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Dissertation

Independent Project ACMA 6013

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20/05/2024

Summary

Caerbont automotive instruments is a manufacturing company who specialize in creating custom gauges for classic vehicles using discrete manufacturing processes. The aim of the study was to focus more clearly on customer needs, explore ways to increase customer satisfaction and ultimately to increase revenue for the company.

The problem statement suggested that CAI experienced a high number of late deliveries in the previous year 2023. This impacted negatively on potential revenue for the company and decreased customer satisfaction.

The method of process improvement used was DMAIC, which, through research, has proven successful when used for similar problems in manufacturing. Defining what the problem was, within the firm, identified issues with the manufacturing process. This triggered a data collection schedule in order to pinpoint an area within the organization to focus process improvement practices. The data suggested that incorrect parts were responsible for increased manufacturing times and added to the bill of materials created through a material requirement planning system.

The study suggested that copy and pasting over the bill of material was the cause, however through further analysis, it identified that the system was the true root cause of long manufacturing delays and for the disruption within the company.

Improvements were suggested on a short to long-term basis in order to create a permanent solution for the company. The short-term solution was to remove duplication features from the MRP system and implement a process to automatically record common parts, enabling a reduction in the assembly list.

The long-term solution was to introduce lean manufacturing methodology into the company and remove the use of bill of materials. A new project was selected to trial a kanban system and proved to be a faster method to create components. The reason for this was its effect on increasing workflow and control of components needed. During the pilot, when this solution was test, a reduction in the time taken to produce the product was seen and it therefore would ultimately increase profitability for the company.

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Introduction

The implementation of new product design is essential to enable a company to remain competitive in its market, continue to innovate and improve products to meet customer needs and generate an increase in revenue.

Caerbont Automotive Instruments engineer and manufacture instrumentation for motor vehicles in the classic car industry in a low volume setting. They provide products for models such as Austin martin and Singer in their classic instrumentation sets within the vehicle dash interior. The company originated from Smiths Motor Accessories and was the subject of a second buyout in 2011. To satisfy a wider customer base, the engineering section focuses on developing low volume and with high variation of product.

While the company invites new innovated ideas and provides solutions to satisfy the customer needs, the process time and introducing a product to the manufacturing environment can prove challenging. The introduction of products to production lines has resulted in delays including that of having to be revaluated by engineering.

Within CAI, there has been little research or evidence found into why these processes are underperforming and no assessment has been undertaken to improve the company's performance. Consequently, this disruption to the workflow, when manufacturing the product, has caused the company to lose profit.

The aim of the study is to be able to utilise the methods examined in previous studies to implement positive change in the workplace and demonstrate that with correct methodology, A better manufacturing process can aid the growth in the company.

The study focuses on examining the company's procedure when creating vehicle gauges and identifying factors that may cause a delay in creating the product. Secondly, evaluating how severe this problem is to the company and to be able to suggest solutions that could improve the company's processes.

Company Background

Caerbont Automotive Instruments is a privately owned company who have been creating products for the classic car, motorcycle, and marine market for over thirty years. The company is based in Swansea with under fifty members of staff employed.

Manufacturing products can be for notable classic car models such as Austin Martin, Jaguar Land Rover, Porsche 911 and various others. The type of instrumentation offered to customers also has a high range or variations, such as speedometer, tachometer, timeclock and fuel gauge. Many of the products are available in complete instrument clusters for the vehicle dashboard.

Customers can range from independent, for singular vehicles, to low to medium volume manufacturing companies requesting five hundred sets of instruments per year. CAI offers services directly to vehicles such as Caterham (2023) and Singer classic (2023) with planned annual volume. Services can include manufacturing specific, authentic components matching the original and created from original tooling. Another option is to have a new concept based on the customers ideas with the innovation of new components.

The role of the design engineer, in the company, involves creating technical drawings of components to fit the assembly of the final product. These drawings are based on a computer aided design software (Solidworks – a 3D design package). The engineer is also involved in the creation of the bill of materials using another software package(Sage200) which the company uses to plan and manage inventory and production. Equally important is the engineers involvement in engagement with the customers, at all stages, before releasing new products into the production line.

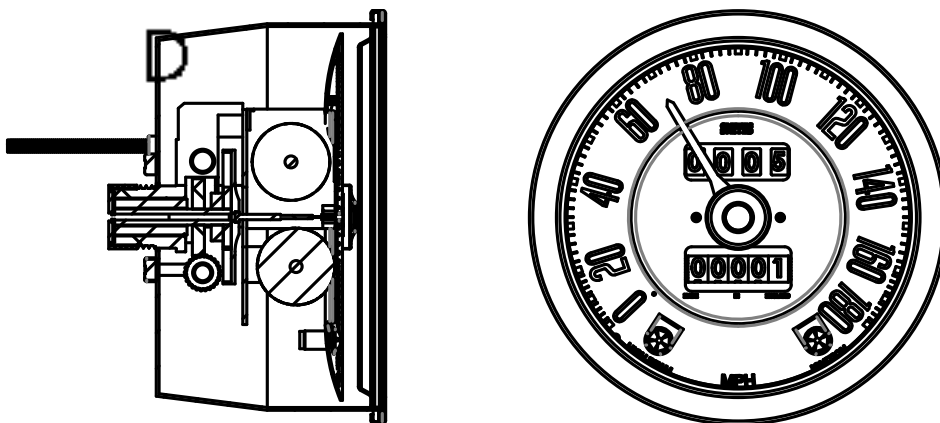


*Figure 1.1 Lotus Elan Mechanical Speedometer
Created by Caerbont Automotive Instruments (2024)*

What's the Project About

The success of a company is measured by the performance of processes and their effectiveness to achieve their intended results. This report examines process improvement and studies the impact of the business's operations, identifying the root cause of the problem and how to refine the process of interest within an organization. The term process improvement is described by Boutros, T (2017) as a term of making process more effective, efficient, and transparent. He then further elaborates to mention that most processes naturally degrade in the three areas mentioned over time and hence require attention.

To elaborate, the report examines how to improve competitiveness and responsiveness to the customers' requirements as a team. This is discussed in the study by Page, S (2010) in the book 'The Power of Business Process Improvement,' who further states that improvement business processes enable productivity for employees and increase return on investment. She further states that most employees understand the end-end of a process and process improvement will give teams the chances to engage and learn the company's systems.

The effects of disjointed processes are potentially related to the problem of interest. Majumder, P (2023) further discussed that this can further hinder the collaboration, increase the errors and impede the growth for the company.

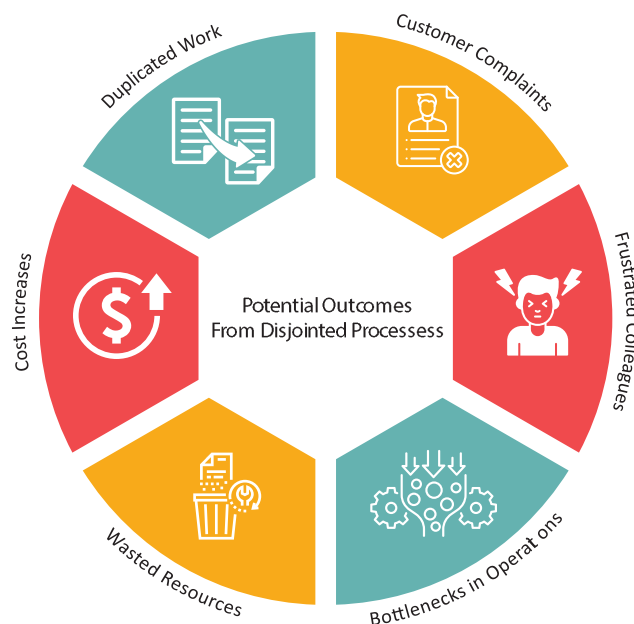


Figure 1.2 Disjointed Process Listed Majumder, P (2023)

Benefits of Study

Regardless of the method used in process improvement a business can benefit is when the entire organization is involved and supports the improvement. In the book, Basics of Process Improvement by Boutros, T (2017) believes the overall benefit of PI is the reduction of costs and increase in efficiency.

One of the main goals of initiation process improvement is to increase accountability to ensure deliverables and functions are on target. Accountability, according to Leonard, K (2022) contributes to results by reducing the amount of time and employees' efforts in productive activities. He goes on to state that without accountability employees can feel directionless and unsatisfied with their work. Developing such goals using 'SMART', which can be defined in Figure 1.3, aids employees set clear expectations which would benefit performance.

One main benefit to process improvement is that employees are given the responsibility of handling information, as it's critical in a time-sensitive business environment. Michailidou. E (2014) mentioned that It's easier to train an individual to run a machine, than to become a team player and described it as a soft skill that can increase professionalism. He also stated the importance of relying on others for them to then rely on management when it comes to processes.

Another important aspect is the reduction of waste when using process improvement. This could involve any of the seven wastes outlined by Toyota (2023) shown in Figure 1.4 although Newton, E (2023) from Lean Manufacturing Junction listed an eight form, that being unused potential. She considered it to be the most overlooked in lean waste. Toyota praise members of staff for their efforts and similarly encourage suggestions from employees as they are experts at their positions.



Figure 1.4 The Eight Lean Manufacturing Wastes described by Newton. E (2023)

Literature Review

The idea of researching literature can be described by Thomas, G (2022) as a method of organizing and establishing what has already been done in process improvement. This approach of research was based on his procedures in the booklet.' How to do you Research Project' which recommended a funneling method, starting with work that is generally relevant, to more specifically related to the area.

The first part of research covered in this review explored where the triggers of process improvement came from in an organization and what has caused this action to take effect. These triggers can be seen listed in Figure 1.5 and cover vast areas in the following subsections based on study by Chapman, R (2023). Some of these triggers could relate to CAI such as from management factors, where some conflicting and unreliable information may be passed out. The lack of documentation relating to specific processes may also result in delays in the manufacturing stage.

These assumptions allow the study to move on into the next stage of literacy, which is total quality management. This can be defined as a philosophy that seeks to 'integrate functions to force on the need of the customer' as considered by Hashmi, K (2007) and the abbreviation explained further in Figure 1.5. TQM is also used in larger organizations as a method of prioritizing the customer's needs, continuously improving process, and having all member of employment involved in the development of the organization.

Finally, the study compares methods such as TQM to Six Sigma, which has also proven successful when used in industrial environments. From a study by Geshan, M (2010) discussing which process improvement method to implement, he suggested Six Sigma takes a lot of TQM methodologies and strengthens where it is weakest such as requiring management backing due to its sequenced structure and group participation to lead its accomplishments.

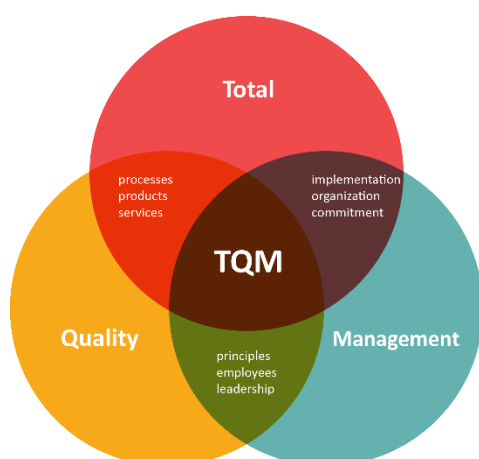


Figure 1.5 Total Quality Management as Mentioned by Hashmi (2007)



Figure 1.6 Triggers Process Improvement by Chapman, R (2023)

Research leading up to the problem.

Initial research involved identifying the specific problem involving the company's manufacturing process. Firstly, internal research into customer orders was seen as a priority. The goal was to gather enough data to aid in constructing a problem statement and would be considered a problem identified for the study.

The finance department stored data regarding specifics of orders, when they were received from the customer, when payment was collected and when the order was finally delivered. This could be considered an acceptable starting point position when finding a problem of magnitude, as literature review examined, TQM methodology values are focused on the customer needs first, as mentioned by Hashmi, K (2007).

The data in Figure 1.7 shows the information gathered from Complaints reported by customers and shows the reason for the delay whether internal or external. It similar study was assessed by Gurradev, A.S (2017) who investigated late deliveries to customers.

Statement

During the production year of 2023. Caerbont automotive instruments had completed over 108 orders for customers. Of those orders 19% have been dispatched later than the scheduled set 6-8 week mark agreed. This has caused customer dissatisfaction and an estimated loss of £22,000 in potential revenue.

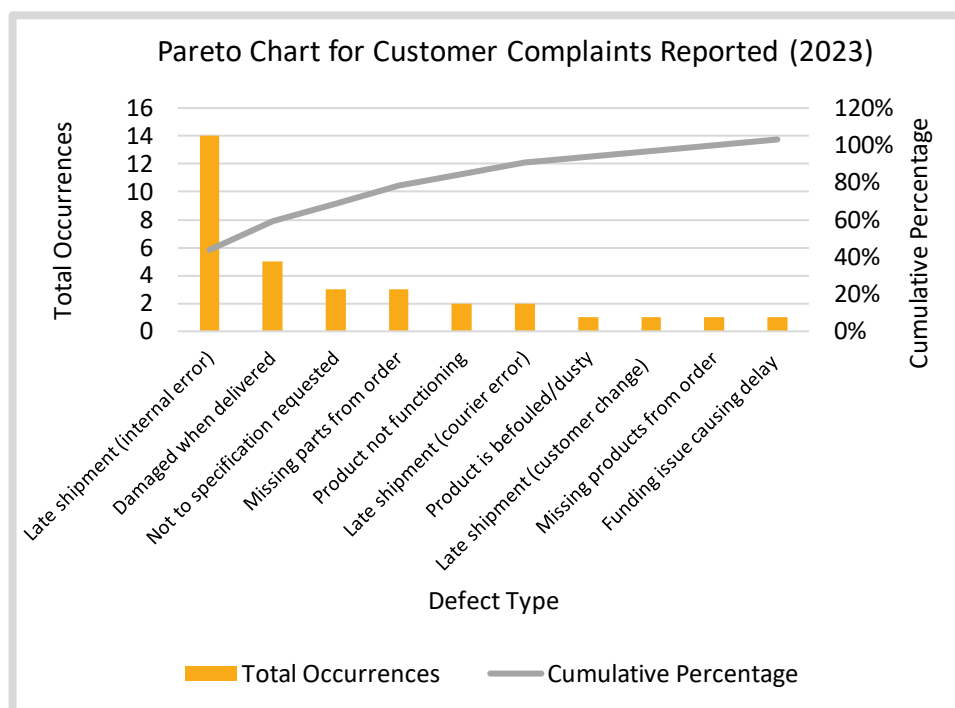


Figure 1.7 Customer Complaints Reported by CAI (2023)

Importance of Study

The improvement of a process at the workplace should be of interest to an employee in an industrial environment. It is important to be able to identify and evaluate the tools needed to improve the company and prevent the failure of implementing a new design in the organization.

The impact of failure of integration was addressed by Bhise, V (2013) who stated that when executed poorly can result in overruns or delays. This would result in the customer being dissatisfied with the services the company has provided and in circumstances affect the overall financial health and sustainability of the company.

Of further importance is the evaluation of the fundamentals of an incorrect design before released into a production environment and how this process affects the company. The research is significant when looking at how this problem affects the unsuitability, and its acceptance in the organization, is researched by Ullman, D.G (2017) who used the comparison between two companies, one who refined their product earlier in development, described to be Toyota (2023) the other being an American automotive company who were still improving their product after it being released to production. Ullmans' study could aid in the justification of refining CAI,s processes layout when creating new products and wherever there is a similarity in behavior to the American firm.

Communication with involved members in the company, in order to improve its performance, is researched by Watts, F.B (2008) who described the gap between design engineering and the rest of the company. He also emphasizes communication with key members of the production team and having clear documentation of the new product when it crosses over the bridge in development.

Research into continuous improvement in an organization has been inherent in such principles from Six Sigma and can be of relevance in the study implemented. The identifying of waste in a process is one of the principles driving companies such as Toyota and when introduced can then decrease the cost and time on a process.

Approached Structure

The structure suggested in the study was DMAIC which focused on the customer requirements in order to achieve project success. This was stated by Setter C.J (2018) who suggests that in order to find a significant solution, a team must combine the knowledge of each phase involved in the DMAIC approach, the anacronym being- define measure, analysis, improve and control.

The reason why DMAIC was chosen was because the solution is not obvious and needs better understanding to identify the cause. This was preferable to other process improvement methods such as Plan Do Check Act which is an interactive form of problem solving according to Laoyan,S (2024). The chosen method was implemented by Kinney L (2023) who suggested using DMAIC for larger problems that have failure- to- meet deadlines and even reported a similar failure percentage of twenty five percent.

Further justifying the value of DMAIC comes from a study by Solkovi, M (2010) who proved that this methodology has the best result when the process is flexible and the team is not fixated on unproductive steps. The overall outcome of his study proved that with DMAIC techniques, a solution can be achieved to satisfy the needs of the team and customer.

Furthermore, another application using DMAIC was researched to be from Tennakoon, B (2015) who used this method to improve the efficiency of delivery times of medium density fiber. While using the DMAIC system, he concluded that the approach aided reduced delivery times by improving the manufacturing performance by reducing the number of defects and down time. This confirmed that the case study could achieve a positive result from applying DMAIC methodology with a suitable application.

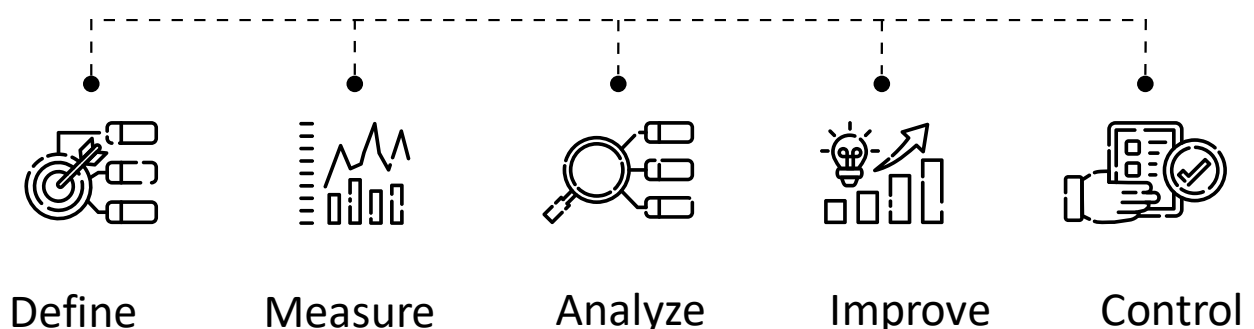


Figure 2 DMAIC Structure as mentioned by Tennakoon, B (2015)

Research into Current Process

The first stage used in the DMAIC process was the define phase. This involved identifying and determining the issues associated for further analysis and exploring what needed to be improved. In addition, and of equal importance, understanding what the company wanted to achieve and the goals of a project established. The define phase is about recognizing the areas of influence to customer satisfaction which should be a company's primary objective as stated by Eckes, G (2003).

Research was done into the company's current processes to give an insight into the current methodology of creating new products and identify those who are involved internally and externally. The method focuses on capturing the set of inputs and outputs by using the SIPOC diagram. The acronym stands for Suppliers- ranging from raw materials to computer aid design software, Inputs- all raw material or consumables needed to complete operations, Output- from components being created within the factory such as enclosure for gauges or fasteners for assembly and Customers- which for CAI can be from distributors of car gauges or vehicle manufacturers like Glickenhause or Jaguar Land Rover. This method gives a high level of overview to employees who are unfamiliar with certain aspects of the business. This is mentioned by Courtneil, J (2020) who suggested further benefits being to act as an instigator to problem solving in business and being quickly conveyed to new members of staff.

The Process section of the SIPOC can be further described through a Process map. The map describes each stage involved in the company's procedures. Contributions to this Process come from various roles in the organization and not only the project leader and as stated by Jacka (2009) the process mapping approved lays down the foundation of self-assessment. This chart would also prove useful when gathering information to add to the map as it gives other members of staff the opportunity to get involved in the problem and not feel disconnected from the identification process, the issue that ultimately would affect them and not only management. The goal is, as mentioned by Brown, J (2023) to create clarity of the processes and gain an understanding as to how much is involved in creating the product for customers.

Further developments involved using the RACI matrix to ensure that the members of the define team understood the roles and responsibilities in each department. It is also stated by Jackson, T (2024) that it enables each employee to be more engaged and reduces the amount of confusion when it comes to their role within the firm.

SIPOC Diagram & Process Map

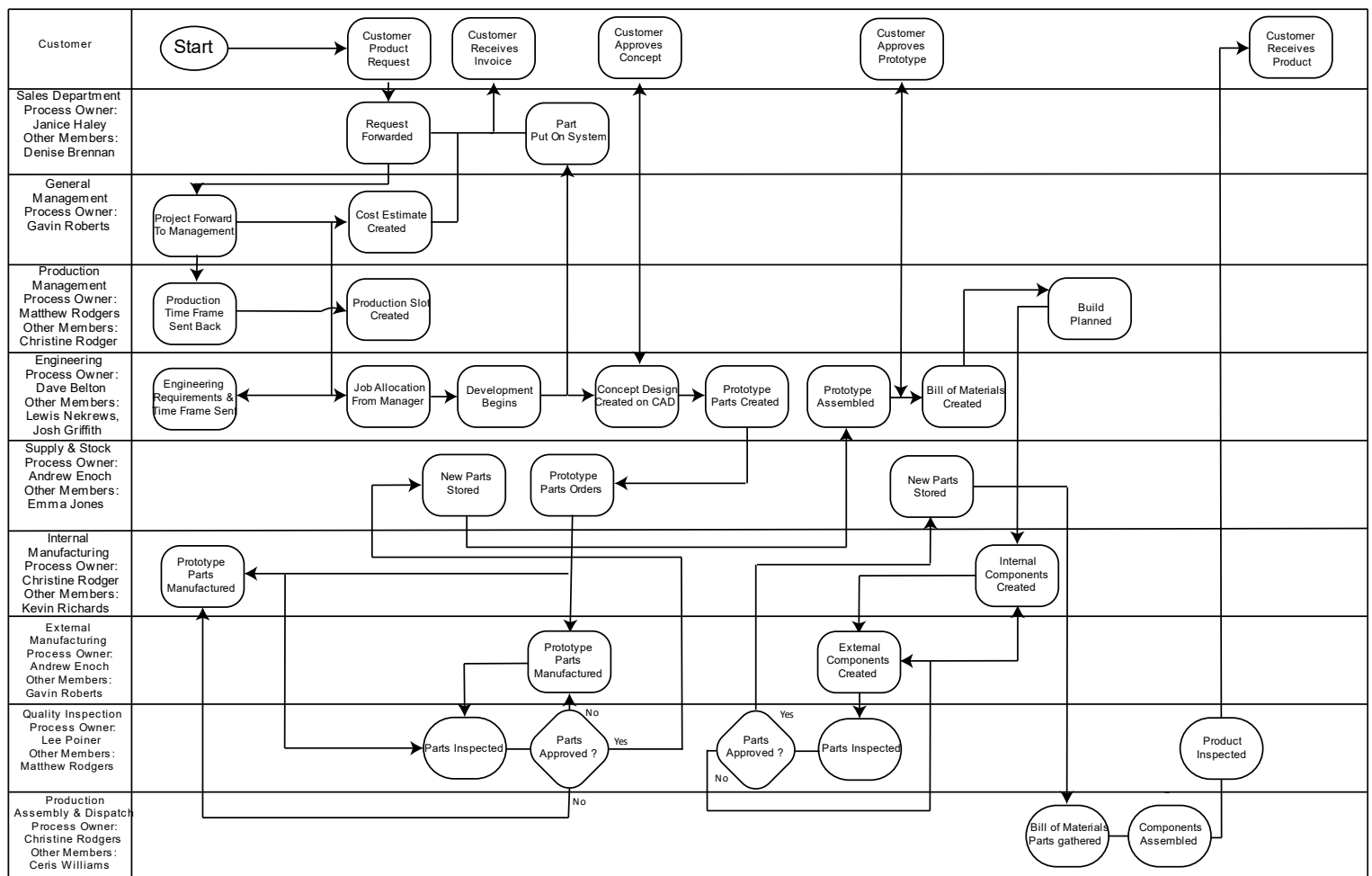
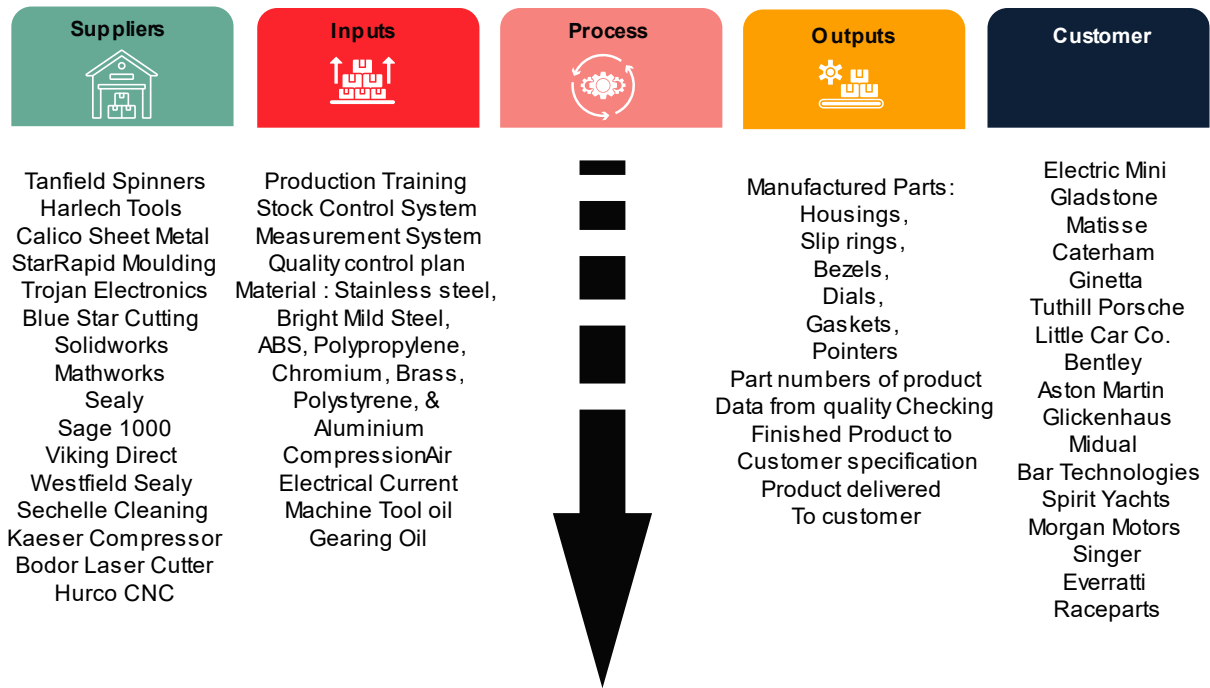


Figure 2.1 Sipoc and Process Map of CAI

RACI Matrix

RACI Matrix																			
R	Responsible : People accountable for the doing the task	Leadership Team				Project Team								External Team					
A	Accountable : Person accountable for Signing off the work	Christine Rodgers Matthew Rodgers Gavin Roberts Dave Ballon	Lewis Nkewes Joshua Griffin Ceri Williams Janet Healey Andrew Enoch Laura Howard Lloyd Baltrick Allan Jones	Sam Price Ben West Darren Drive Doug Taylor															
C	Consulted : Person consulted before and during task																		
I	Informed : Person informed of work progress																		
Work Area	Task Description																		
Sales Department	Deal with customer requested and purchase orders	C	A	A	C	I	I			R									
	Document invoices from customer	I	C	A	I	I	I			R									
	Input customers order onto company 's system	I	I	I	I	I	I			R	R								
General Management	Approve product development	C	A	A															
	Approve product cost for development		C	R												C	C	C	C
	Finalise agreement between company and customer		R	R												C	C	C	C
Production Management	Create time frame for product creation				R	I	I	I	C	I	I	I							
	Plan build of product	A	R	A	A											I	I	I	I
	Allocate members of production to create product					I	I	I		I	I	I				C	C	C	C
Engineering Management	Product concept creation	I	I	I	R	A	A												
	Project allocation by management	I	I	I	R	C	C												
	Prototype creation				R			A				A	A						
	Instructions and bill of materials created	I	I			R	C	I	I	I	I	I							
Supply & Stock Control	Log stock inputs from external supplier													R					
	Log stock manufactured internally by company				A	A	A					A		R					
	Purchase external components needed for build					I	I			R						A	A	A	A
Internal Manufacturing	Manufacture prototype parts					C		A		C		R				A	A	A	A
	Final builds components manufactured					C	C	R											
External Manufacturing	Final builds components supplied					C	C			R				A	C	C	C	C	C
	Manufacture prototype parts supplied				I									A					
Quality Inspection	Prototype parts inspected & approved				I					A	R		I						
	Manufacture prototype parts approved									A	R		I						

Figure 3 RACI Matrix Including Each Department

Voice of the customer

The VOC is to assist in describing the process of capturing the customer expectations and their preferences, whether it's the internal customer, which could be a team member in the business or external customer who we provide a service to. The team must be able to determine the needs and wants of the customer and also organize and prioritize these needs to identify their importance. It is said by Heyes, L (2023) that the success of any VOC strategy is the contribution of every department, as every member plays a role in shaping customer satisfaction.

