure 1 Example of SIPOC Diagram template (Stanke Bob, 2014)

2.2 Measure Phase

After the completion of the Define Phase, PESC need to implement the Measure Phase of DMAIC. PESC needs to identify and describe the key performance metrics to assess their current performance of their process. One-way PESC can do this for their current process is by firstly conducting process mapping. There are several different types of process mapping which include high-level process map, a detailed process map and a deployment process map. A high-level process map should contain only the main stages of a process. PESC's high-level map would have the following stages in order: Metalizing, Capping, Resistance Spot Welding, Spiralling, Coating, Printing, Quality Control and Counting & Packaging. Once this is a completed, each of the main stages identified in the high-level process map can be decomposed using a detailed process map. A detailed process map helps to identify decisions, reworks and bottleneck situations whilst also helping to display key performance indicators (KPI's). It is vital to be very thorough with the detail as this type of map shows exactly what is happening in the present time. (Richard Chua, 2018)

Value Stream Mapping is a powerful tool which PESC could use to improve their processes. Value Stream Mapping is a lean manufacturing technique used by Six Sigma Practitioners that analyses, designs and manages the flow of materials and/or information which is essential in bringing a product to a customer. It is a critical part of a business as it helps to reduce or eliminate waste, whilst identifying the root cause of the waste or Muda as it is known by the Japanese. PESC holds a high volume of inventory which many lean manufacturing experts would class as Muda. (Mukherjee Juni, 2019)

“One of the most important goals of lean manufacturing is the elimination of waste. Taiichi Ohno, father of the Toyota Production System (TPS), defined three categories of waste: Mura, Muri, and Muda. While Muda is the most widely known, muri and mura are equally important to understand.” **(Catarina Martins, 2023)** There are different forms of Muda, which some apply to PESC. These forms are waste in overproduction, waste of waiting between segments of the process, waste of transportation, waste of processing, waste of inventory, waste of movement and waste of defective products. **(Adam Henshall, 2018)**

There are many tools helpful for measuring data in the Measure Phase of DMAIC. These include the 7 basic quality tools, Machine & Process Capability Studies, Measurement System Analysis (MSA) and Control Charts. Pareto Charts are extremely effective in the Measure Phase.

2.2.1 Pareto Charts

A Pareto Chart is useful for measuring data in broader terms, rather than delving into detail during the Measure Phase. The Analyse Phase will delve into deeper detail. The chart contains bars and lines where individual values are shown in descending order by the bars, and the cumulative total is represented by a curved line. Below is an example of a Pareto Chart that an employee could create to measure defects in certain parts of the process at PESC. Please note that the figures are fictional for this example. **(Clinical Excellence Commission, date unknown)**