To be successful in capturing the requirements, the critical to quality concept was studied and used to conduct research. The goal was to identify who the customer is, clarify the customer's needs and requirements and generate the appropriate metrics to evaluate the performance of the company.

Data from the pareto analysis was utilized to initiate the CTQ tree when identifying the initial problem. Problems illustrated from the customer feedback, in the pareto, were translated into the need of the customer. The team enlisted the critical customer requirements outputs, which were related to the need identified. Following this, the CCR's were then translated into measurable requirements. McCarty, T (2005) suggested these must be acceptable statements that satisfy the CTQ concept.

Prioritizing the requirements identified were done through kano analysis where they were separated into three categories in accordance with Munro, R.A (2022). Included in the three were basic needs, which are dissatisfied if they are not met and are features taken for granted in the company's services. Performance needs are those that the customer would like to have included. The final category is delights, which are needs the customer has not yet recognized and would not necessarily miss.

To achieve greater in-depth analysis, the last feature in VOC is the house of quality. The house of quality method provides a way to set targets and then, as a team, debate their effect on product quality. This was used to identify the relationship based on the previously studied CTQ customer requirements and the engineering requirements. The chart identifies the processes that are crucial to improving the product service quality in the eye of the customer. In as mentioned by Lawler, S (2018) the result it encourages into functional communication for the purpose of improving the quality of the process and its services.

CTQ & Kano Analysis

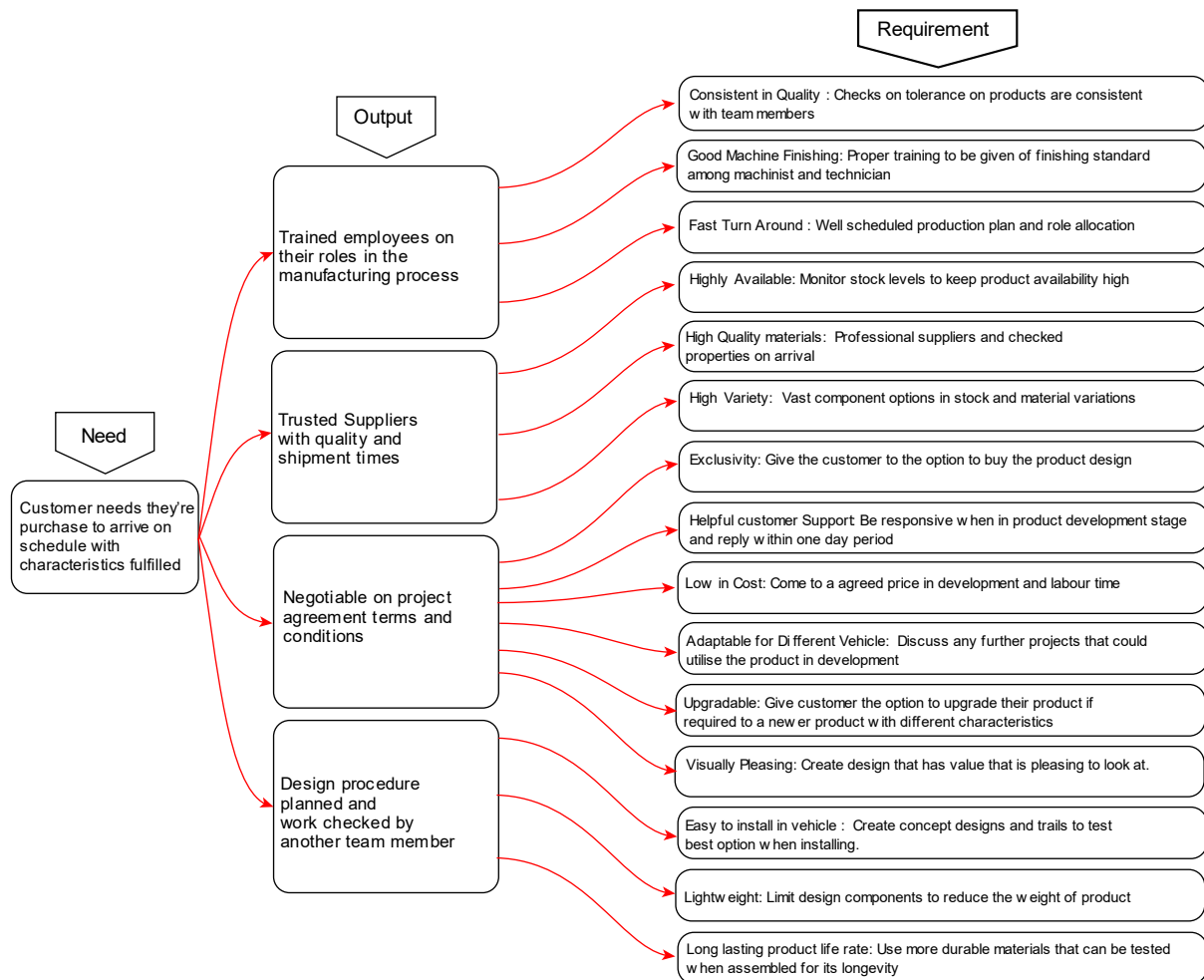


Figure 2.2 CTQ Displaying Need & Transfer to Requirements

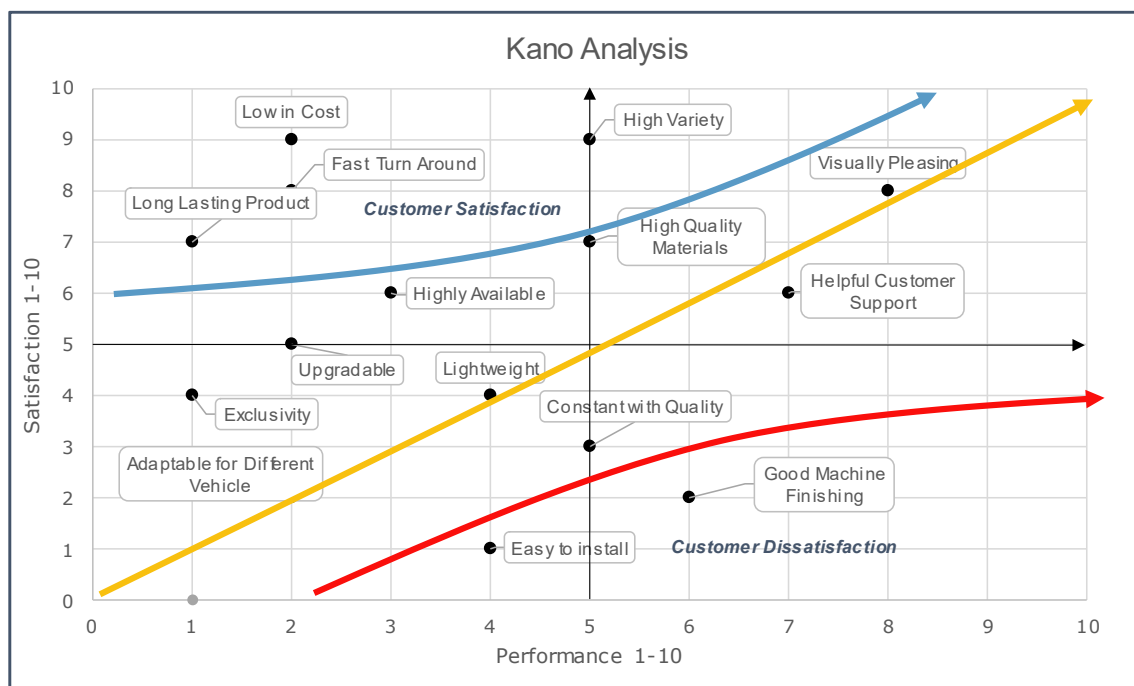


Figure 2.3 Kano Analysis Displaying the Satisfaction level of CAI Product Features

House of Quality

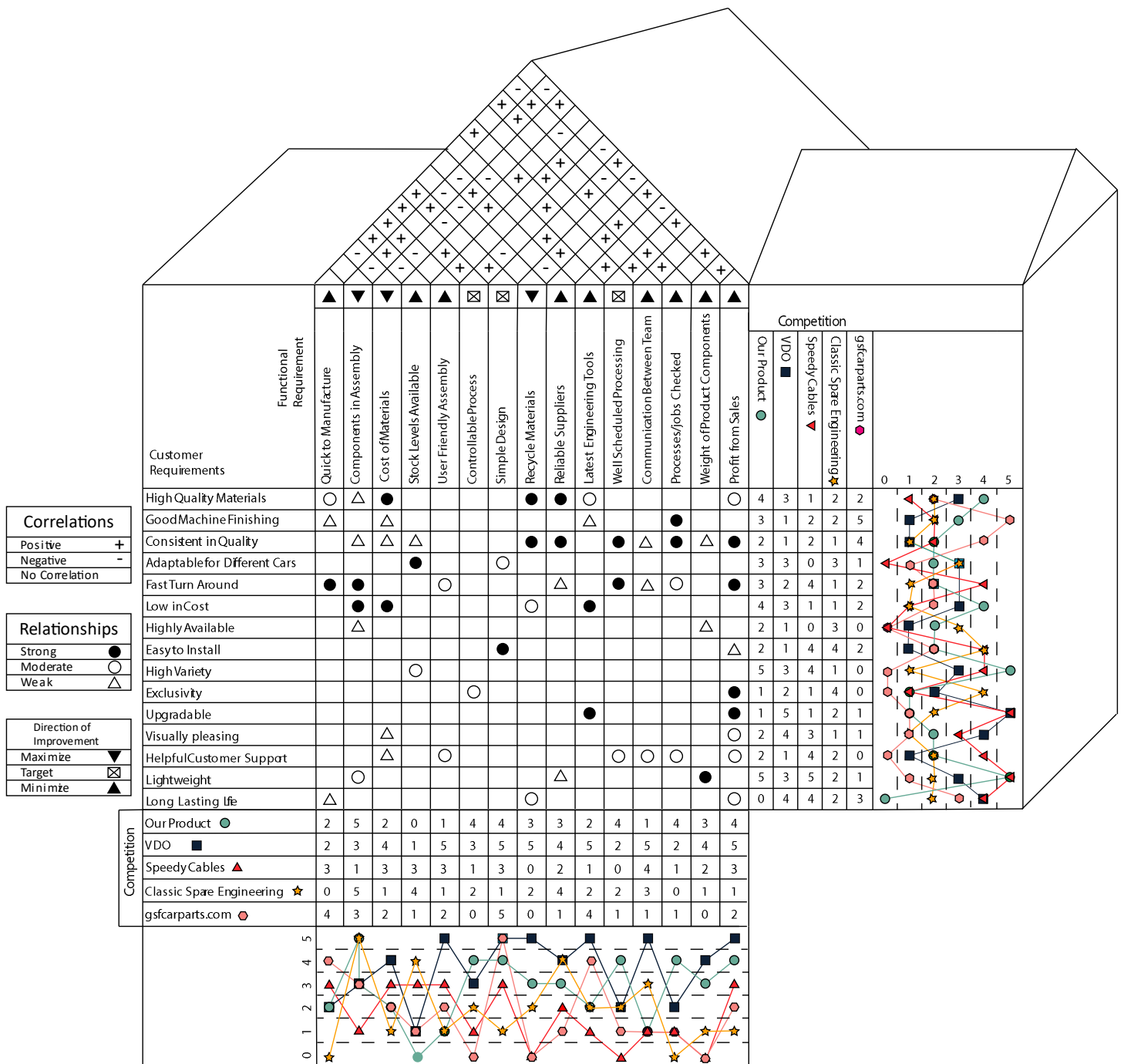


Figure 2.4 House of Quality - Comparing Customer Requirement to Company Requirements

Project Scope

Managing the project scope was a critical step in this phase to control and define what is or what is not relevant. The team and stakeholders needed a clear understanding of the deliverables, consumables, and objectives relevant to the project. The scope acts as a valued reference to the team members and gives clarity to anticipated outcomes. This also assists in avoiding any scope creep as mentioned by Perry, E (2023)- which can occur when the project has added additional requirements, like time and budget. This is also suggested by Eckes, G (2003) who stated that project teams often fail when they don't clearly define what are their main objectives.

It could be seen that there were potentially many areas of the company that could be improved, however the study focused specifically on improving the final manufacturing process. Where value was seen within the company processes, it was included in this section to give the team an idea of the current situation and where they should focus their efforts. Value stream map a lines the processes to identify areas of focus and create a better understanding of the scope of the project. The boundaries are then set in that current state of the process area from the scopes start point to end point.

The second tool used from the project scope was a cause-and-effect diagram, this was used during the define phase to source the type of data to focus the scope. Also known as the Ishikawa diagram, it is a visual tool used to identify a potential cause of product failure. It helped the team create a starting point to focus their efforts rather than spreading out resources to non-beneficial areas. The focus area in the analysis depicted data as concentrated branches - from employees, that create the product, through to management involved in organizing operations. Whereas in the analysis phase it was used to find a potential root of the problem, the tool brainstorms potential x data that was collected in the measure phase.

In addition to the Ishikawa diagram, cause and effect matrix is useful when there is more than the one CTQ involved within the problem. The cause-and-effect matrix, as stated by McCarty, T (2003), is to determine the weight of the causes identified. This gave the team a clear indication the areas to gather data and to confirm the method in the charter.

Value Stream Map

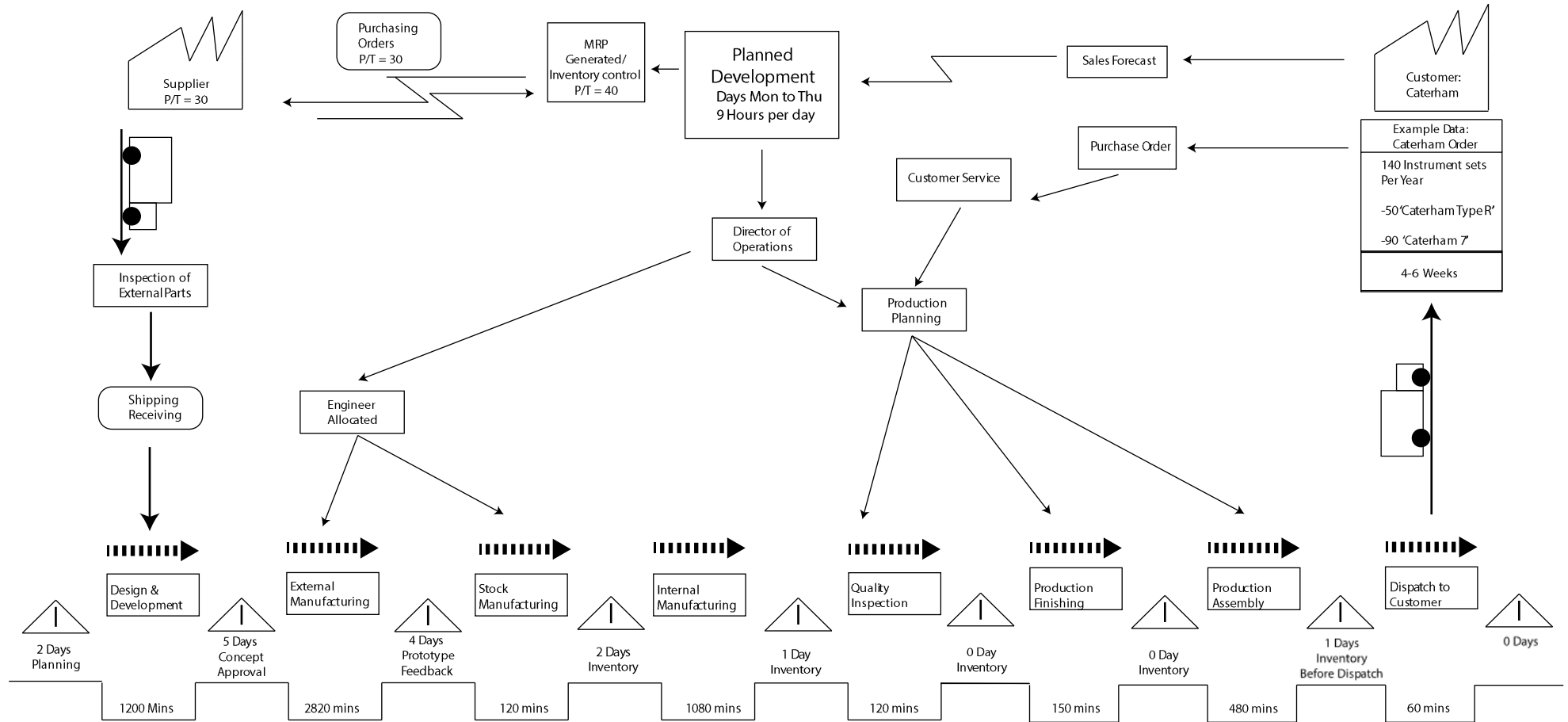


Figure 2.5 Value Stream map - Displaying the amount of Time Needed to Create Product

Ishikawa Diagram

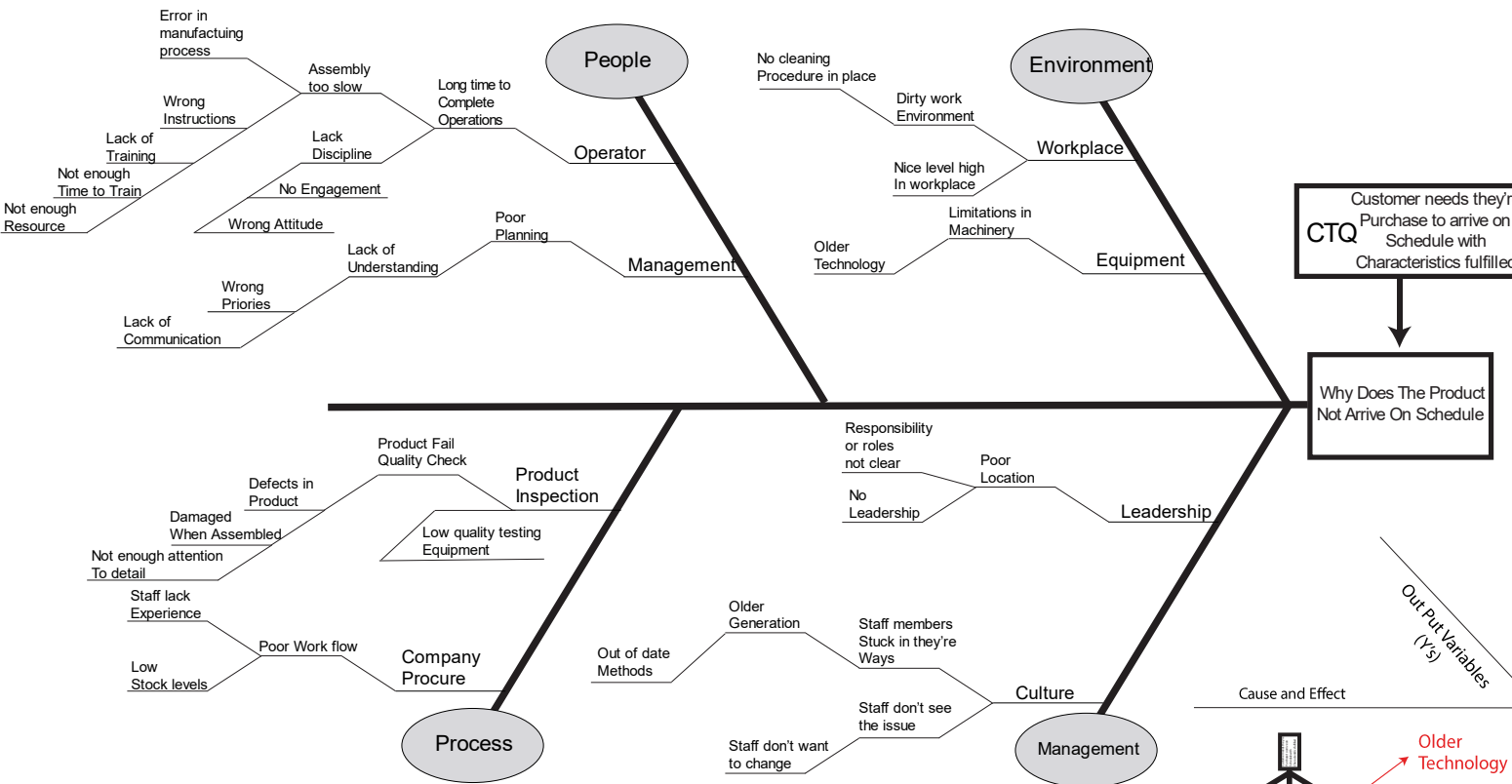


Figure 2.6 Ishikawa Diagram Based on CTQ of Customer

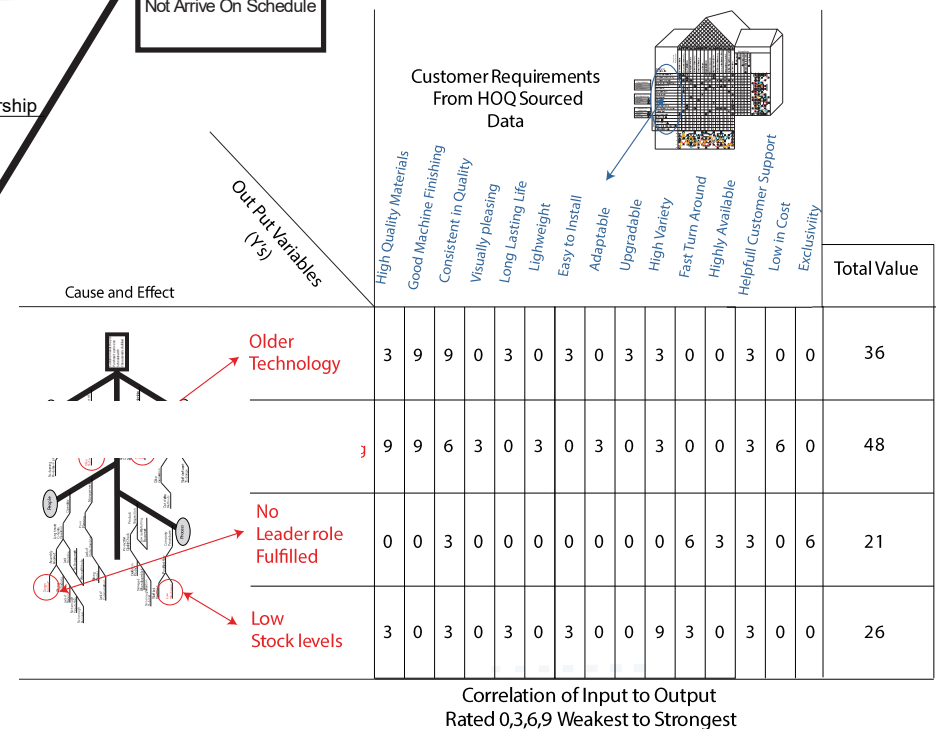


Figure 2.7 Cause and Effect Matrix- Value Added the Customer Requirements Against Potential Cause

Project Charter

The project charter is a documentation that gives the team authority to use organization resources for the project activities. It is described by Keller, P (2011) as a means of controlling and managing the six-sigma project, which then serves as a contact between the sponsor and the project team. The company needed charts to avoid conflict with any other ongoing projects within the company or target anything soon to be obsolete or irrelevant processes. Keller, P (2011) also further mentioned that the importance of the charter is to clearly define the deliverables of the project with given authority by management.

The initial draft, structurally based on methods Motorola include, was created by the team, however further updates were anticipated as the project progressed. The common misconception described by McCarty, T (2003) is that the charter is untouched once created, however the charter should be referred to frequently to make sure that progress stays on track.

A Gantt chart was created to illustrate the timeline of when each section the DMAIC project would be complete. This is mentioned by Martines, J (2024) who stated that the team members and stakeholders should have a visual overview of project information and upcoming milestones. He further stated that the Gantt chart will establish the critical path for the project and is key to understanding the sequence of which task must be completed.

Also included in the Gantt chart is the team members associated with that section of the study. Some areas of DMAIC, such as measure, are better suited to employees that are involved with data analysis while other areas, such as control, can involve more member of the production team, as it compliments their skill set.

Tollgate questions were included in each stage of the project to make sure the team did not move forward without covering their objectives and goals. The questions asked were similarly stated by McCarty, T (2003) as he mentioned that tollgate is to ensure that important aspects have been considered before moving onto the next section.

Charter



Project Name/Number	Delays in Production Delivery Times																																		
Sponsoring Organization	Caerbont Automotive Instruments Ltd																																		
Project Sponsor	Name: Gavin Roberts Location: Caerbont, Abercrave, Swansea, Powys SA91SH Phone: 01639730118 Email: gavin.roberts@caigauge.com																																		
Project Dissertation	Name: Lewis Nekrews Location: Caerbont, Abercrave, Swansea, Powys SA91SH Phone: 01639730118 Email: lewis.nekrews@caigauge.com																																		
<table> <tr> <th>Name</th><th>Title / Role</th><th>Office Location</th></tr> <tr> <td>Jan Healy</td><td>Sales Department</td><td>Sales Office</td></tr> <tr> <td>Denise Brennan</td><td>Sales Department</td><td>Sales Office</td></tr> <tr> <td>Gavin Roberts</td><td>General Manager</td><td>Management</td></tr> <tr> <td>Christine Rodgers</td><td>Production Manager</td><td>Production Office</td></tr> <tr> <td>Mayhew Rodgers</td><td>Production Manager</td><td>Production Line</td></tr> <tr> <td>Dave Belton</td><td>Engineering Manager</td><td>Engineering Office</td></tr> <tr> <td>Lewis Nekrews</td><td>Engineer</td><td>Engineering Office</td></tr> <tr> <td>Josh Griffith</td><td>Engineer</td><td>Engineering Office</td></tr> <tr> <td>Ceris Williams</td><td>Production Worker</td><td>Production Line</td></tr> <tr> <td>Andrew Enoch</td><td>Stock Supplier</td><td>Storage Office</td></tr> </table>			Name	Title / Role	Office Location	Jan Healy	Sales Department	Sales Office	Denise Brennan	Sales Department	Sales Office	Gavin Roberts	General Manager	Management	Christine Rodgers	Production Manager	Production Office	Mayhew Rodgers	Production Manager	Production Line	Dave Belton	Engineering Manager	Engineering Office	Lewis Nekrews	Engineer	Engineering Office	Josh Griffith	Engineer	Engineering Office	Ceris Williams	Production Worker	Production Line	Andrew Enoch	Stock Supplier	Storage Office
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Date Chartered: 19/11/2023	Project Start Date: 19/11/2023	Target Completion Date: 18/06/2024																																	
Sponsor Approval Signature:	Revision: N/C	Date:																																	

Mission Statement

Due to the failure of products during production, the mission is to be able to improve the current state of the manufacturing processes and to implement tools into a procedure that will aid the success of on time delivery

Problem Statement

During the production year of 2023. Caerbont Automotive Instruments has completed over 108 orders for customers. Of these orders 19% of them have arrived later than the set 6-8 week promised to the customer dissatisfaction a estimated loss of £22,000.

Project Scope Boundaries

The area of focus will be at current manufacturing process at CAI.
This project will not consider in great detail other areas of the company out of main product manufacturing.
It will not look into a other external manufacturing processes by supplier or customers .

Business Need Addressed Statement

From the company's perspective, the prolonged time it takes to complete a new product will impact the company's reputation in the market. This will need to change in order to avoid damaging the relationship with customers and could risk losing there business .

Product or Service Created by this Project (Deliverables)
For improving the current process the listed could created:

- Increased in sales
- Reduction in production time
- Reduction in warranty expectancy
- Lower overall cost
- Increase in knowledge & experience in team members

Figure 2.8 Project Charter on Delay's in Delivery Times

Gantt Chart

Project Start Date: 1-Dec-23

Project Name:

Final Project: Product Delivery Delays

[illegible]

Define Tollgate

Question: What is the big Y in the project?

Team Answer: The big Y is the goal of strengthening the performance of manufacturing operations and creating better workflow to avoid delaying the production schedule and to increase the customer satisfaction.

Question: Have the team established the customer requirements in the VOC chapter?

Team Answer: The customer requirements were identified through a voice of the customer analysis valued against the process requirements to establish what the customer wants.

Question: What are the boundaries of the process improvement?

Team Answer: The project charter indicated that the development of a solution will have focus internally and not on supplier or customer plant facilities. The project has limited resources and funds to obtain a permanent solution.

Question: how do the smaller Y's impact on the major Y with the company?

Team Answer: Reducing the time to complete orders by creating a permanent solution could potentially aid the company to grow and increase long term profitability.

Question: What are the goals? Are they achievable in measurable terms and in what time frame?

Team Answer: The ultimate goal is to reduce the amount of time it takes for product completion. An additional goal is it reduce any errors that may be involved in the instrumentation manufacturing processes.

Question: What stakeholders are affected by the project?

Team Answer: The main stakeholders are the customers who expect their order to arrive within the time frame promised by the company. Another is the project team who have the clear goal of achieving a better result and greater customer satisfaction. Management is another who have given the authority to address the area of concern within the organisation and pursue increased revenue and higher company esteem.

Collection Plan & Delivery History

Before proceeding to collect data, it was decided that a review of the critical metrics be taken. This was done by using the data collection plan. The data collection plan ascertained which key metrics should be of interest and who should address these areas, as mentioned by (Kubiak, T.M 2013). A strategy in the collection plan should be identified to state how the data is to be collected and when this task is to be completed. The idea of the plan was to have meaning and validity with the research method which can be beneficial towards the teams' goals. It's regarded by Farida, I (2022) as being almost impossible to improve the efficiency of the company's process without being able to track their performance indicators. In addition to the collection plan, data collection forms were used to assist the allocated members and to meet collection needs. This helped lower the risk of error and keep the team members on track.

The problem statement suggested that the product was experiencing delays in delivery. This gave the team justification to collect data concerning the time of advisory to customers. This information was gathered from client projects in the 2023 order history. The data only included project clients not the distributors of CAI instrumentation to make the data manageable within the timeframe. Further justification as to why client projects were chosen as the data group as opposed to such areas such as distributor data, was because these products were new to production line, which meant that any faults that occurred were from the company's current procedures. Deliveries, created for distributors, because they are older products, may not have given the team enough data to find any pattern.

The main objective behind the research into delivery dates was to identify why these orders were late for dispatch. Reasons for this delay could range from fiscal problems such as lack of customer credit in their accounts to staff shortages in manufacturing. The team were looking for trends or reoccurrences in the products development. This would also give the team an understanding into performance of on- time deliveries and which clients have been affected by this.

Data Collection

Data Collection Plan

Data Plan Phase	What is the Measure		How The Measure is Performed				Who will be performing the measuring	Plan of Gathering Data			
	Y Measure	Operation Definition	Area of Focus	Measurement of Tested Method	Data Required to Stratify	Data Presentation Method	Persons Assigned	What Type?	Where	When	How Many
Historical	Delivery Times of Products	Process time of product development	Internal	Reason for change to product during in past year	Amount of changes and the cause of the change	Histogram Reason for change on against the amount of changes	Dave Belton, Josh Griffith & Lewis Nekrews	Quantitative	Engineering Department Archive	04/01/2024	Change Notices from 2023
	Product Change Notice & Repair	Research in database History for change notices to products	Internal	Reason for change to product during in past year	Amount of changes and the cause of the change	Histogram Reason for change on against the amount of changes	Dave Belton, Josh Griffith & Lewis Nekrews	Quantitative	Engineering Department Archive	04/01/2024	Change Notices from 2023
	Customer Feedback	Customer feedback through Questionnaire via email & Customer reviews	External	Satisfaction Rating Using Questionnaire	Measure the rate of satisfaction using survey	Through spreadsheet format	Jan Healey Creator of survey & Christine Rodgers to send to Customer	Qualitative	Sales/Management department	02/01/2024	10 Customer surveys created
Current	Operator Feedback	Survey questions on performance of company	Internal	Reason for change to product during in past year	Measure the rate of satisfaction using survey & what could be better	Through spreadsheet format	Janet Healey & Matthew Rodgers	Qualitative	Production Line	17/01/2024	All Members (34)
Historical	Performance of Assembly	Performance of Assembly operations on Each line at Organisation	Internal	Hours taken to complete Assembly process	Measure the time to build	OEE, Completion % Defect % Time taken to complete	Dave Belton, Josh Griffith & Lewis Nekrews	Quantitative	Production Line	17/01/2024	Sample Production Cycle
Current	Time to Build Sampling	Time it takes to create the product from a section of the factory	Internal	Hours taken to complete process	Sample a section of interest	Time to build & Gathering component time	Lewis Nekrews & Matthew Rodgers	Quantitative	Production Line	17/01/2024	Sample Production Cycle
	FMEA	Identify the failure modes of the process	Internal	Failure modes recorded & severity rated	Severity of potential failure	FMEA Data sheet	Dave Belton, Josh Griffith & Lewis Nekrews	Quantitative	Management Department	17/01/2024	Failure Count

How will the data be used
Identification of the Big X Identify sources of variation

Data Collection form	
	Change Notice History file
	Application Type
	Amount
	Product
Process Step	

Figure 3.1 Data Collection Plan in Sequence & Collection form Sample

Delivery History 2023 (Client Projects Only)

Overview:

Total Customer: 23

Total Client Orders: 108

Total Delivered Quantity: 1943

Delivered On Time Rate %: 81%

Average Delay (per month): 2

Reason for Late Delivery

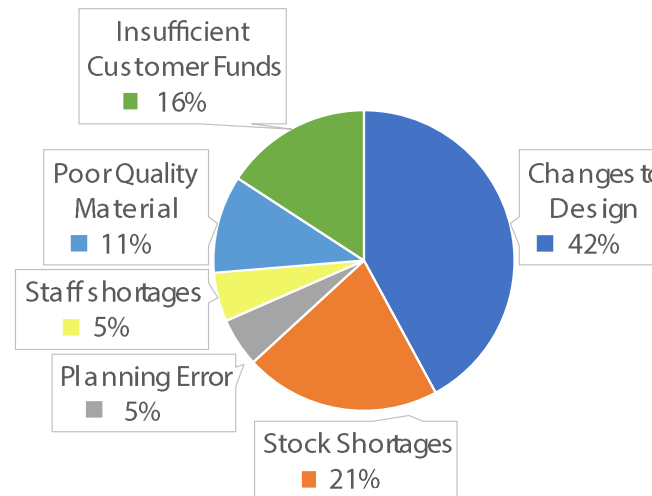
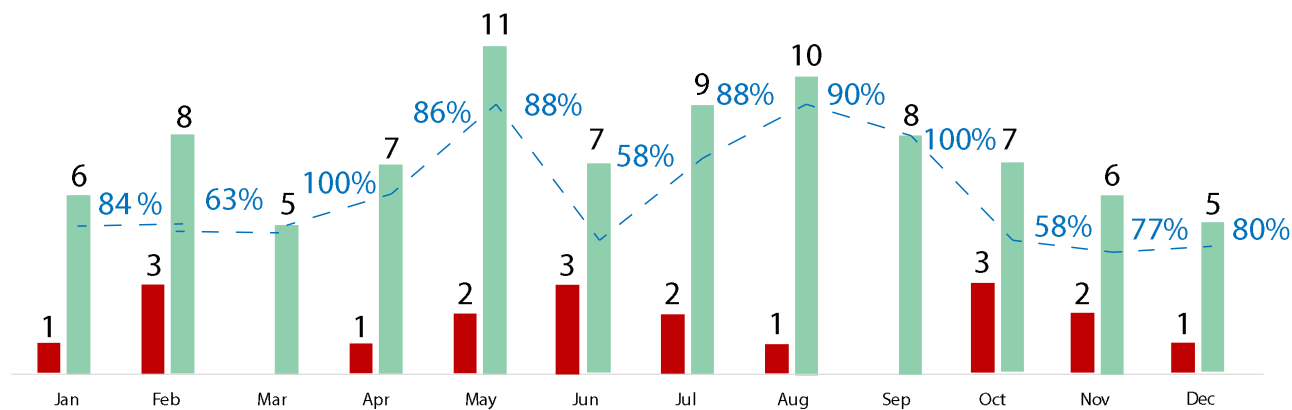


Figure 3.2 Reason's why of Late Delivery

Delivery On Time Status

■ Delay Orders ■ On Time Orders
- - - Percentage of onTime Deliveries



2023 Delivery on time Status

Figure 3.3 Delivery On time Status Per Month (2023)

2023 Client Projects Order Status

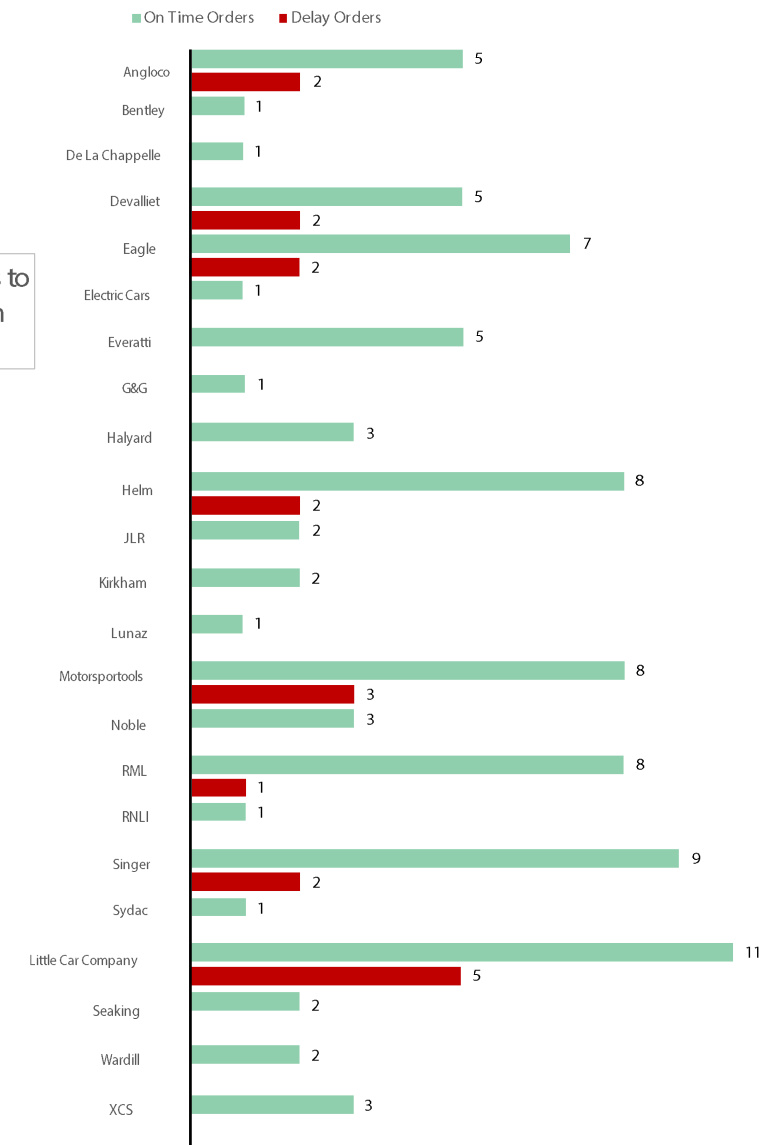


Figure 3.4 Client Orders (2023)

Revision Notices

The delivery data gathered contained many product changes which occurred during its manufacturing process. This assisted in determining the next set of data to be studied, which was change note history which details why these changes have occurred at the later stages of its life cycle. This was an important area to study because changes to the product, after being promised to customers with given dates of shipment, may have been the key factors in the delays reported.

Within the change note data, the employer was noted to identify what change was needed and when the product could be re- released into production. A scatter diagram showed the number of changes being made during the production year of 2002 to 2023. The data from 2023 could then be put into a histogram with the x and y's being the amount and occurrences against the reason for the change. Lastly an operation of the highest occurring fault found in the pareto was defined. This provided a more detailed objective in order to avoid any ambiguity and could direct the team towards further data analysis.

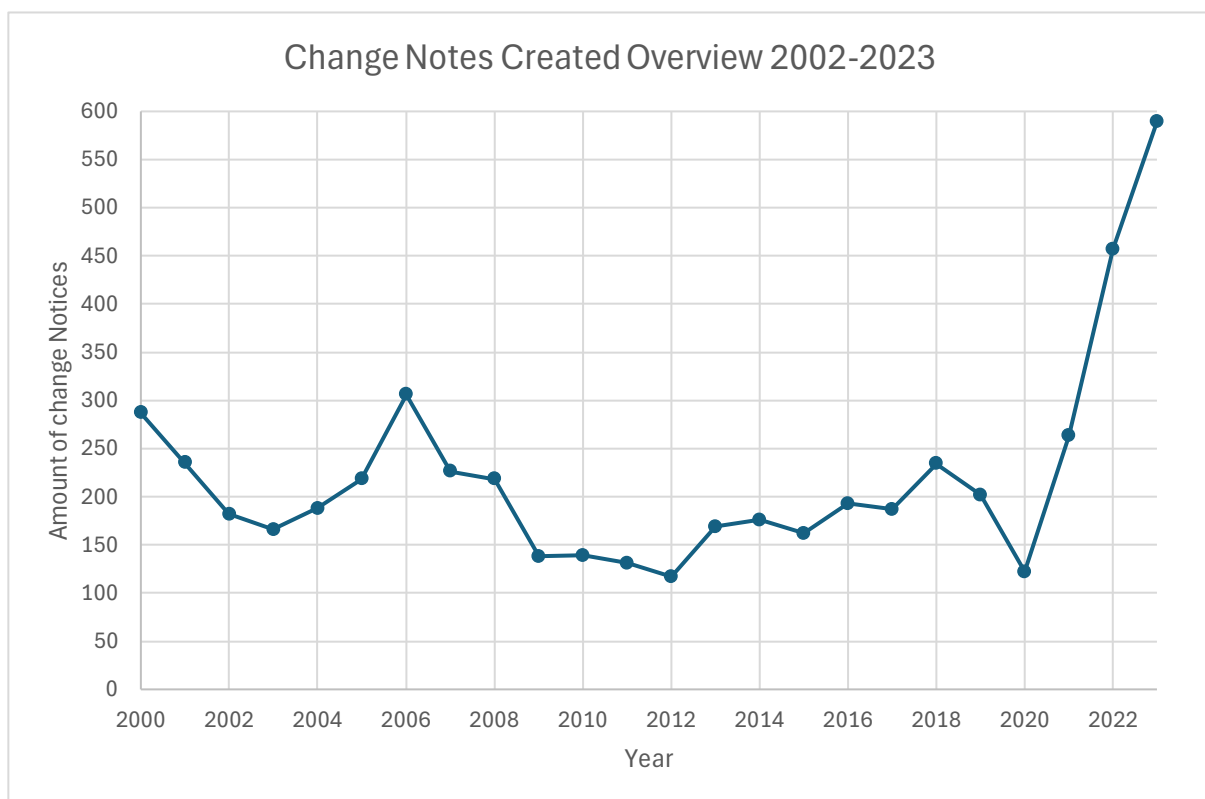


Figure 3.5 Historical Data of Changes to Product From 2002 to 2023

Further Data & Reasons Why

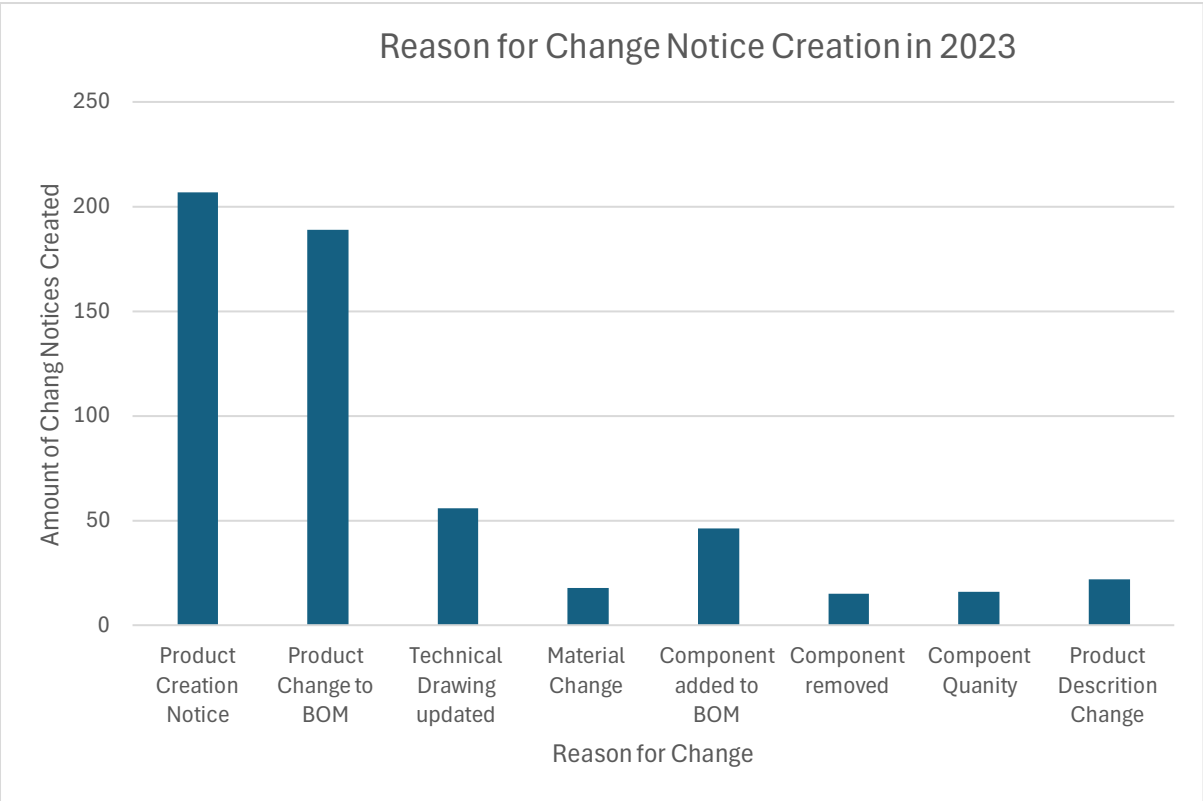


Figure 3.6 Why Products are being Revised 2023

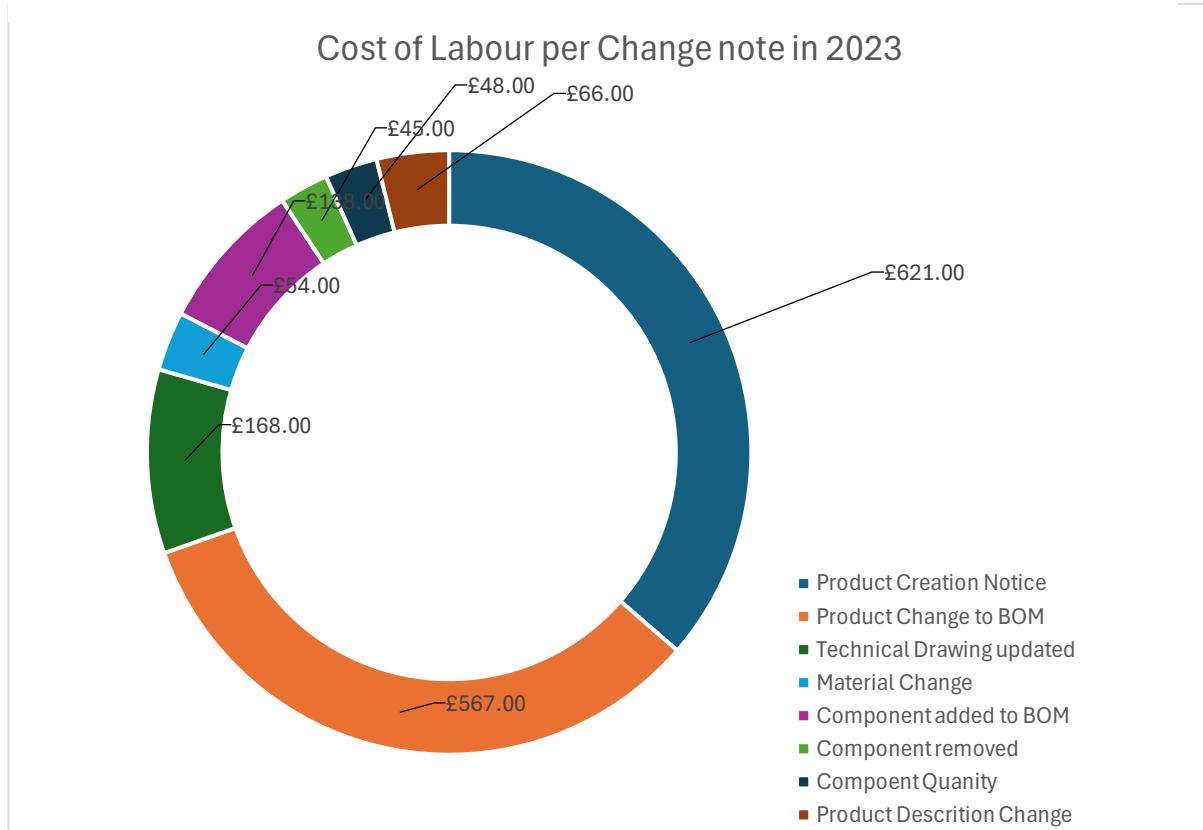


Figure 3.7 Cost of Labour to create Change in 2023

Survey Data Internal & External

Following this, the next part of historical data collection was the Customer satisfaction survey, which is regarded as value -reflective key performance indicators by Kerzner, H (2017). This tool was used to ascertain customer satisfaction within the service and examine where there could be improvement.