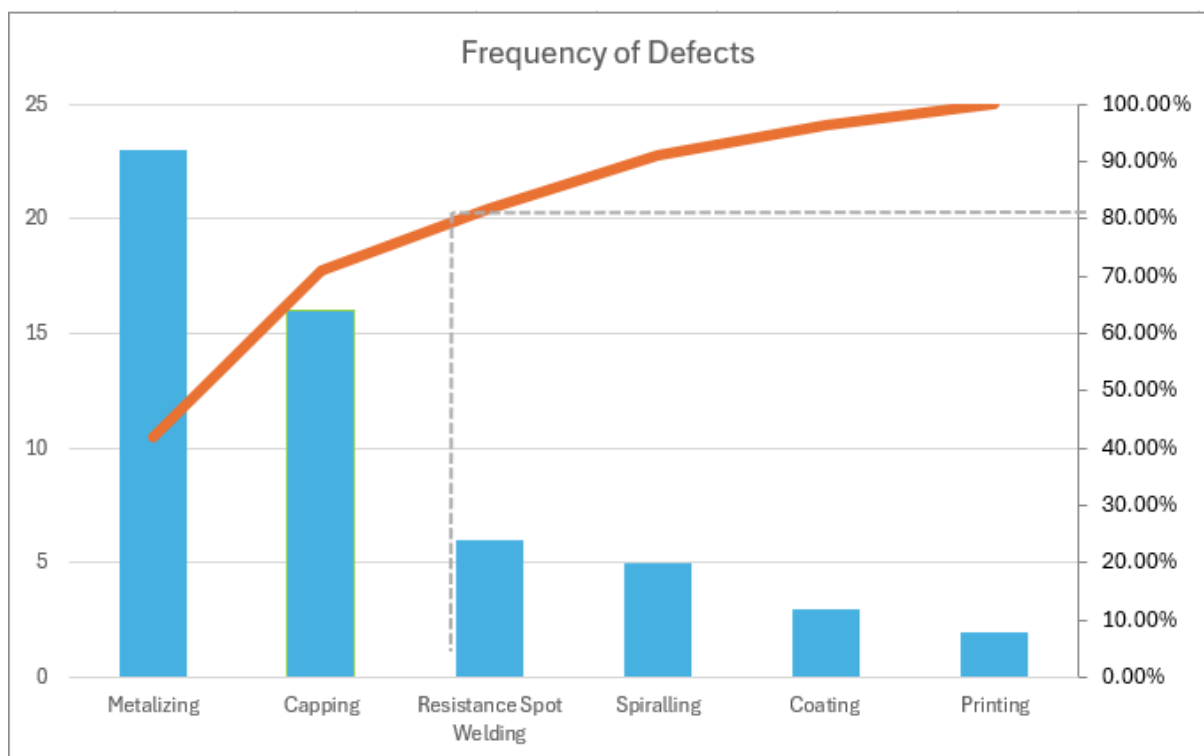


Figure 2 Example of a Pareto Chart that PESC could use.

In the fictional Pareto Chart seen in Figure 2, you can see the bars represent each stage of the process where defects could occur. The red line indicates the cumulative total. The grey dotted line is a marker for where 80% of the defects have occurred on the cumulative total line. The bars to the left of this line, are what is known as the 'vital few' and the bars to the right of this are known as the 'trivial many'. The Pareto Principle or the 80/20 rule as it is commonly known, states that 80% of outcomes are because of 20% of causes. The use of the Pareto Chart would allow PESC to focus on the root cause of the bulk of their defects. **(Carla Tardi, 2022)**

2.3 Analyse Phase

Following on from the Measure Phase is the Analyse Phase. In this phase, PESC would need to analyse the data collected in the Measure Phase to identify the root causes of the problems they are facing. For example, using the Value Stream Map (VSM) created in the last phase, PESC would then go on to do Value Stream Analysis (VSA). This involves analysing the data collected in the VSM to identify sources of Muda, inefficiency and unnecessary costs during processes. **(Jose Pedroto, 2023)** Analysis of a VSM would thoroughly look at things like the Takt Time vs Cycle Time, wait times and WIP, the added value of each part of the process, process metrics like defect rates and timeline totals. **(Plutora 2019)**

Takt Time is the rate in which PESC must produce products to satisfy demand. Cycle Time is the time it takes to produce the product. Ideally a process's Cycle Time should be quicker than the Takt Time. If PESC's Cycle Time is slower than the Takt Time, then they need to identify which parts of the process are slowing it down. Similarly, with process metrics – PESC need to analyse which parts of the process are having higher defect rates than others by in-depth analysis. Tools used to identify root causes at this phase of DMAIC include 5 Whys, Scatter Plots, Cause and Effects Analysis, Hypothesis Testing, FMEA and many more.

2.3.1 Cause and Effects Diagram

Cause and Effects Diagrams, also known as Fishbone Diagrams or Ishikawa Diagrams are diagrams which organise theories about root causes into a visual graphic. The effect is placed at the end of the diagram, with branches leading to it which form the skeleton. On these branches are potential causes split into different categories. If PESC were to use the fictional Pareto Chart created in 2.2.1 in this report, they would focus on the Metalizing and the Capping in their Cause and Effects Diagram. **(Juran, 2018)** They would create a different one for both Metalizing and Capping. For example, Metalizing Defects would be at the head of the diagram, with branches leading off that would have various sub-headings like 'Electronic Failure', 'User Error' etc. These sub-headings would have smaller

branches coming off their branch with more in-depth causes. For example, coming off the User Error branch it could say something like 'Lack of Training'.