Following the guide by Keller, P (2011) the survey questions presented to customers were limited to ones considered most relevant to the terms study with response measures ranging from not very satisfied to one of strong satisfaction. This study's goal was to not make changes on an assumption but rather as described by Needle, F (2023) - as actual thoughts and feelings from those who matter most.

An area considered important was gathering data from the internal customers involved with making these products. This was considered one of the most valued tools for understanding the internal customer's experience with the problem and how it may cause a degrading effect. When employees feel dissatisfied, as described by Duncan, S (2023) this can damage the business's reputation, growth and reduce potential income.

The reason why data was collected in the survey form was essentially to get the perspective of the internal and external customer. This then enabled the team to appreciate what they, as customers, believed to be the problem within the company.

Customer feedback aids in improving the service the company provides and shows that the team appreciate their opinion and values what matters to them - as suggested by Rawson, A (2016).

$$\text{CSAT Formula} = \frac{\text{Number of Satisfied Customer Response}}{\text{Total Number of Response}} \times 100$$

Equation 3.1 CSAT Formula Used for Survey Data

Survey Data Results

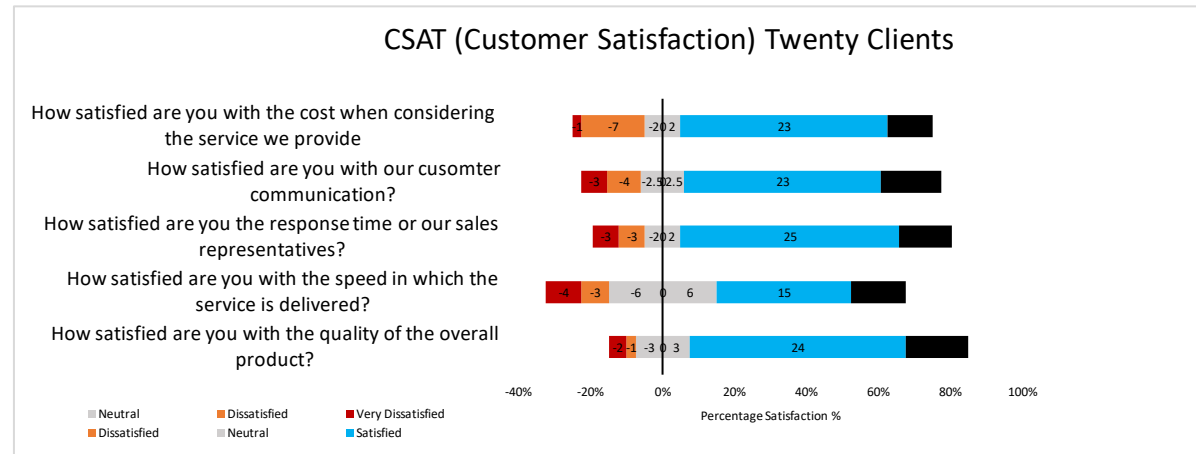


Figure 3.8 CSAT - Customer Satisfaction from Twenty Clients

CSAT (Internal Customer Satisfaction) Eighteen Employees

The salary is competitive to similar organizations providing similar services.
 The benefits are competitive to similar organizations providing similar services.
 I am given the tools I need to provide the services or products assigned to me
 My work environment is comfortable and adequate to the needs of the program/department.
 I am satisfied with the amount of training I receive to do my job.
 I believe that I receive the recognition I deserve for my contribution.
 I receive fair and honest performance evaluations.
 My supervisor provides me resources to improve my work.
 I am satisfied with how my supervisor has worked with me to identify strengths and development areas.
 I am satisfied with the level and amount of supervision I receive.
 If I share my work problems with my direct supervisor he/she would respond appropriately
 I am satisfied with how the organization addresses internal issues impacting our services and products.
 I am satisfied with how the organization addresses external issues impacting our services and products.
 Management's expectations are consistent with the level of resources given.
 My team will utilize constructive suggestions or criticism.
 Members of my team pull together to complete a task.
 I believe clients/consumers are treated with respect by staff
 I am satisfied with the products or services the organization provides.
 I am satisfied with the product or service I provide.
 I am satisfied with the opportunities for growth within the organization.
 I believe management encourages and recognizes process improvement operations

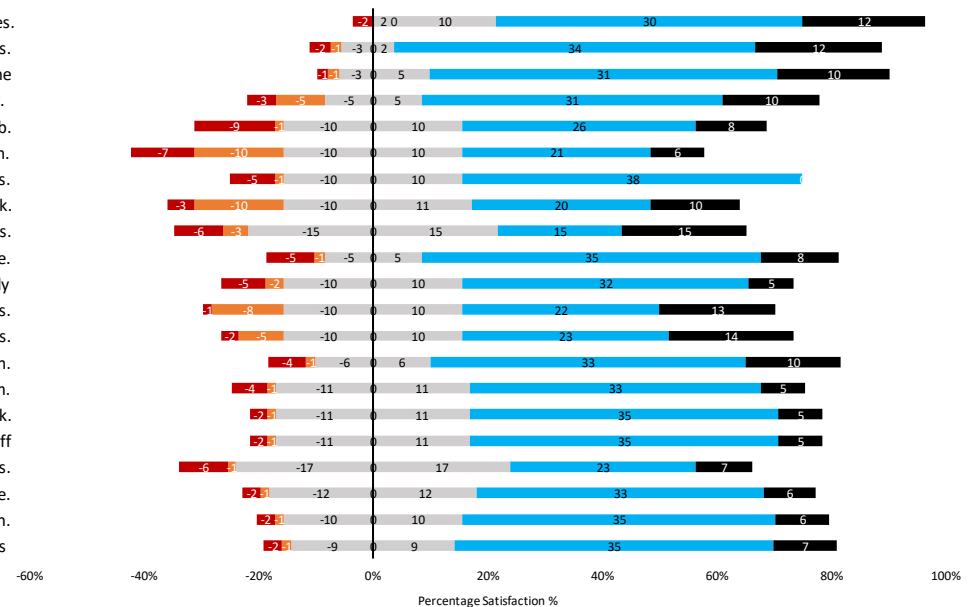


Figure 3.8 CSAT - Internal Customer Satisfaction from Eighteen Employees

Performance on Assembly Lines

The data recovered from change notices and internal customers suggested that the problem could relate to the assembly process. This drew the team's attention to the performance of the line assembly process at each individual section. The discrete manufacturing process should be assessed in each section, from mechanical builds through to more specialized lines, like Porsche 911 assembly line. The data recorded was taken from the fourth quarter of 2023 to evaluate what percentage of the plan had been achieved and what problems may have occurred.

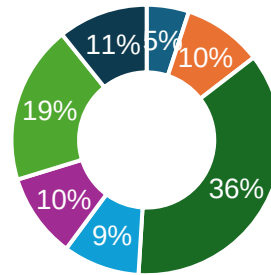
The objective in examining the performance of the assembly was to determine which areas had the highest failure. The gauge assembly process was seen to rely on manual manufacturing processes and its bill of materials to complete the task given. This meant that any interferences during production impacted heavily on the time needed to create the product. Associated costs were also record, with labor time and material expenses estimated within the study of the performance of each line. Following this, the cause of the failure was identified, such as quality issues, material delays or sudden change in production plan. These failures were a direct link to the failure percentage calculated in the performance data.

The second performance indicator that assessed was overall equipment effectiveness. The OEE is a matrix that shows how manufacturing assets perform related to their theoretical maximum capacity. This is mentioned by Scolnick, D (2024) who stated that this was originally introduced for measuring assets within the company, however he stated this can also be used for discrete manufacturing operations. The idea in the OEE analysis was to identify areas where losses occurred and provide insight into the inefficiencies by breaking down separate losses into availability performance and quality. In any organization Scolnick, D (2024) stated that there is always a gap between actual throughput and planned production, meaning the origin of the losses becomes difficult to determine.

Performance of Assembly Section

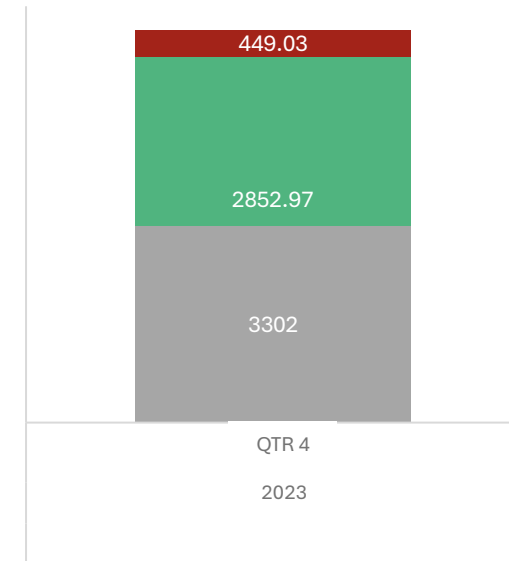
Time to Build Performance (QTR 4 2023)					
8 Working hours Mon-Thu					
Product	Units Per Day (for Each Employee)	Build Time Per Product (Minutes) for Each Employee	UPH	Workers	Labour Cost Per Hour
Nemag (Mechanical)	31	15	4	1	£12.00
Aircored (Electronic)	82	6	10	2	£33.50
Remag (Mechanical)	31	15	4	1	£12.00
PCB Builds(Electronic)	81	6	10	3	£33.50
Timeclock(Electronic)	69	7	9	1	£34.00
Bourdon Tube (Mechanical)	44	11	6	2	£12.00
Porsche Classic(Electronic)	31	15	4	1	£11.50

Reason for Failure %



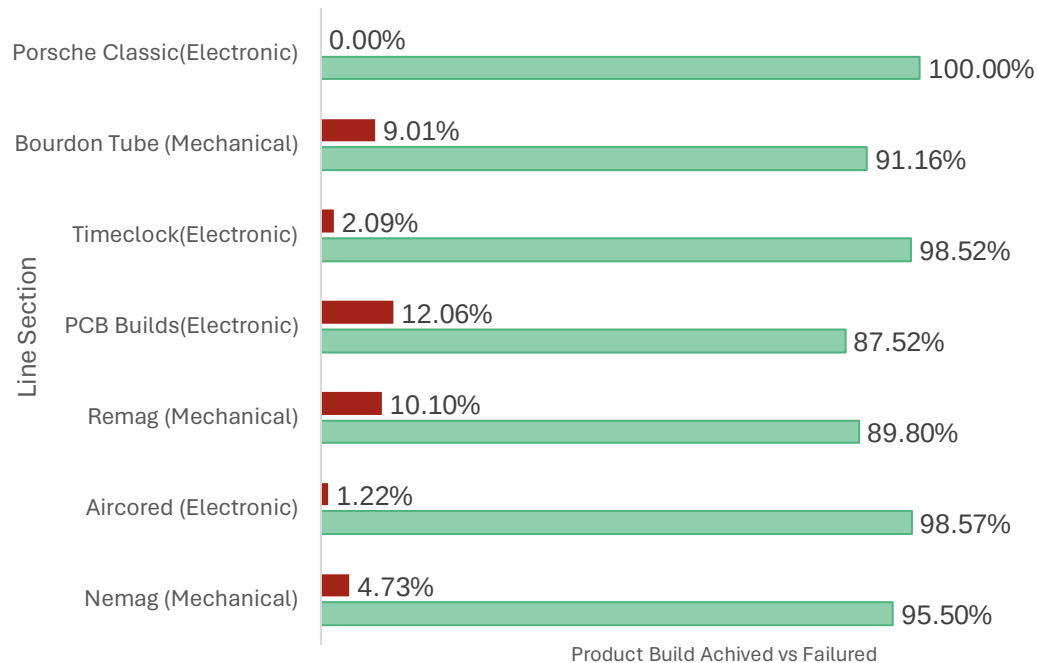
- Machine problem
- Material delay
- Material preparation
- Packing shortage
- Quality issue
- Sudden plan change
- Workers shortage

Time Analysis

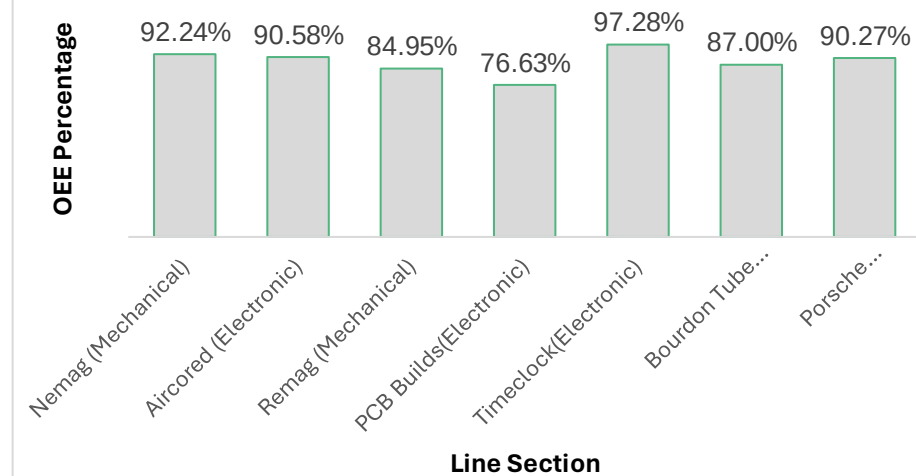


- Sum of Lose Time (Hrs)
- Sum of Actual Run Time (Hrs)
- Sum of Available Run Time (Hrs)

Product Build Achieve % And Failure %



OEE% Analysis



Electronic Gauge Assembly: Time Study

The study into the performance of each assembly line guided the focus towards one specific area, the electronic PCB builds. This had the highest failure rate out of each section, which gave the team motivation to investigate further by monitoring that area's performance. This was conducted using a time-based study which recorded the length of time taken for production to complete their planned tasks daily. This was discussed by Landry, R (2023) who described it as a method to identify inefficiencies and improve productivity.

An ideal result in the study would be to identify any bottle necks in the manufacturing process and then provide enough evidence to analyze what the root cause is in the next phase.

The time study recorded three types of data. The first step was to identify the time taken to build the product, secondly the time taken to collect components and lastly the cost in labor for completing the task. Three operators would be monitored during the study of their daily production schedule set by management.

When considering what time period would be used for data collection, attention was taken into the need for a settling- in period for employees, to feel comfortable when being observed. The team decided on a time of two weeks as being reasonable for the study. Another reason for this would be that the team would still want to be able to stay within the timeframe of the project charter.

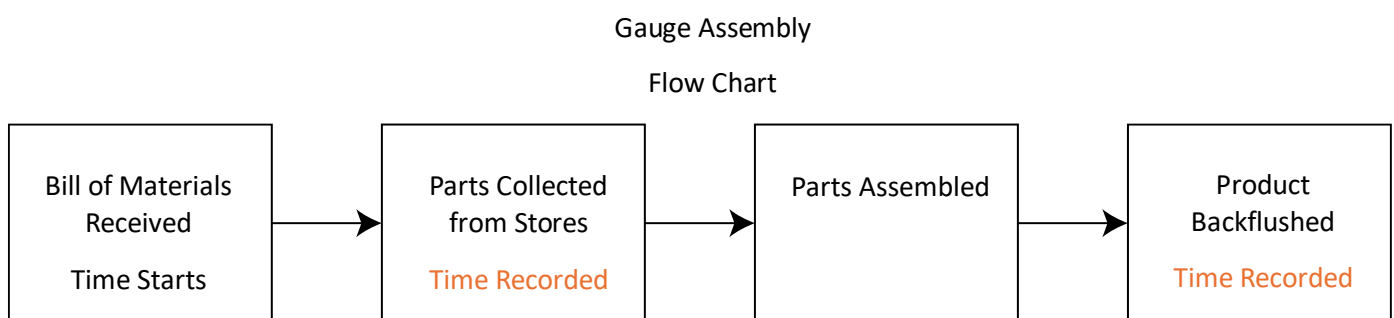


Figure 3.10 Sample Process- Three Employees on PCB Section to be Monitored

Time study Results

Sampling PCB Section

Number of Workers Monitored: 3

Variables: Time To Build & Time Collecting Parts

Timeframe: 2 weeks (8 working days)

Expected time of Completion: 8 Hours

Expected Quantity to be completed each: 81 Products

Goal: Identify Bottlenecks (8>) or Patterns in Data

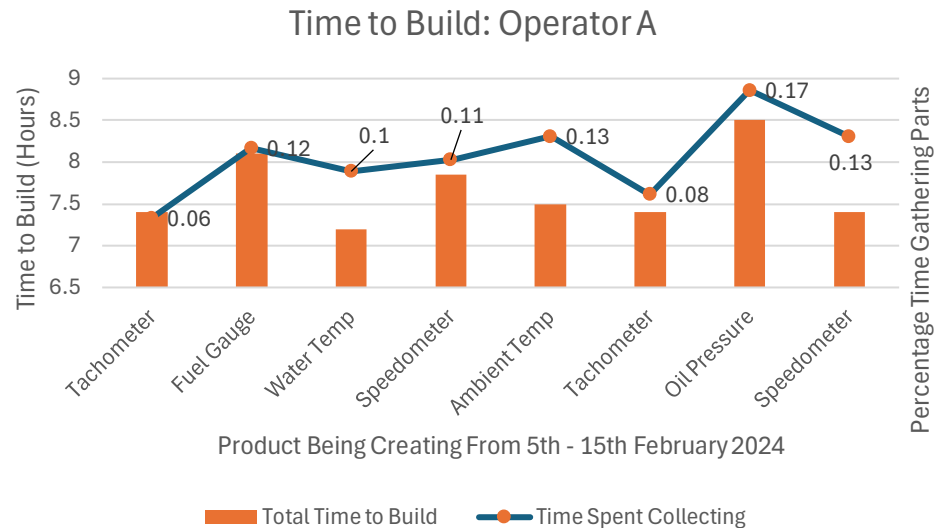


Figure 3.11 Sample Results- Operator A Data

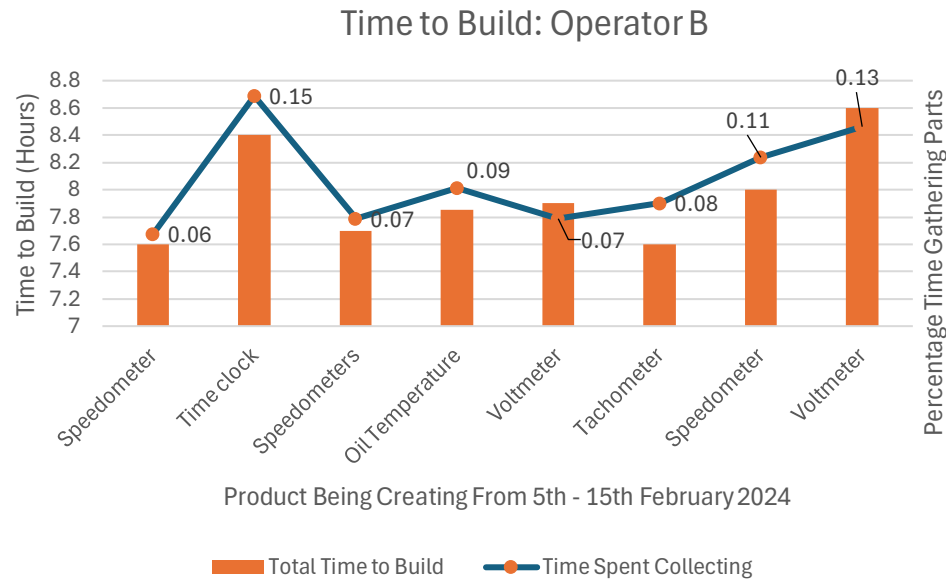


Figure 3.12 Sample Results- Operator B Data

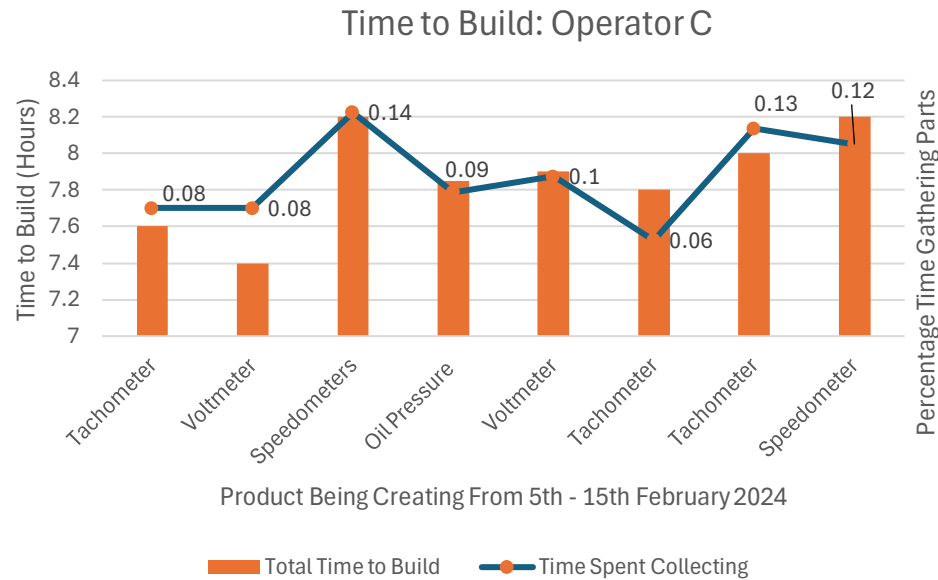


Figure 3.13 Sample Results- Operator C Data

Identifying the Modes of Failure

In the last section of the measure phase, the failure modes were identified. The failure mode method analysis was used to identify ways in which a process in place would fail. The information was prioritized based on the severity of the possible cause of failure and the likelihood of failure occurring. This method was suggested by Mccarty, T (2005) as a tool to make the team more comfortable with any proposed changes they may apply in further development while considering what can go wrong with the change.

At the end of the measure phase the team developed an understanding of the main factors relating to the problem and the processes needed to be able to meet the requirements of the customer. Tollgate was used in this section as it enabled the team to discuss the gathered information and identify any possible further requirements in data collection.

FAILURE MODE AND EFFECTS ANALYSIS															
Item: Car instrument Assembly			Responsibility: Lewis Nekrews			FMEA number Measure Issue 1									
Model: Issue 1 Gauge Assembly			Prepared by:			Page : 1 of 1									
Core Team: Ceris Williams, Lewis Nekrews, Gavin Roberts, Dave Belton,						FMEA Date C13/02/2024 Rev. 1									
Function	Potential Failure Mode	Potential Effect(s) of Failure	S e v	Potential Cause(s)/ Mechanism(s) of Failure	O c c	Current Process Controls	D e t	R P N	Recommended Action(s)	Responsibilit y and Target Completion Date	Action Results				
											Actions Taken	S e v	O c c	D e t	R P N
Gauge Assembly Process	Wrong material added to assembly	Stock loss due to missing components	8	Assembly was not signed off before release	8	Assembly checking procedure by another design engineer	7	448	No Jobs to be released until checked	Engineering 03/02/2024	All jobs to be checked before released	3	2	1	6
			8	Bill of material duplicated from older product with wrong components	8	Input each part individually	8	512	Remove duplicating capability's	Engineering 03/02/2024	Duplication will result in disciplinary	5	2	4	40
		Delay in production as correct parts may not be available													
	Out of tolerance Assembly parts	Delay in production as parts need reworking	8	Technical drawing incorrect	4	none	10	320	Drawing checked before released	Engineering 28/02/2024	New advanced computer purchased	1	3	2	6
				Supplier created part incorrectly	5	Parts checked before stored	9	360	Check with supplier before manufacturing	Supplier manager	Supplier to Correspond	5	3	2	30
	Product Description conflicts with bill of materials	Confusion on production causing delay in product	5	Mistake in description creation	3	none	2	30	Checked before given to production	Engineering 28/02/2024	Checked product	2	1	2	4
	Incorrect components assembly	Wrong specification given to customer	3	Lack of experience in assembly process	5	none	5	75	Training to be given on building process	Process Manager	Training given	2	2	5	20
			5	Poor instructions given	2	Description included brief assembly	5	50	Exploded assembly given to production for visual	Engineering 28/02/2024	Assembly drawing supplied	5	2	1	10
	Lack of availability components to complete build	Delay in production assembly	9	Stock showing on system	4	Stock to be monitored and checked	5	180	Stock check frequency	Stock control department 28/02/2024	Stock control items needed	7	5	1	35
	Plan changed stopping assembly process	Disruption to workflow	7	Low stock making plan	3	Plan Assembly	3	63	Control stock levels to avoid						

Figure 3.14 FMEA - How Could the Current Process Fail

Measure Tollgate

Question: What were the key metrics and processes measured in this phase?

Answer: The key metrics used in the study was the time taken to build the product on the assembly line. Another metric is the cost associated with the gauge assembly process.

Question: What was the performance baseline during the measurement study?

Answer: For the delivery date, the baseline was the six-week timeframe the customer was given until they received their product. Assembly baseline would be the eight-hour mark that was the given necessary for production to complete their daily run.

Question: Have appropriate sources been selected in the data collection plan?

Answer: The data selected was based of the company's goals and the built on the given problem statement data.

Question: What was put into place to avoid omitting valued information or data.

Answer: The data collation plan was in collected in sequence to correctly filter into the assumed problem area.

Question: What were the functional requirements determined?

Answer: Through collected data, ideally avoiding disruption in the assembly process, meant less time spent building the product, leading to a more cost-effective process.

Analyzing the Data Gathered

Analysis was possible and the next phase introduced once sufficient data had been collected. The aim of this phase was to identify the root cause of any performance issues noted, using a series of tools and processes. The goal was to find patterns within the data sets which would enable the team to identify the sources of variation and then get to the root cause of the problem. It is also stated by Keller, P (2011) that the objective is the determination of the process drivers, to be able to correlate the little y's to the requirements of stakeholders and how they impact with the process output.

When looking at the data assembled, it was observed that the original process map in the study was incomplete. The processes missing from the organization that were not correctly recorded were regarded as hidden factory and classed as drawback for the company, as sources of waste are then concealed. - as suggested by Feldman, K (2023). An important factor was for the team to identify the illusion of performance because they could then loop the process back, to correct deficiencies which could damage efficiency. The hidden factory for CAI showed that when the assembly received the bill of materials, they spent prolonged time collecting components. Historically, data from change notes identified a need for the engineering department to revise the bill of materials.

A method such as the process value analysis assisted in looking at which processes could be streamlined or improved, especially as the product production time was under evaluation. Process value analysis would identify customers specific requirements and allow the team to streamline procedures, eliminating any unnecessary steps. Kenton, W (2022) recommend this tool as a method to lower costs and provide a more rapid service. The benefits for team members conducting this analysis were to enable study into where inefficiencies could be removed and what services they affect. This would improve the quality of future operations.

Any observed potential opportunity to reduce the process duration was scored for future improvement plans. Greater opportunity was identified from both the quality inspection stage and production assembly process.

Hidden Factory & Value Analysis

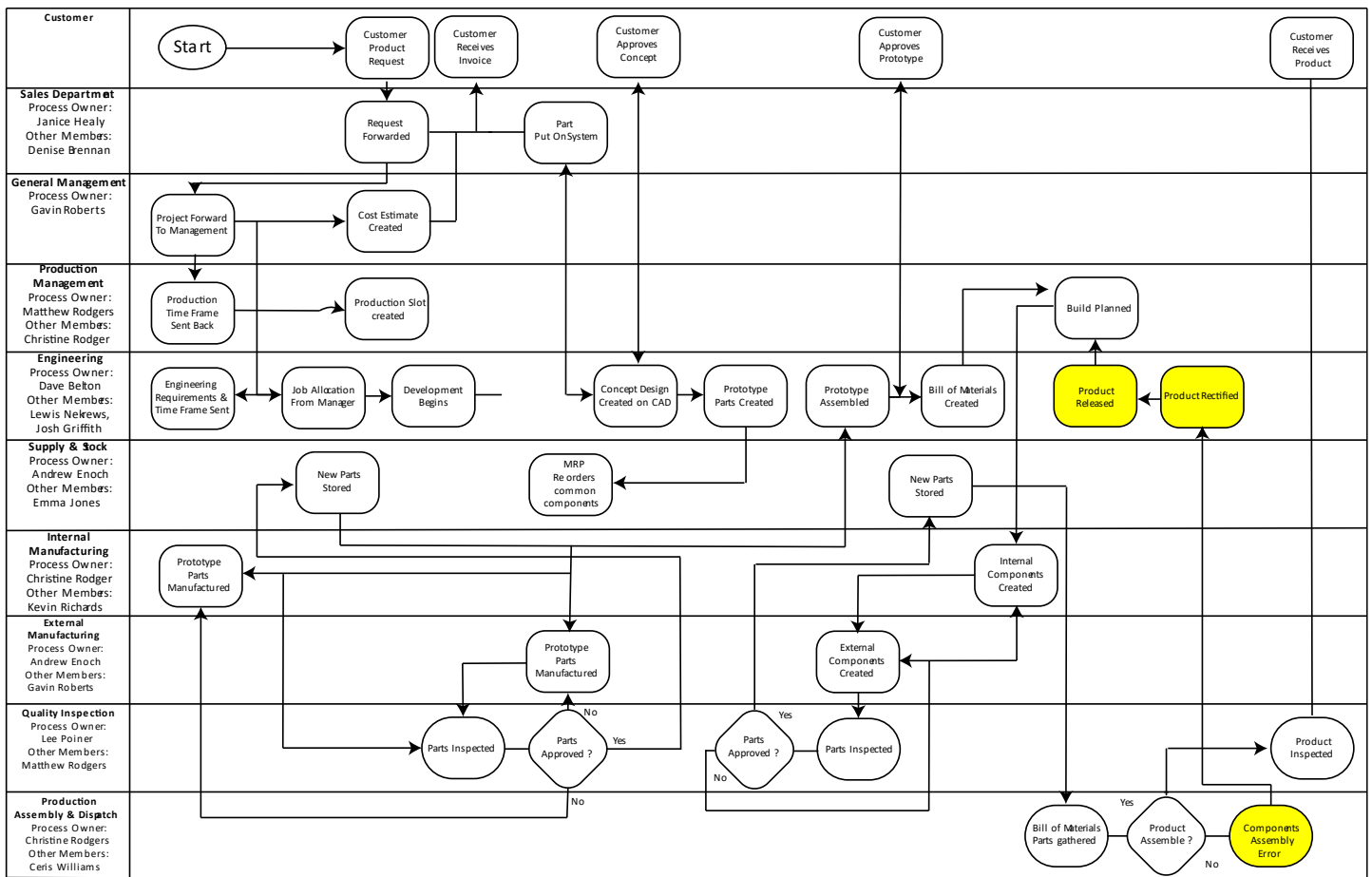


Figure 4.1 Hidden Factory – Hidden Process in Yellow

Value Analysis (From Process Map & Measure Phase Data)									
Process Step	Description	Type of process	Process Duration (Minutes)	Percent of Process Flow (%)	Falls in Pareto	Value Add Analysis	Future Plan	Potential Process Duration	Sum of Reduction Opportunity
1	Customer Order	Input	40	0.72%	No	Value Enabling	Keep	40	0
2	Sales Team Transaction	Sub Process	30	0.54%	No	Value Enabling	Keep	0	30
3	Purchasing Orders Components	Sub Process	30	0.54%	Yes	Value Enabling	Keep	15	15
4	Design & Development	Process	1620	29.19%	Yes	Value Enabling	Keep	1600	20
5	External Manufacturing	Process	1820	32.79%	Yes	Value Enabling	Keep	1800	20
6	Stock Management	Process	120	2.16%	Yes	Non Value added	Analyse to Reduce	50	70
7	Internal Manufacturing	Process	1080	19.46%	Yes	Non Value added	Keep	820	260
8	Quality Inspection	Process	120	2.16%	Yes	Non Value added	Analyse to Reduce	45	75
9	Production Finishing	Sub Process	150	2.70%	Yes	Value Enabling	Analyse to Reduce	0	150
10	Production Assembly	Delay	480	8.65%	Yes	Value Enabling	Analyse to Reduce	370	110
11	Dispatch to Customer	Process	60	1.08%	No	Value Enabling	Keep	60	0

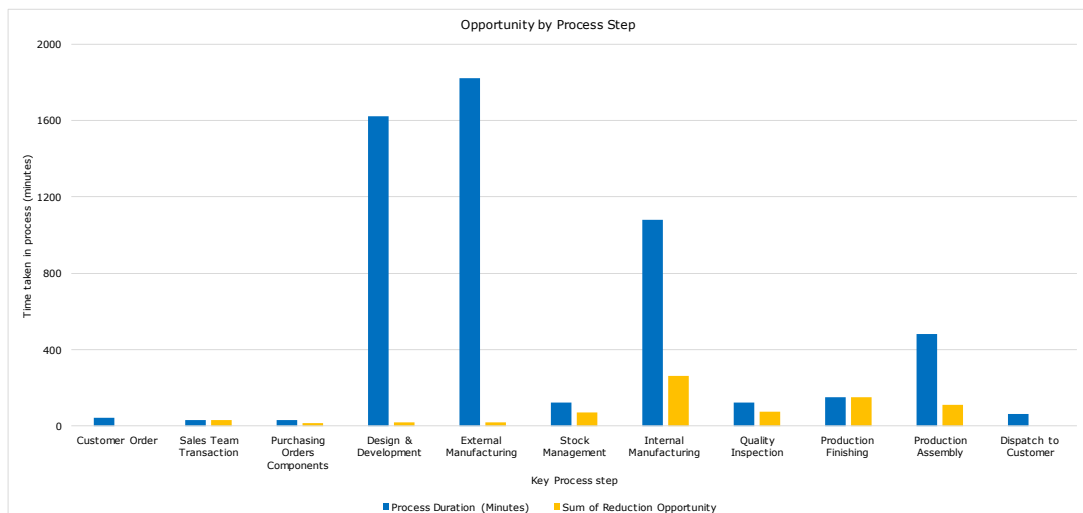


Figure 4.2 Value Analysis – Showing Opportunity For Improvement in Yellow

Pareto Analysis

When introducing the pareto analysis, the team were able to visualise where the bulk of the problems originated and could then tackle the largest source of inefficacy. This is regarded by Pugh, T (2018) as a method to improve the customer service and quality by looking at the problem from a new perceptive. The team used the data to locate areas of process to be addressed. Areas of data collected were given weighted value. The pareto then separated the vital few problems in the study from the many which is mentioned by Pierre, S (2023). The data in the pareto was extracted from the value analysis and displays the opportunity to improve in certain processes.

Before arriving at the root cause analysis, the pareto gave a clear understanding of where to prioritize further study. The team understood that the highest frequency problems in the pareto would then be used to question why this was affecting the businesses processes.

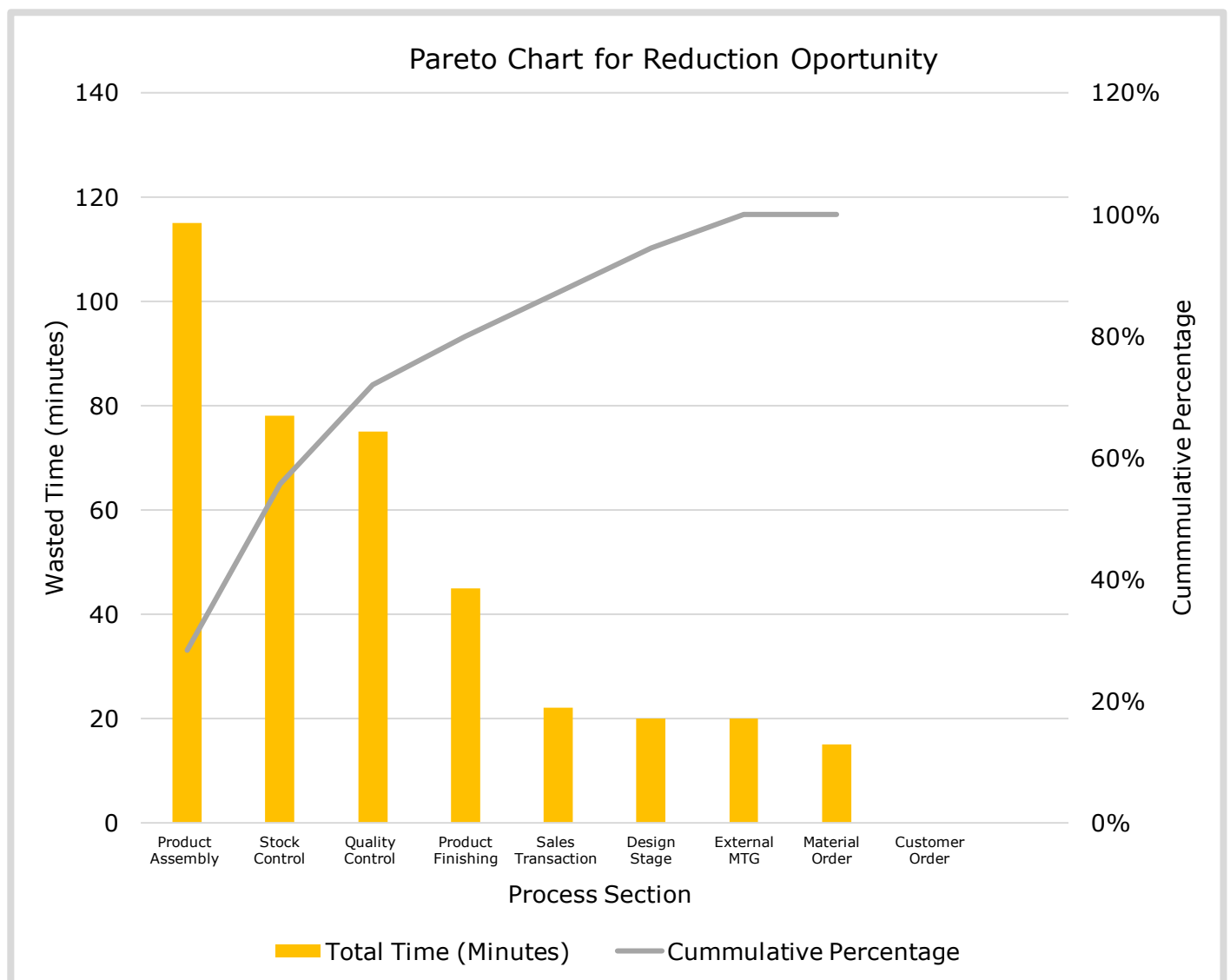


Figure 4.3 Pareto – Displaying How Much Time Is Being Wasted in Process

Root Cause Analysis

In the next stage of analysis, identification of the root causes through methodology was implemented. This involved using information identified in the previous pareto and looked at the other areas of the analysis stage. The deliverables in this stage were to understand why the problems were occurring using a selection of researched techniques.

In this section of analysis, collaboration with the team members was considered most important to gain a diverse range of expertise and experiences. This was mentioned by Han, E (2023) who said that giving a difference perspective will aid in getting to the true cause of the problem.

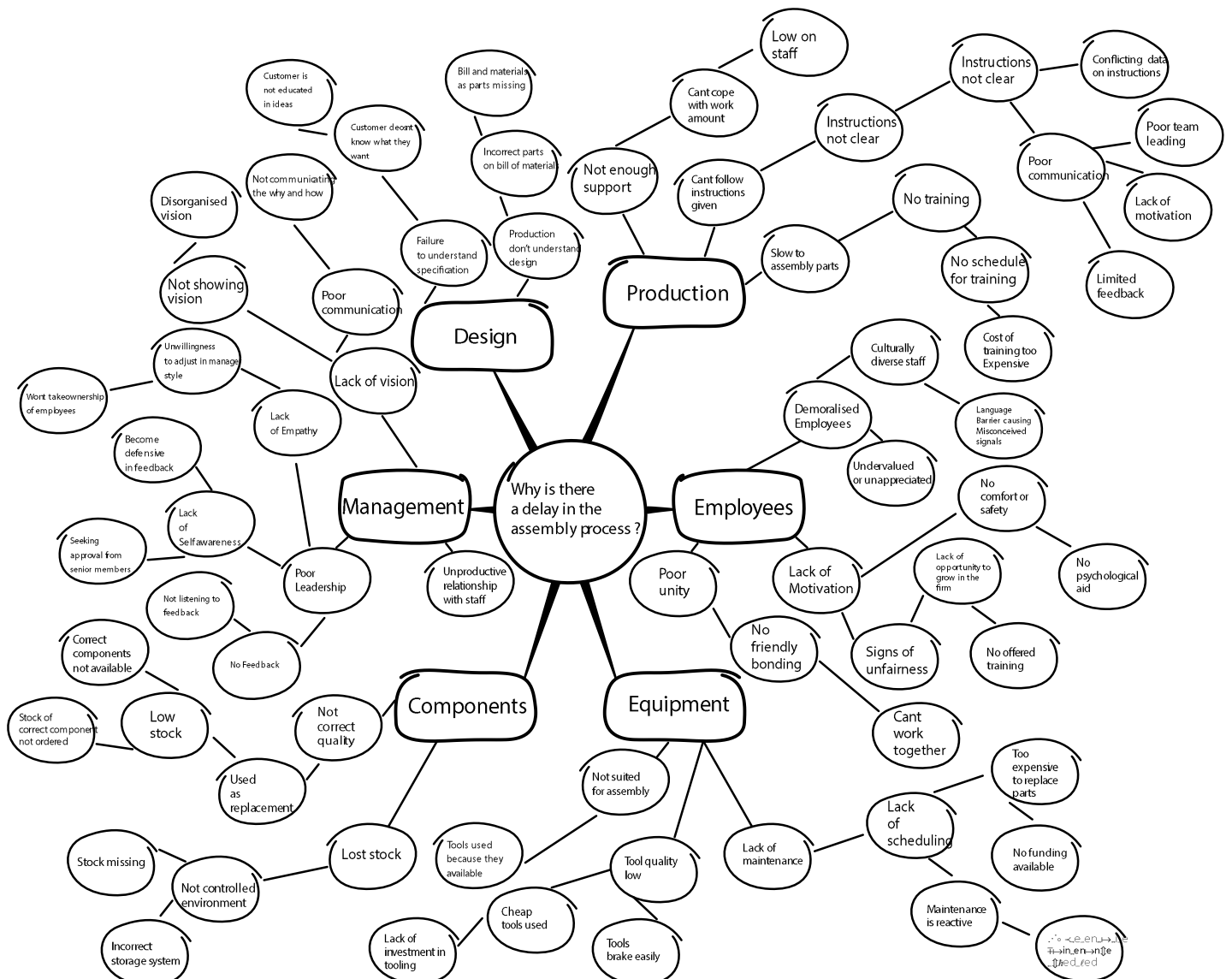
Another important aspect considered was that criticizing other areas of the organization would be unproductive and preferably avoided during the study. This was mentioned by Han, E(2023) who emphasized creating a blame free culture so that that employees can openly share their insight.

When studying the root cause analysis, brainstorming was the first tool to be implemented which Goerge, M.O (2010) described as giving a large pool of potential causes to invent range. When using the brainstorming method of problem solving for a team, the aim is to gather quantity rather than quality information and avoid judging people's root cause answers, as specified by Brainstorming by Wilson, C (2013).

An important aspect not to be overlooked was the correlation between the process steps and customer requirements, with their importance ranked. This was done through using a cause-and-effect matrix which provided a method of mapping out how value is transmitted from input factors at X's to the product output produced at the Y's, as Gygi, C (2016) stated. This method was used because it enabled the team to understand the priorities when assessing the inputs and outputs of the company.

Cause & Effect Matrix & Brainstorming

Product Cause and Effect Matrix (Pareto Data Driven)			Rating of Importance to Customer (Rating Scale of 1-10) >>											
			10	10	8	8	7	10	8	7	9	8		
Step	Process Step (Pareto DATA)	Inputs	Output (Y1)	Output (Y2)	Output (Y3)	Output (Y4)	Output (Y5)	Output (Y6)	Output (Y7)	Output (Y8)	Output (Y9)	Output (Y10)	Weighted Total (Do Not Edit Formulas)	Percentage Value
	Product Assembly	Building Product quantity within given time frame	1	3	3	0	3	3	3	9	9	1	291	27.20%
2	Stock Control	Control all components used in Assembly process	1	3	3	0	0	3	0	0	3	1	129	12.06%
3	Quality Control	Inspection of Product components and after assembly	0	0	0	3	0	3	3	0	3	0	105	9.81%
4	Product Finishing	Coatings and spray painting pre assembly process	0	3	0	3	0	0	1	0	0	0	62	5.79%
5	Sales Transaction	Receive customer payment for product	0	3	3	0	0	0	0	0	0	0	54	5.05%
6	Design Stage	Create bill of materials for assembly and components if needed	1	3	1	3	0	0	1	1	1	0	96	8.97%
6	External MTG	Manufacturing processes that could be from Machinists or injection moulded parts	3	0	9	3	0	0	0	1	3	0	160	14.95%
7	Material Order	Supplier who is responsible for ordering external components	0	0	0	0	0	3	1	1	3	0	72	6.73%
8	Customer Order	Purchase order from customer	3	3	1	0	0	0	0	0	1	3	101	9.44%



Ishikawa Diagram

Subsequently, the next tool used was the Ishikawa diagram which combined elements of both brainstorming and systematic analysis. This was used by the team to further understand and then systematically evaluate the causes, as described by Andrewson, B (2006). The Ishikawa diagram started when the team defined the problem to correct identify the causes. It had been established that the bill of materials was causing delays in production. This problem was placed at the 'fish head' of the diagram and the team identified categories that related to the problem at that stage in the project.

Some tips on calculation on the fishbone diagram are described by Croft, D (2023) who stated that inviting other members outside the team can lead to more input and greater feedback. The goal was to get close enough to the root cause so that most members could be in agreement and not to select areas where there are only symptoms of the problem.

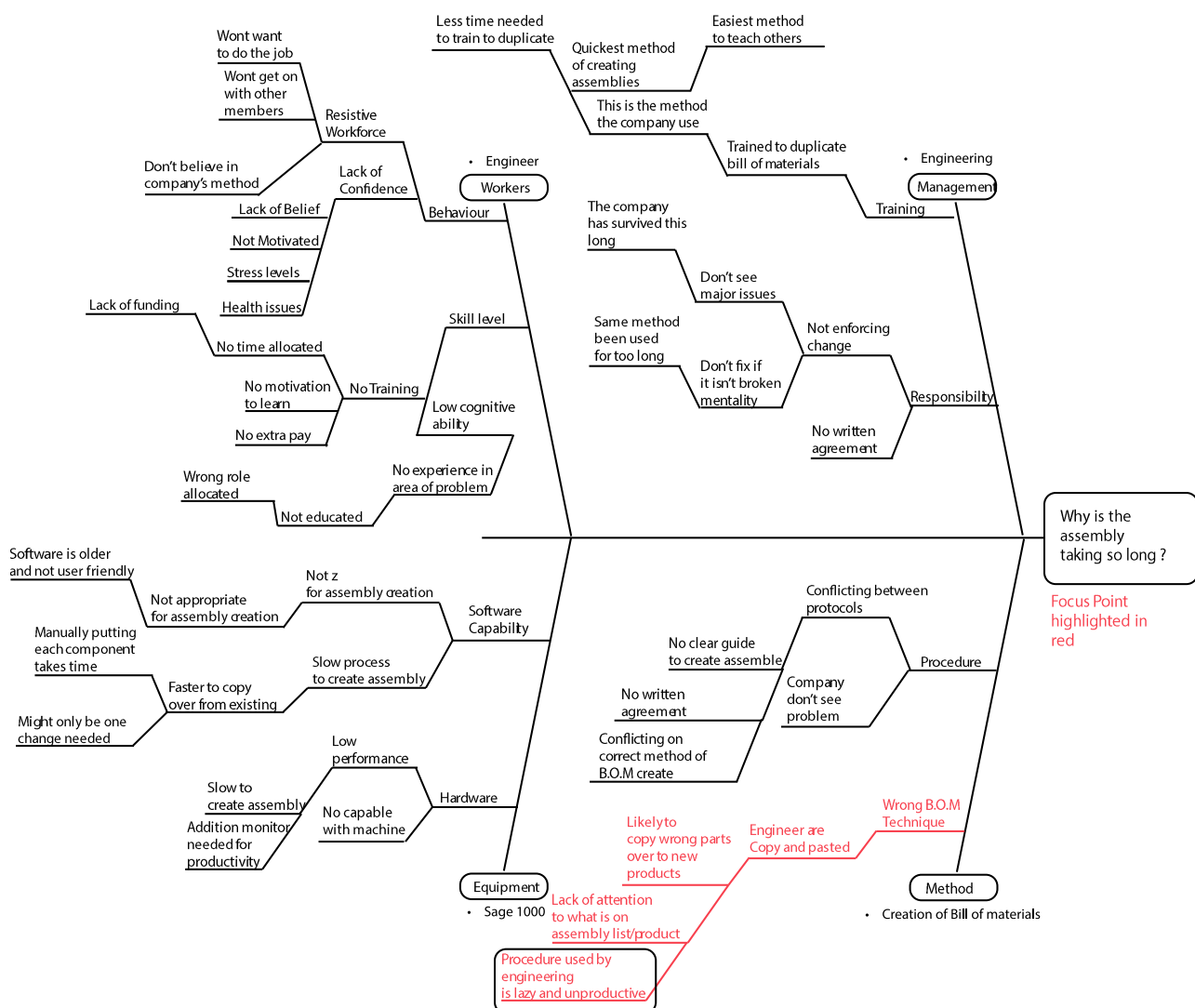


Figure 4.5 Ishikawa Diagram – Red Section Showing Area of Focus

5 whys & Tollbooth

The 5 whys problem solving tool was used as an extension to what information found in the cause-and-effect analysis. The 5 whys enabled the team to further locate the actual problem within the given time constraints. By encouraging the team members to look beyond mistakes made by other members or individuals, it helped them ask why it is that this problem occurred in the first place- as stated by Channell, M (2021). This then gave employees an insight as to why the company continued to provide a service in its current form when there were clear issues that negatively affected product quality.

5 Whys Diagram					
Problem Stated in Ishikawa Diagram	Engineering Use Copy and Paste Feature to Create Products		Date :11/05/2024	Area: CAI	Part number: N/A
Primary Cause			Team Members:	Lewis Nekrews, Dave Belton, Mathew Rodgers, Josh Griffiths, Kevin Richards	
Why ?	Because its faster than inputting each separate component				
	Why ?	Not enough time given to create manually			
		Why?	Sourcing each component on system is difficult		
			Why?	Assembly list have high number of component variation	
				Why?	Incorrect Process used to create product
Contributing Problems	Lack of attention to materials list				Root Cause
Why?	No guide to contract materials list				
	Why?	No process set or sign off procedure			
		Why?	No schedule time for checking		
			Why?	Havant got time to check other people work	
				Why?	Lack of discipline in checking Procedure
Other contributing Problems	Assembly list too long to manage				Why
Why	List have too many components to create product				
	Why?	Components need common comments to assemble correctly			
		Why?	Because MRP needs to know they are required		
			Why?	Parts have to be available to create product	
				Why?	To be able to deliver product on schedule

Figure 4.6 Five Why's– Getting to the Root Cause & Showing Contributing Problems

Analyze Tollgate

Question: Have the team members fully examined and identified the bottleneck?

Answer: The root cause analysis described the bottleneck to be from copy and pasting the bill of materials.