Figure 3 Example of a Cause and Effects Diagram (GoLeanSixSigma, 2012)

2.3.2 The 5 Whys

After the Cause and Effects Diagram has been created, the members involved in finding the root causes of problems at PESCC, will vote on what they believe is the most likely cause of the problems arising. The potential causes with the most votes will be chosen to have more in-depth analysis.

(DiLeo Michael, 2024)

Once the decision on the most likely potential causes has been made, PESC could use a tool called the 5 Whys to further analyse the potential causes. The team at PESC that performed the Cause and Effects Analysis, would then use the 5 Whys to decipher the causes posed by the potential problems highlighted. For example, if they voted that ‘Electronic Failure’ was one of the more likely causes of defects – a facilitator would ask something like ‘Why was the voltage not at the required amount?’ in which the rest of the team would come up with an answer. This should be repeated at least 5 times for the selected potential causes. The facilitator should then help to come up with solutions, which will be at the Improve Phase of DMAIC. **(Wesley Chai, 2020)**

2.4 Improve Phase

In the Improve Phase, PESC need to implement strategies to reduce defects in their manufacturing process, focusing on the root causes they procured in the Analysis Phase. There are an array of strategies that can be used to improve processes such as Poka-Yoke, FMEA, 5S, Kaizen and Pugh Matrix.

2.4.1 5S

The 5S principle is a Japanese concept that essentially means that having a tidy and clean workspace allows workers to perform tasks efficiently without wasting time on decluttering etc. The 5S are as follows:

Seiri = Sort

Seiton = Set in Order

Seiso = Shine

Seiketsu = Standardise

Shitsuke = Sustain

The 5S is a vital part of Lean Manufacturing and if embedded into an organisation, will improve the efficiency by keeping the workplace tidy and removing all Muda. The Seiri part of 5S means to sort items/tools into areas of the workspace that they are needed. Also, sort items that may be needed into their own area – these will be monitored, and after a while, if there is no use over a long period of time then they will be moved into the not needed area. The items not needed get removed from the organisation.

The Seiton of 5S is to set in order the items and tools in an organised fashion, making easy access for regularly used tools for example. A company like PESC for example, should use cupboards or containers for items which can be grouped to make it easy for them to locate necessary tools.

Seiso is essentially ensuring the work area is kept looking aesthetically pleasing, including all equipment used. Having a workspace that is neat and clean gives workers pride in the place that they operate and is believed to improve employee performance.

Seiketsu means to standardise. Standardising is the bridge between Seiketsu and Shitsuke – at this stage of 5S it is important to make documents on how to commit to the first 3 S' named above.

Shitsuke is to sustain all the work done in the first 4 S' by creating a cleaning schedule and ensuring all employees are trained on the 5S' to ensure working environment standards are to a high level. If PESC were to implement 5S' to their organisation, significant improvements would be visible in each department and less defects would occur. **(LeanProduction, 2024)**

2.4.2 Just In Time (JIT)

As stated in the initial problem statement in this report, PESC hold a lot of excess inventory in anticipation of high demand from customers which can lead to a lot of wasted time and money. If they were to implement a JIT philosophy, they would save on costs emphatically. JIT means to provide goods to customers' demand exactly in terms of time, quantity and quality. Rather than holding back up stock in anticipation of peak fluctuations in demand, PESC would have suppliers who can turnaround parts for them rapidly to work to actual customer demand. This would save them from a substantial amount of Muda. **(University of Cambridge, 2016)**

2.4.3 Poka-Yoke

Poka-Yoke is a term created by the Japanese which means 'mistake-proofing'. It means to design a process in such a way that it is almost impossible for human-error to occur. **(Steven Calhoun, 2021)**

For example, in PESC's printing stage of their process where they colour code bands – they could simply have a massive poster clearly visible to operators which shows them exactly which colour to code each item. Poka-Yoke is very simple but extremely effective and can reduce defects significantly.