The five whys however, came to the conclusion that the true cause was that the MRP system is insufficient for manufacturing within the time needed.

Question: Have any quick wins been identified by the team?

Answer: Quick wins were identified through team building which enabled a solution to be found. The team grew in confidence and have proven to work well together.

Improvement Decision Making

The main goal, during the improvement phase of the project, was to identify and develop alternatives towards increasing performance and then agree on an approach with the team. These types of improvements are discussed by Pakdil, F (2020), - alternative solutions are developed either by using advanced methods or by implementing modifications on a smaller scale. The data from the analysis phase was used to assist in the decision-making process regarding any improvement that would reduce variation.

An affinity diagram assisted in the suggested improvement ideas, from not only the team involved in the project but every department. It was imperative that these suggestions were not criticized by any other members as this encouraged greater participation. Debating and questioning of input was also discouraged. The affinity diagram was then used as an overview and synthesis of findings to try and focus on major insights, as described by Dam, R.F (2023).

When all possible solutions were collected, it was necessary for these to have a value added to them in terms of how effective these solutions would be in solving the problem. This method can be used when the current method was not meeting the customer needs or performing as required, as mentioned by Baxter, R (2015). The benefits of this method are to produce reduced emotion and bias in the decision-making process and is also considered a more cost-effective approach in selecting the best solution for a company. This method rates the solution from the company members to the selected customer needs. The solutions found to have the highest scoring being, potentially, the best possible solutions.

The largest scoring methods to be suggested were then assessed in a researched method called a criteria matrix. This would prioritize group potential alternatives which would then be weighed against a list of weighted factors of company importance. This is described by Butler, A (2014)- it is a much easier method to reach consensus when making decisions if the criteria are identified and agreed upon. He also makes the statement that people are much more likely to relinquish their preferred choices when they are shown that it doesn't meet the criteria required for improvement. Three methods were chosen to use for the study- short-, medium- and long-term solutions.

Solution Process-Affinity Brainstorm to Criteria Matrix

Solution Selection Matrix										
Goal: Implement successful method to reduce production time and increase bill of material accuracy										
	Low Effort	High Impact	Cost-Benefit Ratio	Acceptable time	Acceptable Risk	Resource Availability	Cultural Acceptance	Addreses Root Cause		Implement ? Y/N
	0.1	0.1	0.15	0.2	0.1	0.1	0.1	0.3		
Potential Solution	(1 No, 5 Somewhat, 9=Yes)								Total Score	
Invest in different software to make assembly easier	2	9	7	1	1	3	2	7	28	
Use a new engineering management protocol to control team	1	8	5	1	1	2	1	1	18	
Remove duplication capability, new checking procedure implemented	5	7	4	5	9	7	6	8	41	Y
Check bill of material before released by management	1	1	3	2	2	1	1	1	10	
Modify Assembly list after released to production	4	1	9	2	9	1	2	1	21	
Purchase additional aid to check assembly before being released	1	8	1	9	5	9	2	4	37	
Lower the amount of components on assembly to improve control	1	3	1	2	1	2	4	2	14	
continue to duplicate and react quickly to problems in assembly	2	1	2	5	2	2	1	2	13	
Use AI technology to check assembly list is correct	1	9	2	5	9	7	1	9	41	
Get production to point our mistakes	1	1	1	9	1	2	1	1	15	
Create Models & bill and materials through modelling software like SolidWorks. Then transfer data into SAGE200	1	5	5	9	4	6	5	2	35	
Check bill of material before released in engineering	7	8	9	4	3	3	7	2	29	
Remove assembly list completely and stock adjust out components after completion	1	2	1	5	1	5	2	3	18	
Collect components before creating assembly to check if they are correct	1	2	8	6	1	2	3	4	25	
Bring in BARCODE scanning technologies to detect incorrect components	5	8	3	4	2	9	4	5	30	
Create check sheets to aid in accuracy	9	2	9	5	5	5	8	9	34	
Include Automated assembly process	1	9	2	1	1	2	3	9	26	
Release first and the adjust later when mistakes are found	2	2	3	9	1	2	1	1	17	
Ask customer to find own components and then we can assemble	9	2	5	5	1	1	2	2	9	
Organise a third party to control and create bill of materials	3	5	2	5	4	9	2	1	25	
Create CAD models for all products to improve visual learning	5	7	5	4	3	4	5	8	31	
Create more continuous flow method of manufacturing	5	2	4	6	2	3	5	5	22	
Reduce the amount of components on bill of materials by using automated re order system	7	5	4	5	4	5	8	9	33	Y
Create AI scanning method to check specification	8	9	5	7	6	5	8	9	41	
Training members to created better practices	5	6	4	8	2	6	5	7	33	
Employ expert manifesting team to aid	2	3	4	6	7	2	5	5	30	
Tell customer defects are unavoidable and increase lead time	1	1	1	2	2	5	4	2	16	
Employ new engineering team for fresh start and sack old team	5	9	9	5	4	8	2	1	33	
Introduce Leaner method of manufacturing using Kanban system to replace	5	9	9	5	7	8	6	1	40	Y
Copy methods used from competitors to fix issue	9	5	2	3	4	8	9	5	27	
increase working hours to increase chances of success	3	4	2	5	4	2	3	4	21	
Remove stock and externally supplier	4	5	3	2	4	2	4	1	17	
Created signed agreement to check & not to duplicate BOM	5	5	7	5	6	4	7	5	34	
Ask advise from other manufacturing forms for support	2	6	4	5	7	5	2	4	31	
Design brand new products with lowest possible assembly number	3	2	4	2	4	3	5	7	24	

Figure 5.2 Solution Matrix– Weighing the Solution to Create Three Options

Affinity Brainstorming Table						
Sales Department	Mechanical Engineering	Electrical Engineering	Management	Production	Quality Department	Stock Controllers
1	2	3	4	5	6	7
Upgrade SAGE software to assist in B.O.M	Invest in different software to make asmbly easier	Create CAD models for all products to improve visual learning	Modify Assembly list after released to production	Create bill and materials through modelling software like SolidWorks	Check Bill of material before released in engineering	Collect components before creating assembly to check if they are correct
Lower the amount of components on assembly to improve control	Use a new enigneering management protocol to control team	Ask advise from other manufacturing forms for support	Remove duplication capability's forcing manual component entry	Bring in BARCODE scanning technologies to detect incorrect components	Employ expert manufacturing team to aid	Ask customer to find own components and then we can assemble
Remove assembly list completely and stock adjust out components after completion	Check bill of material before released by management		Use AI technology to check assembly list	Include Automated assembly process		Create AI scanning method to check specification
Create check sheets to aid in accuracy	Purchase additional aid to check assembly before being released		Get production to point our mistakes	Release now and the adjust later.		
Tell customer defects are unavoidable and increase lead time	Design brand new products with lowest possible assembly number		Organise a third party to control and create bill of materials	Training members to created better practices		
Copy methods used from competitors to fix issue			Create more continuous flow method of manufacturing	Employ new engineering team for fresh start and sack old team		
Created signed agreement to check & not to duplicate BOM			increase working hours to increase chances of success	Remove stock and externally supplier		

Figure 5.1 Brainstorm – All Solutions Suggested from Employees

Criteria Matrix							
Term		Short		Middle		Long	
		Upgrade software to remove duplication capability & aid in new sign off procedure		Improve MRP system to be able to have stock available		Remove MRP from Maufacting process & intruce Kanban	
Desirable Criteria	Weight	Score	Wtd. Score	Score	Wtd. Score	Score	Wtd. Score
Long term profits	8	10	80	2	16	8	64
Short process time	6	7	42	9	54	9	54
Consistent in results	9	9	81	7	63	9	81
Easy to implement	9	6	54	5	45	3	27
Long term solution	10	9	90	4	40	9	90
Acceptable finatilly	6	5	30	1	6	5	30
Compatibale	5	2	10	7	35	7	35
Flexibility	5	2	10	10	50	9	45
Educational	9	6	54	8	72	8	72
Modifiable	5	5	25	1	5	5	25
Accurate	2	1	2	2	4	2	4
User firendly	3	5	15	9	27	9	27
Availability	1	1	1	2	2	2	2
Precise	10	4	40	4	40	6	60
Deveopment possibltys	5	8	40	2	10	4	20
High Quality	8	8	64	10	80	10	80
Reduce assembly time	9	9	81	7	63	7	63
Well researched	9	9	81	8	72	8	72
Complexity	9	9	81	9	81	9	81
Low risk	9	10	90	2	18	5	45
Potential customer growth	4	2	8	9	36	9	36
			979		819		1013

Figure 5.3 Criteria Matrix– How the Solutions Meet the Companies Needs

Short Term: Manual B.O.M Implementation

This option, chosen by the team, was considered one of the simplest methods of reducing the number of errors occurring, namely forcing a new bill and materials procedure by removing duplication capabilities. Removing this function, would change the way the engineer would perceive the creation of products and focus their attention more accurately on the assembly list.

When creating products on the company's system, the engineer needed to gather enough data on each component before inputting on the gauge build. This should result in the assembly being more accurate and ensure that all individual parts are present and in the right quantity. A correct price estimation would also be created as each supporting part would be accounted for in the final pricing decisions before releasing the product.

Minimizing the amount of rework required would also be an advantage to a correct B.O.M as this would directly impact on the waste being produced, in components scrapped, and reduce time needed to fix the problem. The enhancement of quality control would also be effective as it would stop the supplier from either overstocking unnecessary components resulting in waste increase or having shortages and risk losing customers, due to late shipments.

This manual method of creating an assembly necessitates the introduction of a new procedure, set by the team. Supporting the engineering team and employees was essential for the significant change of procedure to be successful. Workflow comparing the duplication method to the manual implementation method was further improved by introducing a checking system.

The checking process was introduced before the release of the product to the material equipment planning system. This was to avoid ordering the wrong components that would result in increased cost to the company. The product was then checked by another engineer and signed for release.

Middle Term: Optimizing Procurement Processes

Material requirement planning is the supply planning method used to help balance the inventory and schedule the production to deliver the right product to the customer on time. The company's methods were considered to contribute to the root cause as the product had proven not to reach the customer on schedule. Another factor was the inaccuracies seen in the bill of materials which could cause further problems with stock control.

Streamlining the procurement of components, commonly used in the gauge building process could prove a solution to increasing efficiency and eliminate the need for manual intervention. This was discussed by Lavelle, E (2023) who also suggested the benefits of reducing the risk of delays in production, associated with the problem suggested, which will increase customer satisfaction.

Certain components like fasteners, injection molded enclosures and glass were just a few examples of items that could be added to a cost management system. This could address any risk of delays and inefficiencies in time. With the correct data gathered of how frequently these components occur, they would then be introduced onto an automated process which could possibly reduce the risk of human error.

The principal steps of streamlining can be seen, listed below. Selecting the right supplier and negotiating the best deals is further described by Lavelle, E (2023) as to optimize the procurement process while saving money, time and leading to the reduction of risk.

Step	Streamline Procuremnt
1	Identify the components needed on a regular basis
2	Evaluate who is the best supplier needed to provide the components
3	Negotiate with supplier the terms of purchase and discuss potential discount
4	Purchase order is finalized
5	Payment is processed and invoice is reviewed
6	Order is delivered and audited
7	Record of invoices are accurately maintained

Figure 5.4 Streamline Procurement– Solution to Lower the Assembly list mentioned by Lavelle, E (2023)

Long term Solution: Remove MRP System

Rather than relying on the bill of materials to order components, a lean manufacturing method could be introduced potentially reducing the amount of waste and lowering the lead times. Materials shortages can cause delays in product delivery because the company is basing the quantity of components on assumptions. When these assumptions of stock are inaccurate, they are then changed but the reasons for the inaccuracies are not addressed. It is mentioned by Stakeholders, R Van (2013) that Deming's funnel experiment explained this, where making changes to a process can have adverse effects without studying the possible causes.

Kanban is a visual project management method only considering the actual consumption of materials and is designed to simplify the management of inventory. The lean system is explained by Gross, J.M (2003) who explained that the aim is to control and reduce the cost of storage of materials, increase the amount of available components for assembly and reduce the production downtime.

Comparing MRP to Kanban is described by Deloin, A (2024) who stated that MRP works as a push flow process and Kanban is pull flow system. The MRP system relies on accurate technical data and often requires adjustments in decision making, leading to unbalanced stock. The Kanban does not rely on any sort of forecasting to decide when to purchase components and relies on actual consumption to trigger reorders. This can reduce the amount of inventory to what is required "just-in-time" further mentioned by Gross, J.M (2003).

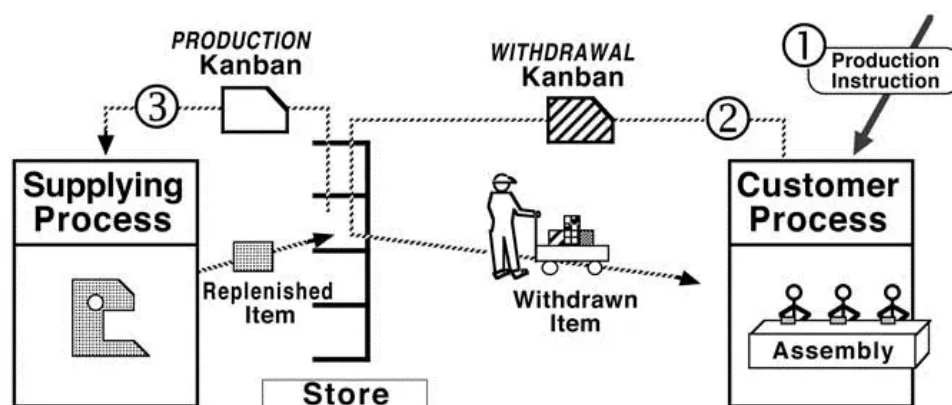


Figure 5.5 Kanban System Illustrated from Deloin, A (2024)

Failure Modes

The improvements explored by the team meant there was a possibility of failure and awareness should be made of what could go wrong during introduction. The company may be challenged by the change in assembly creation due to the amount of effort and knowledge on components needed for product success. Lack of experience in sourcing the correct components, leading to inaccuracies in product creation could be recognized as failure mode. When copying the bill of materials over to a new product, much of the process is already complete and the employee may be unknowledgeable in how to correctly apply these methods.

In the same way, failure mode could also be the unwillingness to learn, causing a detrimental effect on the engineering team performance. During the adapting period, employees could become frustrated with the new process and consider it time-consuming. This could result in disciplinary action for this employee who may be reluctant to change and, as according to Miller, J (2022) a poor employee is regarded to be worse than no employee.

Failure to simplify the MRP could also have some potential failure occur when determining what components should be added to the automated renewal system. Considering the bill of materials have proven to be incorrect, accurate determination of what parts are regularly in demand could prove challenging. There is also the potential failure of losing business to a regular customer which would mean ordering more stock than required and the automated system would need to be adjusted quickly in order not to incur losses in revenue.

The long-term solution of removing the Kanban system can also have failure modes. One of the failure modes is overreaching, which can occur if the company tries to implement Kanban on too large a scale. This would require, as mentioned by Radzikowska, A (2001) a level of organizational maturity and experience with a specific Kanban practice. Anything with a larger scale will require a deeper organizational maturity. Starting the Kanban system in a smaller section of a specific gauge build helps develop a culture of small improvement rather than what Radzikowska, A (2001) mentions as- big bank changes.

Cost benefits & New Process Map

Changes to a design process may initially involve increased costs to the company as the long-term benefits of getting the design correct the first time can be impactful. The Cost of missed requirements in the design process is mentioned by Tan, J.Y(2017) who concluded that by assessing the impact of changes early, the design team can correct quickly with reduced costs to the company. Initially, this meant Caerbont spending more on resource however checking and manually imputing components into the bill of material can prove to save the company money in the long term.

Simplifying the MRP system by streamlining the procurement of components regularly used in production, and the cost involved, can depend on the negotiation process with the supplier. This is discussed Kennemer, J (2023) who mentioned that negotiations involve more than just hammering down prices but balancing the cost of efficiency and quality of the components. The cost-benefit analysis implemented were direct costs which included the materials presumed to be used on regularly. The benefits are discussed by Stobierski, T(2019) who suggests that it assists in unveiling any hidden costs that may occur from streamline. He also mentions the drawbacks of using a cost benefit analysis, which relies on the data being correct for it to be valid.

Lastly to be considered is the cost of including a Kanban system in the current manufacturing process. This examined the cost and benefits of only one type of build initially, as implementing Kanban onto the entire factory would have been a huge task in management and investment. Included in the cost was the training and equipment needed to initiate the Kanban process. Such equipment included containers and bar codes scanners to further assist in productivity.

The final process map would then introduce all three stages suggested for process improvement. This included the new process of engineering design of bill of materials where they are signed off by another team member.

FMEA Results & Cost Benefit Analysis

IMPROVEMENT FAILURE MODE AND EFFECTS ANALYSIS														
Item:	New BOM creation process				Responsibility:		Lewis Nekrews							
	MRP Simplification,				Prepared by:		Lewis Nekrews							
Core Team: Lewis Nekrews, Lee Poiner, Gavin Roberts, Dave Belton, Christine Rodgers, Mathew Rodgers														
Process Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s)/ Mechanism(s) of Failure	Occurrence	Current Process Controls	Detectability	RPN	Recommended Action(s)	Responsibility and Target Completion Date				
New Bill of Material Process, and checking procedure	Failure to adjust to new manual BOM creation	Delays on delivery	8	Lack of training on new process	2	None	10	160	Construct clear and concise guide to creating bill of materials	Josh Griffiths, Dave Belton, Lewis Nekrews				
		Customer dissatisfied	9	Lack of experience in components	5		5	225	Inform managerial staff of new change to process and organise resource and training					
		Discipline action to employee	9	Resistance to changing method	6		5	270	Suggest to employee that this method is better and should consider the chance of improvement					
	Failure to schedule time from another member to check product	Further delays on production	8	Lack of leadership to control schedule	1		2	16	Schedule meeting to discuss time needed in checking work	Josh Griffiths, Dave Belton, Lewis Nekrews				
		Might revert back to not checking product	8	Schedule proven too complex and long to implement	1		2	16						
		Checked after released to MRP	7	Stock can be incorrect or overstocking	5		9	315						
	Bill of materials still being incorrect even after checking	Further delays and cost of components	9	Not enough attention to detailed	2		2	36	Have product to be signed by members of design team to promote attention					
	Simplification of MRP	Unable to reach agreement with supplier	Customer moved to another company corrupting MRP system	7	Overstocking of components		9	None	9	567	Contract research into best supplier available and create good relationship	Janet Healy, Gavin Roberts		
			Loss of sales n	9	Could also put company into difficult position financially		5		2	90				
		Incorrect supplier selected due to poor research	Loss of time & resource	7	Cost company loss in profits long term		2		9	126				
Kanban System	Failure to train employees on system	Longer lead times to produce product	6	Could loose customer interest	2		2	24	Correct training to be organised by engineering and manufacturing mangers	Christine Rodgers				
		Staff frustration in new process	8	Could mean employees leave the firm	4		6	192						
	Not putting anything on the board	New procedure will have to be created to ensure	7	No stock available	5		2	70		Lewis Nekrews, Dave Belton				
	Kanban board has become too complex	No long term solution created due to complex nature	8	People are unsatisfied with their work due to complexity and create low morale	7		6	336	Remove board and label process with scanning bar codes system. The scanning process then signals to supplier to order more parts	Gavin Roberts, Jane Healy				
		Employees not able to adjust to new process	4		6			144						
	Labels getting lost falling off	Can loose track of component that need reordering	8	Stock loss due to lack of indication	6		6	288		Gavin Roberts, Jane Healy				

Figure 5.6 FMEA – What Could Fail with The Solutions

Estimated Cost Benefit Analysis New Short, Medium & long Term Process				
Overall Cost to Benefit Ratio: 1 to 1.73				
	YEAR 1	YEAR 2	YEAR 3	TOTAL
COSTS				
Phase Bill of materials Creation Procedure	Bill of materials Assistance Sheet Creation	£780.00		£780.00
	Sign off checklist Creation	£560.00		£560.00
	Labour time Bill of materials creation	£160.00	£150.00	£460.00
	Labour time to check and sign off	£500.00	£75.00	£650.00
	Training cost of new process	£700.00		£700.00
MRP Streamlining	Design process new schedule plan Meeting	£400.00		£400.00
	Identify needs and objectives	£54.00		£54.00
	Conduct market Research	£420.00		£420.00
	Create Procurement strategy	£150.00		£150.00
	Select new Suppliers	£500.00		£500.00
Kanban Implementation	Contact over Negotiation	£240.00		£240.00
	Performance evaluation	£75.00	£75.00	£225.00
	Training staff on new system	£800.00		£800.00
	Double Containers needed for components & bar codes	£1,000.00		£1,000.00
	Racking (mobile)	£540.00		£540.00
	Stock indicators	£120.00		£120.00
	Kitting Cases & Separators	£380.00		£380.00
	Equipment	£230.00	£0.00	£230.00
	TOTAL	£7,609.00	£300.00	£8,209.00
	BENEFITS			
	Stock Ordered	£1,500.00	£3,500.00	£4,500.00
	Saved in Bill of Material Correction	£540.00	£546.00	£1,632.00
	Time to build Product	£542.00	£542.00	£1,624.00
	Stock Control	£500.00	£500.00	£1,500.00
	TOTAL BENEFITS	£3,082.00	£5,088.00	£14,256.00
NET BENEFIT OR COST				
	-£4,527.00	£4,788.00	£5,786.00	£6,047.00

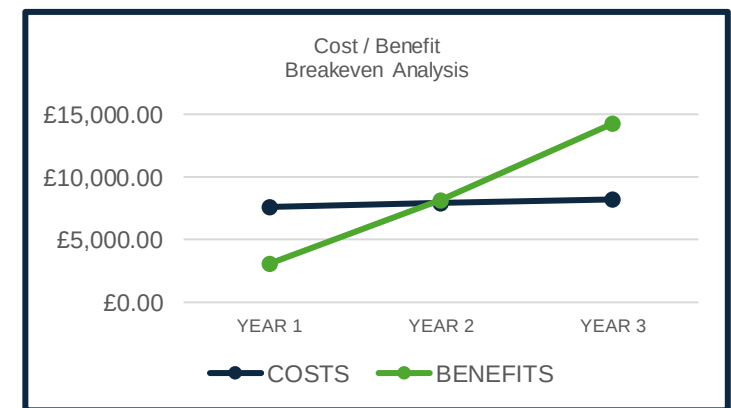


Figure 5.7 Cost/ Benefit – Showing How Long Until Profit

Process Map Long & Short/Mid Term

Short and Medium term Solution (BOM Creation and MRP)

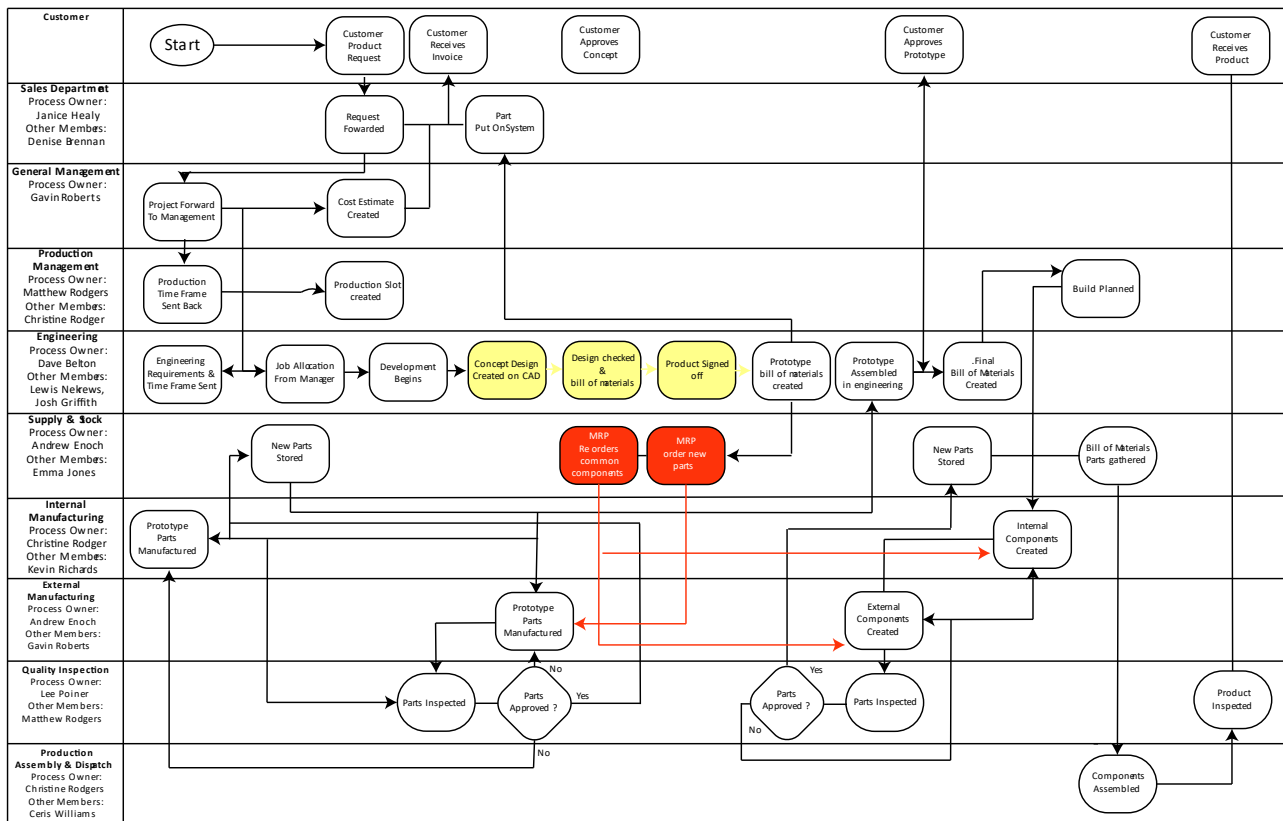


Figure 5.8 Short to midterm Process Map

Long term Solution (KANBAN System)

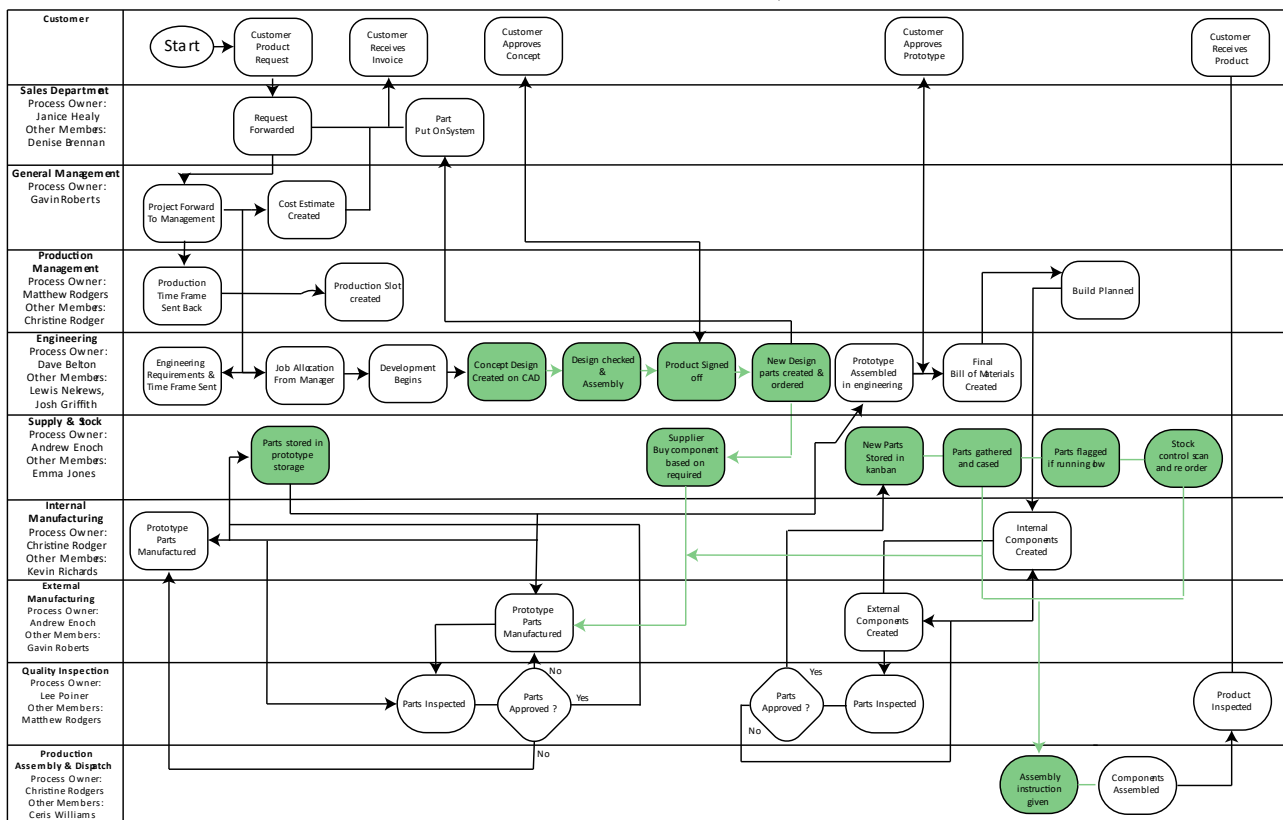


Figure 5.9 Kanban Process Map

Short and Mid-term Solution Pilot

The solution for the company on a short to mid-term basis should have a pilot plan. This would assist in getting the team involved and help them understand the schedule regarding the steps of implementation. It would also explain who is involved in the implementation and when they are expected to complete the task of improving the current process.

The first step was to introduce a new bill of materials (BOM) creation procedure. This gave the engineers a guide as to what should be placed in sequence with the gauge build. This helped the engineer, when finalizing the build, using steps from the gauge enclosure to the pointer needle. Having this mindset prevented components from being omitted on the bill of materials. Similarly, this method was used when dealing with the product description where details of the product were filled in more accurately by using the guide as a prompt. The idea of a BOM guide was discussed by Bracken, M (2020) who explained that it should be the best practice to build a BOM to suit the needs of the project and not try and shoehorn the project into a previous one. In addition, all copy and pasting of bill of material are no longer available to engineering teams with the aim of reducing the errors being created.

The next stage in planning was the development of a check sheet which would be checked and then signed by engineering management. This was necessary as the engineering management are the only ones authorized to release to MRP. This gave management overall control with the engineering operations.

The last section of the pilot examined the MRP procedure and explored how it may be improved. This improvement was implemented through a process guide. This is based on the 7 – step procurement process by Overest, M (2024) and described the importance of sourcing standards when automatically re ordering components that are regular used in production. This is with the intention of reducing the strain of MRP and simplifying the manufacturing process.

Project Pilot Plan						
Phase	Pilot Plan or task	Estimated Effort	Planned start	Planned finish	Dependencies	Employee Responsible
Short	Bill of Materials Guide Template	2 Hours	27/04/2024	28/04/2024	Creating guide when creating bill of materials	Dave Belton, Lewis Nekrews, Josh Griffiths, Andy Marks
	Check sheet and Sign off by Management	1 hours	29/04/2024	29/04/2024	Formal method of signing of products	Ceris Williams, Christine Rodgers, Mathew Rodgers
Mid	MRP simplification Guid	2 weeks	29/04/2024	30/04/2024	Reduce complexity to bill of matters by introducing automated stock replenishment	Lewis Nekrews, Ceris Williams, Andrew Enoch
Long	Kanban Systemic Implemented to Morgan Plus Six Build	3 months	29/04/2024	30/08/2024	Kanban to replace MRP and bill of material for Morgan project	Dave Belton, Christine Rodgers, Lewis Nekrews, Mathew Rodgers, Josh Griffiths, Andy Marks

Figure 5.10 Pilot Plan Long to Short Term

Pilot Short & Mid Term Layout

BOM Creation Guide		
Step	Title Description	Field Status
1	Creation of Product Code	
2	Creation of General Description	
3	Where the product is used	
4	Complied by ?	
5	Description Section	
	Size of Instrument, Type of instrument, Vehicle, Voltage input, Cathodic Protection	
	Build Type, Signal Type, Start up Routine, Range Displayed, illumination	
	Enclosure , Dial Face , Needle pointer , Needle centre cap, Bezel, Slipping	
	Dial face , Print on dial, Enclosure Finish, Needle, Bezel	
	Bill of Materials (In Build order)	BOM Quantity
6	PCB	1
7	Light guide	1
8	Light guide Spacers ♦	3
9	Dial Printed	1
10	Dial screws ♦	2
11	Pointer Blade	1
12	Pointer Boss ♦	1
13	Pointer Cap	1
14	Case Enclosure ♦	2 or 3 (Gauge Size Dependant)
15	Case Screw Spacers ♦	2 or 3 (Gauge Size Dependant)
16	Encloser Screws ♦	2 or 3 (Gauge Size Dependant)
17	Slipping	1
18	Glass ♦	1
19	Bezel Gasket ♦	1
20	Bezel	1
21	Enclosure gasket ♦	1
22	Fixing Bracket ♦	1
23	Packaging Box ♦	1
	Testing Instructions	Issue Number
	Product Instructions:	Issue:
		Change Note
		Date

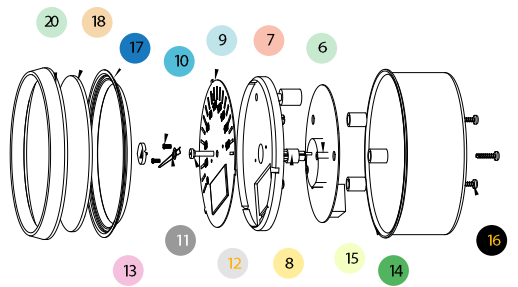
Image Guide (Generic Build)	
	

Figure 5.11 Guide to Bill of Material Creation With Colour System

Product Sign off Sheet	
	Correct y/n
Top level code follow correct product coding format	
Title description filled	
Description of build is accurate and mirror product bill of materials	
Bill of materials Quantity's & units used	
Bill of material Bin location Number is allocated for each part	
Mechanical stack up is checked and accurate for build	
The components are in order that they would be assembled	
Software is available for Product	
illumination has been tested	
Change note number is allocated	
Product introduction is included and is correct variant	
Sub assembled are correct to product	
Cosmetics and finishes are to what customer has requested	
Assembly check by	
Product checked by	
Software checked by :	
Management Signature :	

Figure 5.12 New Sign Off Sheet

MRP Simplification / Automated Re order Guide		
Sequence No.	Task	Solution
1	Identifying Needs and objectives	Goods to be included are items regularly used through product such as the marked on assembly '♦'
2	Conduct Market Research	Research into suggested components to be automatically reordered for Best potential supplier Market Trends Pricing Structure
3	Develop a Procurement strategy	Appropriate procurement method could be the follow: Competitive bidding process Negotiations Strategic part ships
4	Supplier Selection & Qualification	Assess and evaluate optical supplier based on various criteria such as : Financial Stability Reputation Quality of the goods and services Compliant and regular requirements
5	Contract Negotiation and Award	Once a suitable supplier is sources, next step is the pross engage in negotiations which involve Pricing of components Delivery schedules Defining terms and conditions
6	Order Fulfilment and delivery	Forums is now shifted towards monitoring the supplier performance with tracking and ensuring the agreement is being met.
7	Performance Evaluation and continue improvement	Evaluation of key performance indicators to help identify areas for improvement and make sure that procurement process remains aligned.

Figure 5.13 Procurement Plan (What Could be Done)

Long term solution

The long-term solution was intended to solve the problem of incorrect bill of material by removing it entirely from the manufacturing process. This also meant not using the MRP system to order components but instead using a Kanban. The implantation started with a recent project, yet to be released to product, Morgan Plus Six speedometer.

The first step was to plan the tasks required for the project and the resources needed for the process. To visualize the workflow involved, the team set up a Kanban board to break down the work needed to assemble the Morgan gauges. These were separated into work to do, work in progress and completed tasks in the building process. The idea was to keep work moving smoothly and to visually indicate the production order as mentioned by Jones, S (2020).

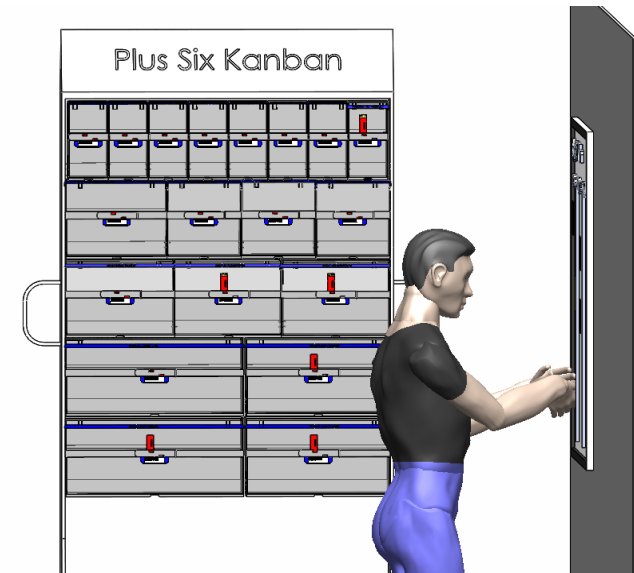
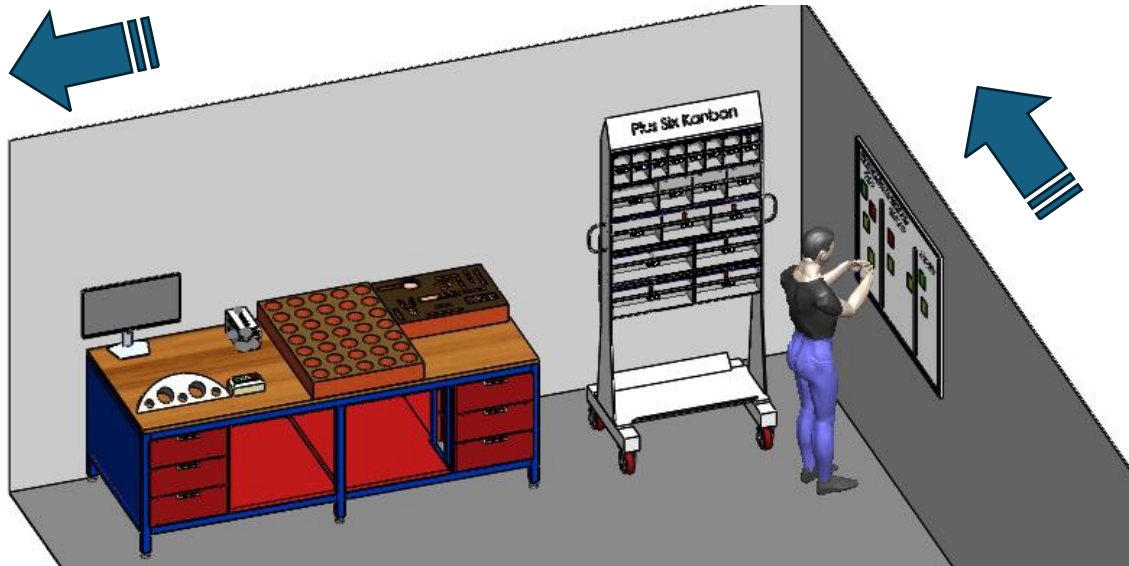
Limiting the work in progress is considered important by Kivimaa, H (2024) who suggests this will improve efficiency and reduce the amount of waste. The limit will be based on the analysis of the product workflow and typically should contain only three to five tasks within the column. The team also managed the flow of the pull system, this was to avoid any bottleneck in the production process that may cause disruption, such as parts being unavailable in stock.

The goal in implementing the pilot to the production line was to improve the time to build of the product to customers, which is the main problem identified. The company would then optimize the inventory levels and reduce the amount of waste to improve their profitability and reduce the risk of overproduction. This also initiated continuous improvement with the teams ,where they may further implement Kanban of other products and evolve the manufacturing process.

Similarities		MRP Method	Kanban System
		1. Enables inventory to be managed without paying attention to demand fluctuations 2. Not suitable when sharp demand fluctuations are typical 3. Helps keep inventory management costs down. 4. Conducive to use in an automated reordering system	
Differences	Information and goods	Information and goods are kept separate from each other (inventory [=goods] is managed according to the warehouse entry/ exit vouchers [=information])	information (kanban) and goods are kept together
	Management	Require constant inventory management (warehouse entry / exit management)	Does not require management
	Visual control	Does not enable visual control	Enables visual control
	Relationship with factory	Management separately from the factory	Closely related to the factory and factory operations
	Relationship to improvement activities	None	Decreasing numbers of kanban's indicate the need for improvement

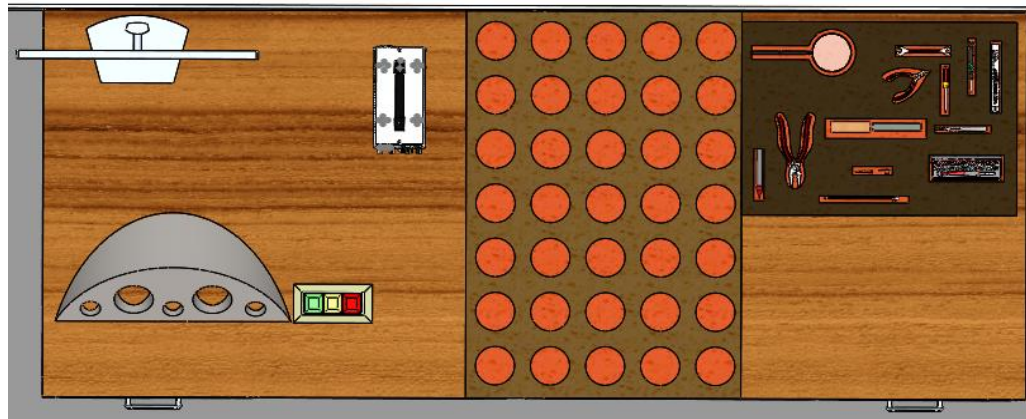
Figure 5.14 Comparing MRP/Bill of Material to Kanban System

New Kanban Map Layout



Step 1: Check kanban board for next product to build.

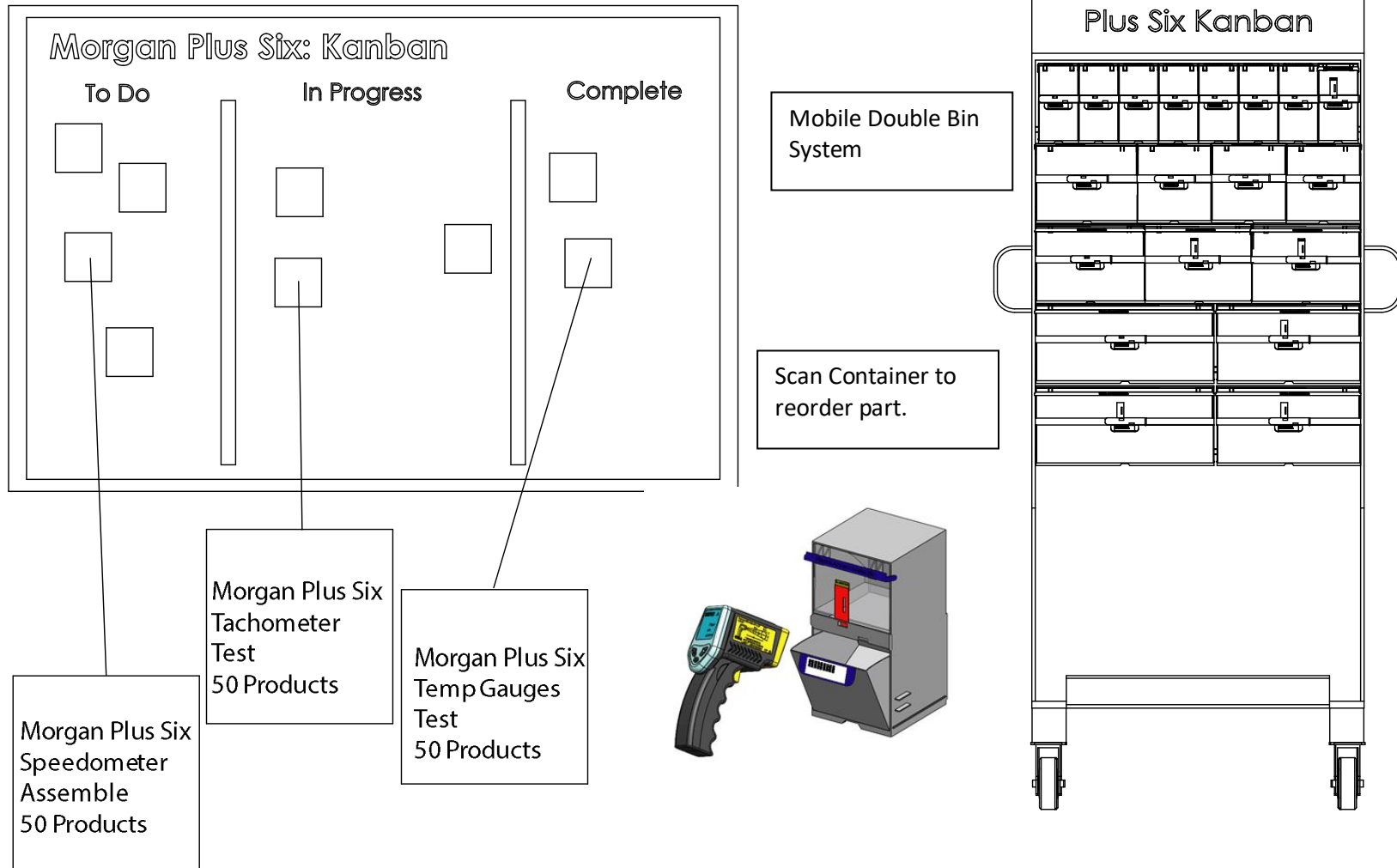
Step 2: Collect components needed from kanban mobile storage system.



Step 3: Assemble product using 5s setup where product is place into holders.

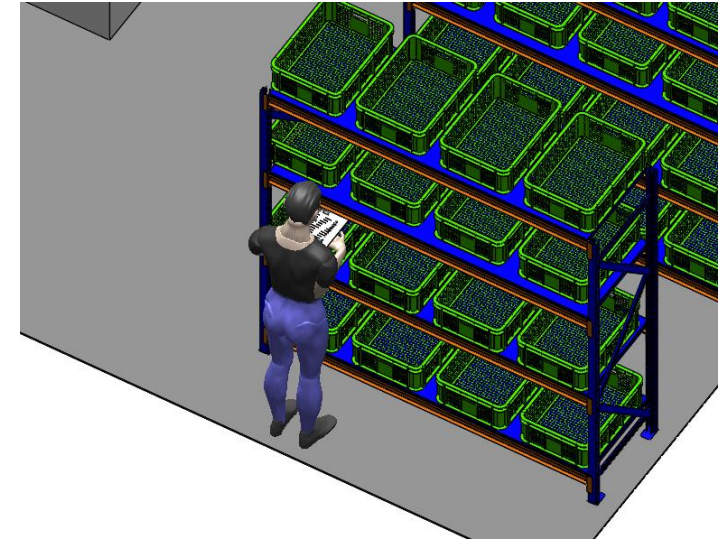
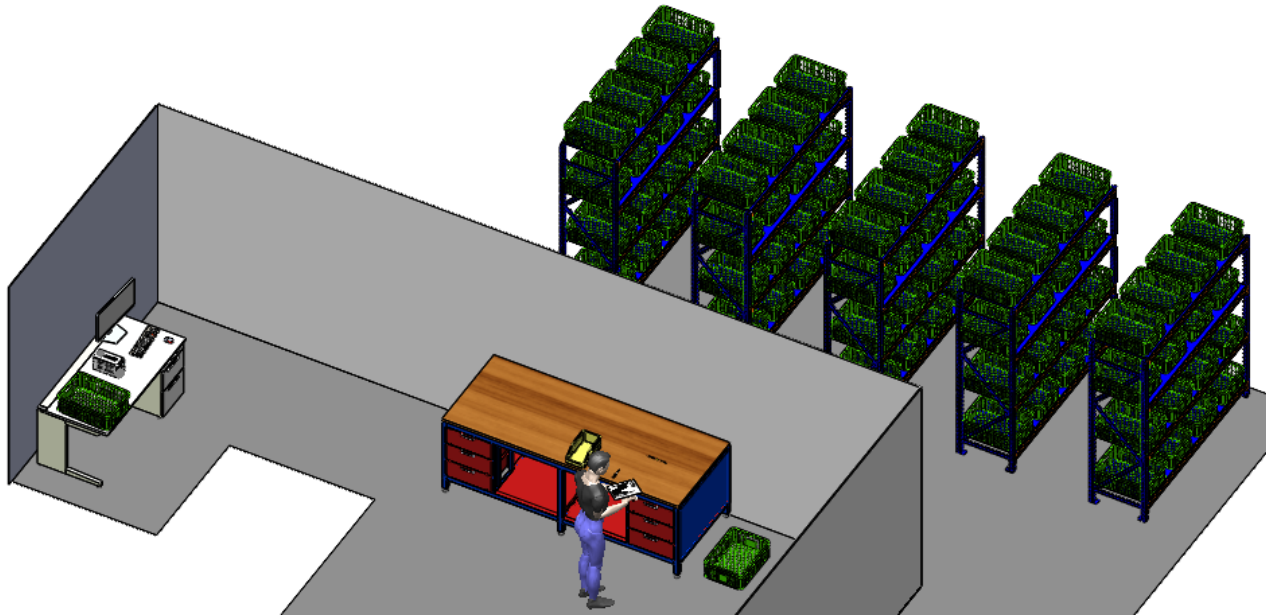
Step 4: Test product using Stop/Start CAN testing system for functionality.

Further Elements of Kanban



Current Method

Step 1: Use given bill of materials to collect components located in storage.



Step 2: Create product at work bench then place back into container box

Step 3: Product to be tested is tested in another station through programme.

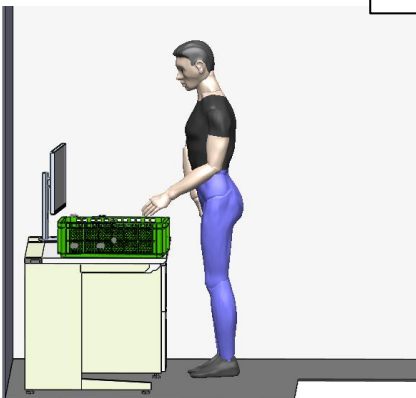


Figure 5.16 Current System of Product Creation

Long Term Solution Pilot Results

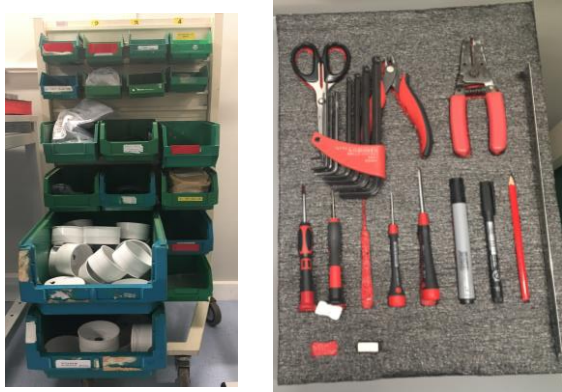
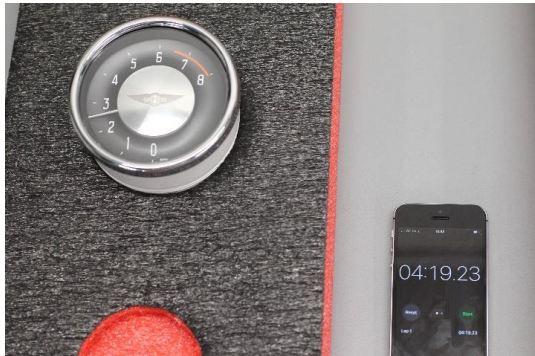
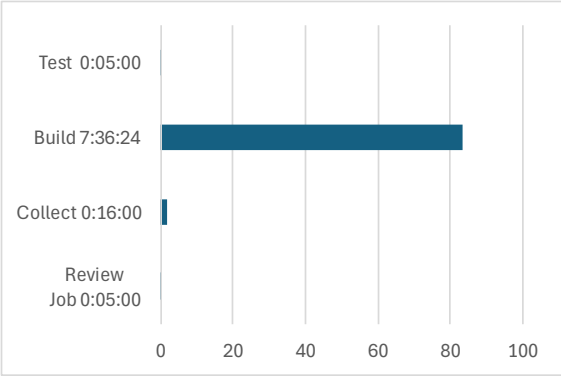
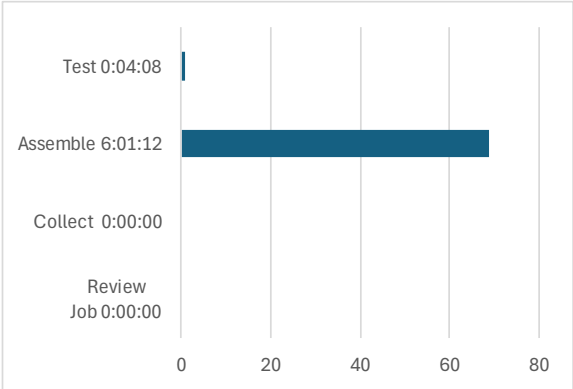
Stage	MRP System	New Kanban
Setup		
Storage		
Assembly		
Results		

Figure 5.17 Results From Kanban System

Pilot Results & Implementation Factors

The long-term objective in the improvements scheme was to reduce the time it takes to build the product. The example product, Morgan Plus Six, was used to demonstrate a leaner method that could be introduced to the company to help solve this problem. Another factor would be lessening the skill requirements of the operator whilst increasing their productivity. This was demonstrated through the use of Kanban storage system rather than using storage locations which required more time for the user to search for parts.