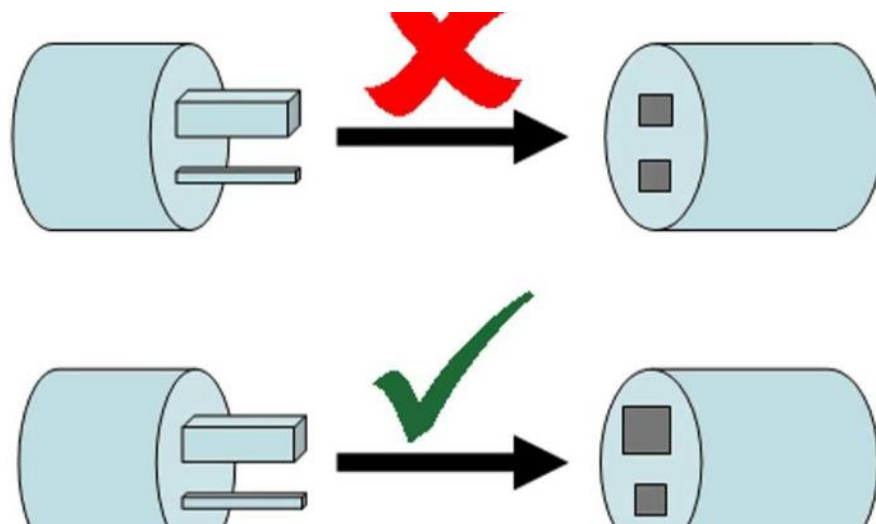


*Figure 4 Poka-Yoke example clearly showing a user which way to insert a plug into a socket
(Subhash Kumar, 2016)*

2.5 Control Phase

Finally, the Control Phase of DMAIC is to implement controls to sustain the improvements made in the last phase. These controls can be as simple as training employees on the new and improved procedures and updating standard operating procedures. There are plenty of tools that PESC could use to ensure that improvements are sustained such as Control Charts, Scorecards, Final FMEAs and Process Capability Studies.

2.5.1 Failure Modes and Effects Analysis (FMEA)

An FMEA is a powerful control measure which is a live document, being updated continuously as processes improve. High members at PESC should create an FMEA document which shows a breakdown of steps in the process, the potential failure modes, the potential effects of failure and the potential causes of the failure. Each step has its own severity, occurrence and detection score applied to it. The use of this live document provides transparency to all employees of the current processes and potential failures that could occur which ensures all staff are vigilant and aware of anything that could go wrong. Keeping this updated as processes improve ensures that everyone at PESC will be on the same wavelength on current procedures. **(American Society for Quality, 2016)**

Process / Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Criticality	Potential Cause(s)/ Mechanism(s) of Failure	Occurrence	Current Controls	Detection	RPN	Recommended Action(s)	Responsibility and Target Completion Date	Ac
												Actions Taken

Figure 5 FMEA Column Titles produced by Diamond Centre of Wales Ltd CAD Department

3 Conclusions and Final Recommendations

The research undertaken in producing this report shows the reader that PESC can apply multiple different tools, techniques and philosophies from the DMAIC Framework to drastically improve their operations which would lead to a significant decrease in costs, a better continuous flow of work processes and more satisfied customers. By applying somewhat simplistic ideas created by Lean Six Sigma experts, an organisation such as PESC can completely transform itself into a highly effective and sustainable place of work.

Final recommendations to PESC would be to train members of staff in Lean Six Sigma to ensure the organisation adheres to Kaizen – which means to change for good. Or hire Lean Six Sigma experts for a faster improved impact.

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