Some of the factors considered were the control of the process. The ability to allocate parts to specific produce meant easier stock management. The system also indicated when new stock was required and can easily reordered through a scanning device. Time to build was reduced with the new system as the workers remained almost static, as opposed to leaving their work area to search for parts, suggesting that they would be more productive. Also, the inclusion of 5S can aid in the productivity of the employee.

Cost is also an important factor when considering the proposed changes in the system. The company-controlled stock in higher quantities than required. The system of restocking only when stock becomes low could reduce the cost of control and storage of parts. Lower quantity also meant that the control of quality of parts would be easier due to the low volume, meaning less likelihood of errors. Training was the last factor to be considered and could be beneficial with staff learning new skills and methods in manufacturing.

Tollgate Questions

Questions: How did the team come up with ideas and how did they come to a solution?

Answer: The team used brainstorming methods to score their ideas through a metric then decided on three of the best methods of improvement for short to long terms effects.

Question: How will the need for change be explained to the stakeholders?

Answer: Explain to the stakeholders how this will benefit them and how it could fulfill their needs. Define clearly the change and the vision of the team, together with the opportunities it presents for the company.

Control: Long Term Solution Only

During the control phase of the project, the team would have successfully implemented lean methodology to replace the existing material requirement planning system. The objective of this phase is spoken by Wiesenfelder, H (2024) who states it ensures the gains obtained from the improve are maintained and also concerns the standardization of the new improvement. Introducing lean methods into an environment is regarded by Hines, P (2011) as a work lifestyle to stay lean and not to just survive during manufacturing.

To avoid compromising the new system, by reverting into long lead time delivery dates and returning to a survival state, it is important to understand the risks involved during the introduction of lean methodology. A manufacturing environment may have relied on the same methods for over fifteen years according to the BOM creation dates. Transiting to Kanban relies heavily on the members discipline and self-regulation. This is described by Leopold, K (2015), who discusses how the team may become complacent or move away from the best practices which would impact on the overall results.

Another risk to be considered concerns the visibility and access that management have on the Kanban board. It could be considered unproductive for management or a team leader to be unable to continuously monitor progress. This is mentioned by Novkov, A(2019) who suggested that a digital kanban system would be the ideal solution to give management better visual updates and keep an eye on progress. Novkov also discussed risks in the work breakdown and mentioned the concern of structuring work in an agile method, which can prove challenging with the issues in connecting board cards to the project.

This may cause confusion with the production team in the current project and further disruption to time- to- build goals. A portfolio could be used to aid the organization of deliverables by adding a workflow lane onto the board to help prevent disorder.

The final risk to mention concerns the capability of moving the kanban to more challenging areas of production. The complexity of these certain areas can prove difficult to appreciate with the small workforce of staff members at CAI available to train. The solution would be to concentrate on one section at a time when implementing this solution and supporting the manager with the changes.

Control Phase Schedule				
Process Step	Method to use	Method Instructions	Employees involved	Date of completion
Assess the Risks in system	Risk Assessment	1: Review and evaluate the new system & identify anywhere where may impact negatively 2: Determine the likely hod of that risk occurring 3: Decide step to prevent risk	Christine Rodgers Mathew Rodgers Lewis Nekrews	02/04/2024
Change Management	Force Field Analysis	1: Define the objective of the new system 2: What are the driving forces 3: what are the forces restraining ? 4: Evaluate forces and create action plan	Gavin Roberts Lewis Nekrews Josh Griffiths Dave Belton	03/04/2024
Step by Step Instructions	Standard operation procedure	Ensure uniform and quality out while reducing the amount of miscommunication and ambiguity	Lewis Nekrews	04/04/2024
Conduct Training for Staff	Training plan	Assessment of employees needs customise training to suit the employee needs through training metrics Use a Varity of methods of training such as On-the job & off the job training	Christine Rodgers	05/04/2024
Monitor the line performance	Key performance indicators	Evaluate performance of method through kpi, compare method to older system	Ceris Willaims Lewis Nekrews	06/04/2024
Further Lean Implementation	Rigerouse inpsctions	Concentration on supplier quality using a process and inspection feedback system	Lewis Nekrews Josh Griffiths	07/04/2024
	End of line Testing	End of line testing procedure, is inspection before shipment using visual tools	Lewis Nekrews	08/04/2024

Risk Assessment Becoming Lean (not doing lean)											
Unique ID	Risk Description	Caused by & Consequences	Risk Owner (s) Name and Role	Probability	Impact	Risk Rating	Control (s)	Control Owner (s) Name and Role	Residual Probabilit y	Residual Impact	Residual Risk Rating
1	Failure to replenish stock levels when required	Caused by: Lack of awareness of trigger calling for stock replenishment Consequences: Assembly compose to haul causing delay	Lewis Nekrews, Christine Rodgers, Josh Griffiths	Medium	Very High	Critical	Correct training and procedure put into place to ensure replenishment is established	Dave Belton(Engineering Manager), Lewis Nekrews(Mechanical Engineer), Allan Jones(Stock Control)	Low	Medium	Moderate
2	Employees resist new way of assembling	Caused by: Lack of understanding benefits Consequences: High turnover, low morale	Mathew Rodger, Dave Belton	Medium	High	Severe	Ensure to listen to what your employees have to say	Josh Griffiths(Mechanical Engineer), Mathew Rodgers (Project Manager)	Low	Low	Sustainabl e
3	Lean disintegration from lack of support	Caused by: Management don't believe the processes needs to change Consequences: Concept reverts back to original design	Gavin Roberts, Mathew Rodgers	Medium	Medium	Moderate	Significant and pervasive change throughout organisation and constantly reinforcement	Christine Rodgers (Production Manger), Emma Jones (Finance)	Medium	Medium	Moderate
4	Too many tools implemented	Caused by: Poor Planning or training in the process of new equipment Consequences: Lack of progress due to overwhelming culture change	Josh Griffiths, Mathew Rodgers,	Low	Low	Sustainable	Implement one section at a time before fully committing to lean methodology	Dave Belton, Christine Rodgers, Gavin Roberts	Low	Low	Sustainabl e
5	Struggle to maintain improvements	Caused by: lac of continuous improvements (kaizen) Consequences: Process will revert back to original form	Christine Rodgers, Dave Belton, Jan Healy	Low	Very High	Critical	Evaluate and improve process on a regular basses an ensure we are meeting the needs of the customer	Dave Belton, Christine Rodgers, Gavin Roberts	Low	High	Severe
6	Loss of initial profits	Caused by: Funds on training and education damage labour times Consequences: Lean project could get pulled and the company could enter survival mode	Christine Rodgers, Dave Belton, Jan Healy	Very Low	Very High	Severe	Market to customer and promise quicker turnaround with new method	Christine Rodgers (production manager),Jan Healy (Sales)	Low	High	Severe
7	Employees Demand more money for training	Caused by: New processes causing more thought Consequences: Employees leave if demand re not met	Christine Rodger, Mathew Rodgers	Medium	High	Severe	Support Employees and offer other benefits and certification in system methodology	Christine Rodgers (Production Manger), Emma Jones (Finance)	Low	Low	Sustainabl e
8	Lack of leadership	Caused by: New Process has created less labour demand Consequences: Bad Publicity to company for not supporting employees	Dave Belton, Christine Rodgers, Gavin Roberts	Low	Low	Sustainable	Offer other work or job within company	Dave Belton, Christine Rodgers, Gavin Roberts	Low	Low	Sustainabl e
9	Short term vision	Caused by: Lack of understanding of company's goals long term Consequences: Bad Publicity to company for not supporting employees	Christine Rodgers, Dave Belton, Jan Healy	Low	Medium	Moderate	Make sure understating of vision is clear long term with regular meeting to measure members	Dave Belton, Christine Rodgers, Gavin Roberts	Medium	Low	Moderate

Figure 6.1 Risk Assessment & Control Plan

Change Management

The integration of a new process was not only a challenge in the workplace technically but also with regard to human dimensions of transformation. Change management was an important factor in the report because it complemented the lean methodologies by engaging employees with the changes and thereby minimizing resistance. Transition into lean, as discussed by Murali, L (2024) is one of the risks mentioned in risk management and by using change, can identify the direction needed for smooth transition.

The control phase in DMAIC involved sustainability and reinforcing the results making it a permanent solution. Resistance to the new process by staff members was possible. Ignoring the human factors of emotions are suggested by Kempton, L (2023) to cause humans to resist change and then cause the resulting change to fail.

To understand resistance, the ADKAR model was introduced. This was created by Prosci (2024) the acronym being awareness, desire, knowledge, ability, and reinforcement. This tool addressed the challenges of engaging the employees and helped them understand why this change was important for the company. This focus was to drive individual change and enable organizational results to be achieved. The advantage of using this method is further mentioned in the book 'The ADKAR Advantage' by Ball, K (2024) which explored the adoption of a new mindset around change and how to create actions that will then guide and encourage sustainable change.

Furthermore, another type of diagnostic instrument, suggested by Croft, D (2024) is the force field analysis created by Kurt Lewin in 1940 and considered a cornerstone in understanding and managing change in organizations. He further suggests that understanding the forces driving change and the restraining forces can create clarity in complex processes. Such driving forces could be seen to be the growth of the company and a step closer to creating more flow in the gauge building process. Using a more modern approach to manufacturing could also boost the skill level of the employees resulting in another driving force. Conversely, the other side of the analysis shows there were restraining forces, one example being the ability to learn a new method of manufacturing after employees have become accustomed to using the current system. By identifying this on the force field analysis, the team could be prompted into action and support employees with appropriate training.

Force Field Analysis

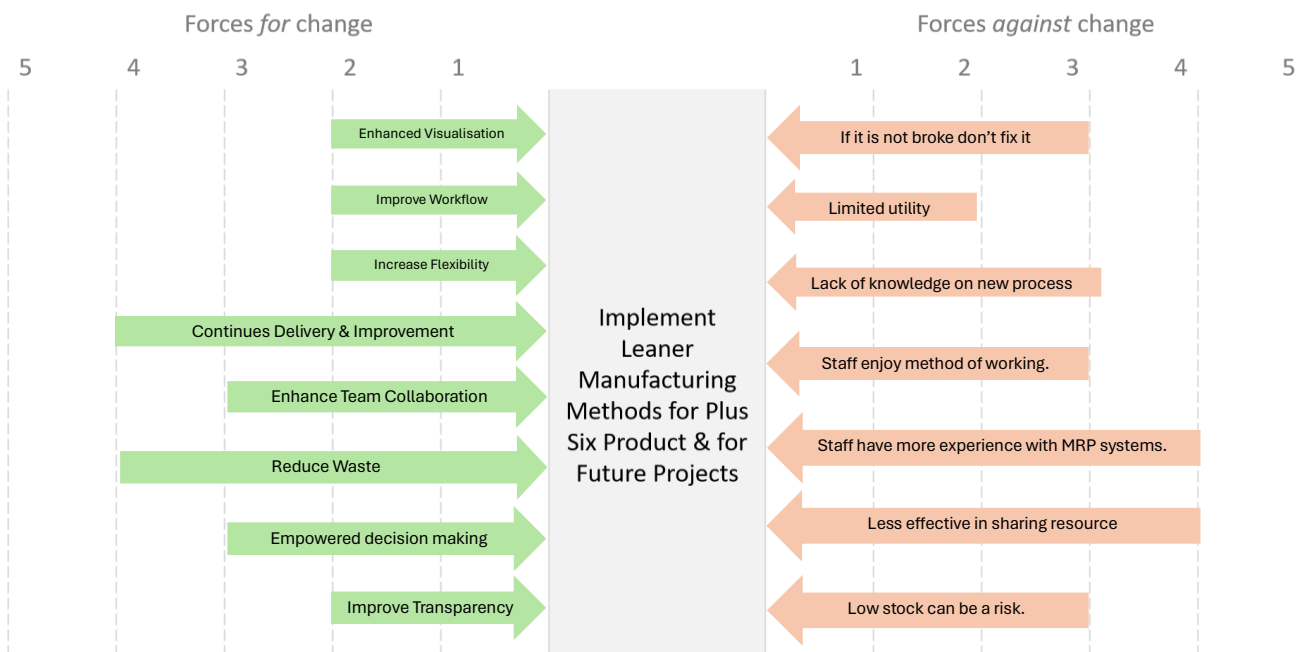


Figure 6.2 Force Field Analysis For New System

Awareness (Why change is needed)	Desire (How it helps them)	Knowledge (What knowledge is important for change to occur)	Ability (Able to play their part)	Reinforcement (The way to track and improve)
Visualise the workflow: the company can gain a clear understanding of how tasks flow at each of its stages. Help the company to see the status of items and identify the bottlenecks Limit work in Progress: The system limits the amount of work given and helps the team compile the tasks rather than moving onto to new ones meaning a reduction in multitasking	Reduce Waste: Reduce the amount of wasted resources and time wasted in processes. Enhance flexibility: Able to change prioritize or requirement quickly due to continuous improvement and flow management Better collaboration: Everyone in the team able to contribute to the task as kanban promotes teamwork and the shared responsibility Increased transparency: The kanban system aid in explicit process policies and provide a clear understanding on progress status.	Understand current process: Kanban is to do with continuous improvement and start with understand current workflow of the process Pursue incrementation and agree change: The kanban system is understanding that its starts with small changes then builds over time. Leadership is to be encouraged: Suggested improvements come from everyone involved Focus on customer needs: Expectation and the needs of the customer are prioritized to elevate the quality of the service	Service delivery: Ensure a smooth work flow is the main goal from employees as management look to help the team focus on increasing the speed and shorten response time. Service request: Interpret the customers need and their expectations and could be considered as assessing and reducing risk. Cross functional group ability: the ability to pull work from the backlog and compiling task set in a timely fashion. Communicate with each team member to ensure workflow is efficient. Provide input and feedback: Stakeholders ability to support the team and provide resources needed.	The importance of metrics: Cycle time data points can be tracked through control charts which will then show the average time to compile a assembly of the product Monitoring the flow : Cumulative flow diagram can allow members to se the flow of task across each of the stages. Improve forecasting: metric such as lead time and cycle time to give realistic deadlines and expectations to teams.

Figure 6.3 ADKAR- Ease Transition into New System

Training Plan

The kanban system was used to visualize and manage the flow of production and inventory. The previous method of training employees was by using the Push system, involving production approximation, which led to a firefighting managed environment. In contrast, the pull system is based on a just-in-time manufacturing model which relies on communication between team members through the kanban board. The transparency of the pull system allows for prompt resolution and would help the team prevent disruption. This means that training in the pull system encourages collaboration with other employees to address problems and ensures smooth workflow.

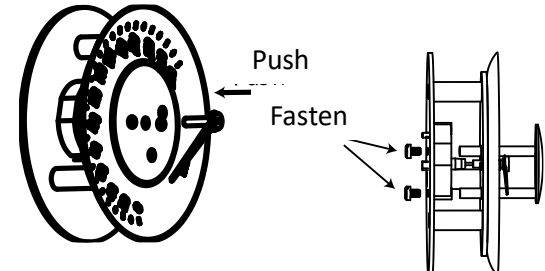
To introduce training in this system, it was suggested by Lestal, J(2024) to assess the training needs of the employees. This involved identifying the gaps between the skill and knowledge of the process of interest. Some employees may already have used a similar pull system at another firm and others may be inexperienced with the concept. A training matrix was used to collect and record information on an employee's skill level. This tool is mentioned by Koval, V (2023) who explained that it can eliminate any roadblocks in a process and can bridge the gap between current and required skills needed for the new system.

The next important step was to leverage a training format in the form of a visual guide created through SolidWorks models. The illustrations included the full assembly of the sample product, namely a Morgan Plus 6 speedometer. The guide states, concisely, how to use the kanban board, how to gather each component from the double bin system designed and lastly, how to assemble the product in sequence. This guide would be used as either a reference in training on the new line or as a point of reference that the operator can read at their own pace.

The learning objective should be clearly explained to the team involved in the line project. This is mentioned by Borwn, J (2023) who also stated that the roles of the employees and their responsibilities should align with the company's goals of creating a leaner manufacturing system that can solve the company problem. Feedback after scheduled training is also effective in getting ideas from team members on where the system can improve.

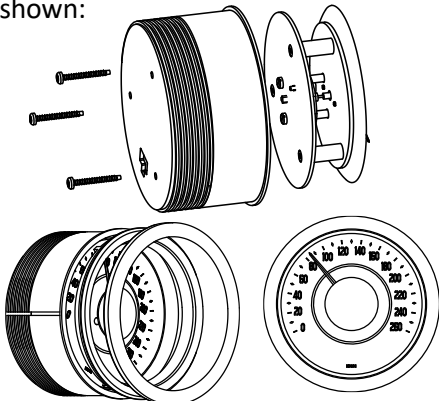
Standard Operating Procedures & Training Matrix

Step 5: Assemble parts collected as shown:



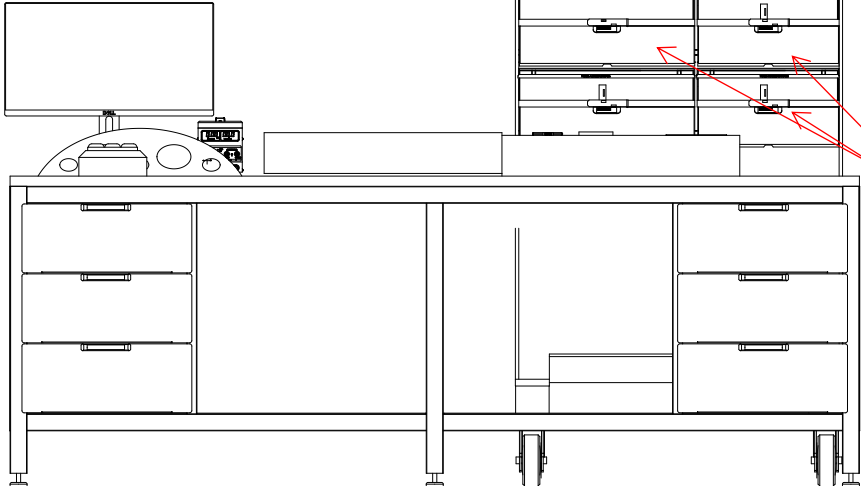
Step 4: Collect for parts labelled, pointer cap, pointer needle, pointer boss, centre cap & centre cap screws.

Step 7: Assemble parts collected as shown:

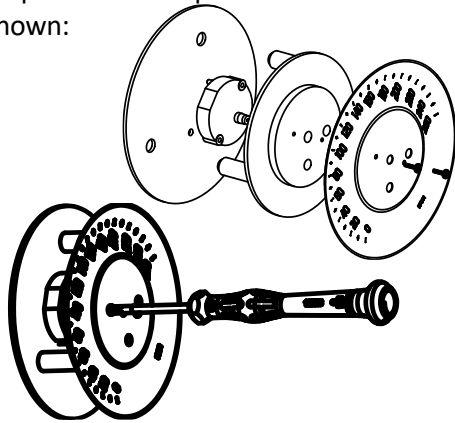


Step 8: Test product functionality then package

Step 6: Collect parts labelled: Enclosure, enclosure screws, slipring, glass & bezel



Step 3: Assemble parts collected as shown:



Step 2: Collect parts labelled PCB, Dial, Dial support & Dial screws.

Step 1: Collect Plus Six product from 'to do' to 'in progress' section i.e. Speedo

PlusSix Production line	Kanban Board													
	Kanban Board	Double Bn Storage	Assemble Product	Able to Use Ss	Test/Product	Lean system functions	Fundamental of Kanban	Production Quality std	First Aid	Team building	PPE	Scanning equipment	Health and safety	Manage Production Plan
Member														
Ceris Williams	1	2	2	2	3	2	2	2	2	2	2	2	2	0
Lewis Nekreus	1	1	1	1	1	1	1	1	1	1	1	1	3	0
Mathew Rodgers	4	1	1	1	1	4	4	4	4	3	4	4	4	0
Christine Rodgers	0	1	1	1	1	1	1	0	0	2	2	2	2	4
Kelvin Richards	0	0	0	2	2	2	2	2	0	2	2	2	2	2
Lee Pointer	1	0	0	0	0	2	2	2	0	2	1	1	3	1
Josh Griffiths	1	3	1	2	2	2	2	2	0	2	2	2	3	0
Gavin Roberts	0	2	2	2	2	2	2	2	1	1	1	1	1	0
Dave Belton	2	2	2	2	2	2	2	2	2	2	2	2	2	0
Allan Jone	0	0	0	0	0	0	0	0	0	2	2	4	2	0
Peter Wilkinson	2	3	0	0	0	0	0	0	0	0	0	0	3	0
Nina Williams	0	3	3	3	3	3	2	2	3	3	3	2	2	1
Debbie Jones	2	2	2	2	1	1	1	1	1	1	1	1	1	0
Hailey Williams	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Total	16	22	17	20	20	24	23	22	16	25	25	26	32	10
Average	1.1429	1.571429	1.2143	1.428571	1.4286	1.714286	1.64286	1.571429	1.142857	1.7857	1.7857	1.8571	2.28571	0.71429
Target	2.5	2	3	2.5	2.5	2	3	2.5	2	2.5	3	2.5	2.5	1
% of Target	45.71%	78.57%	40.48%	57.14%	57.14%	85.71%	54.76%	62.86%	57.14%	71.43%	59.52%	74.29%	91.43%	71.43%
	0	Untrained	1	In Process	1	Trained	3	Seasoned	4	Trainer				

Figure 6.4 SOP- Showing the Assembly Of Plus Six (Morgan, 2024)

Control Process

A control plan was implemented to ensure that the operations of the improvement to the line always meet the customer requirements. This is discussed by Breyfoble, F.W (1999), who described it as a systematic approach to finding or resolving out of control issues and offers a troubleshooting guide for operators to meet their targets. He goes on to state, in his study, a successful control plan should explain the strategy without the need of tampering and provide a vehicle for initiation.

The control chart was a concise and easy to read documentation that informed the team when to monitor, how to monitor and specified the target time to complete the assembly of the instrument when using the new lean method. At the end of the documentation, corrective action was also included at a process level, meaning that the employee could initiate this themselves when necessary and as mentioned by Setter,J.C (2018) it helps employees get involved with the quality process.

Additionally, it is essential that the performance metrics are monitored during the production stage to represent the workflow stability and variability when the system is running. This is suggested by Siderovara, S(2024) who mentioned that monitoring progress and the measurement of performance is the key component of the kanban system.

In this way the process can be tracked and even improved if bottlenecks were visible in the data. The first workflow metric is the cycle time, which directly measured how long it takes to deliver the task. This is similar to what was seen in the measure phase, when the time to build is low, the team is working efficiently, and higher cycle time means the process is less efficient.

Throughput was the second performance metric which measures the total amount of work delivered in a certain period. The reason why this is an important metric was because it tracks what could be achieved in a certain set period with regard to the situation at CAI , the time frame would be the eight hours shift. This can also map how often the team hit their target over a period.

The final matric of interest was the work- in- progress with all three metrics connected to Little's Law, which is the relationship between all three metrics previously stated. As shown in Equation 1, if the work- in progress is to decrease this will ultimately decrease the cycle time while increasing the throughput will reduce it.

$$Cycle\ Time = WIP/Throughput$$

Equation 6.1 Littles Law's Show the relationship Between the Three Basic Flow Metrics

Control Plan

Control Plan		
Company : Caerbont Automotive	Control Plan Created by: Lewis Nekrews, Mathew Rodgers, Josh Griffiths,	
Process: New Bezel Component/method added to assembly process	Control Plan Created on: April 2024	
Process Owner: Josh Griffiths & Lewis Nekrews		
Process Step	Assembly of Morgan Plus Six	
CTQ/Metric	Time to Build sample order of 81	Time Complete Assembly
Limit Specification	USL:6.2 hours	USL:5 mins
Unit of Measurement	Hours	Minutes
Method of Measurements	Production log file	
Sample Size	Each Batch of Products	Each Component Complete
Frequency	Each Production Phase (Estimating monthly)	Each Production Phase (Estimating monthly)
Employee	Andy Marks	Ceris Williams, Nina Williams
Record Data in	Log created by QD in MS Files	Operation log with Company Database
Correction action if required	Ensuring steps are present before problem-solving, Making sure to use correct hand tools and using the 5s System in place.	

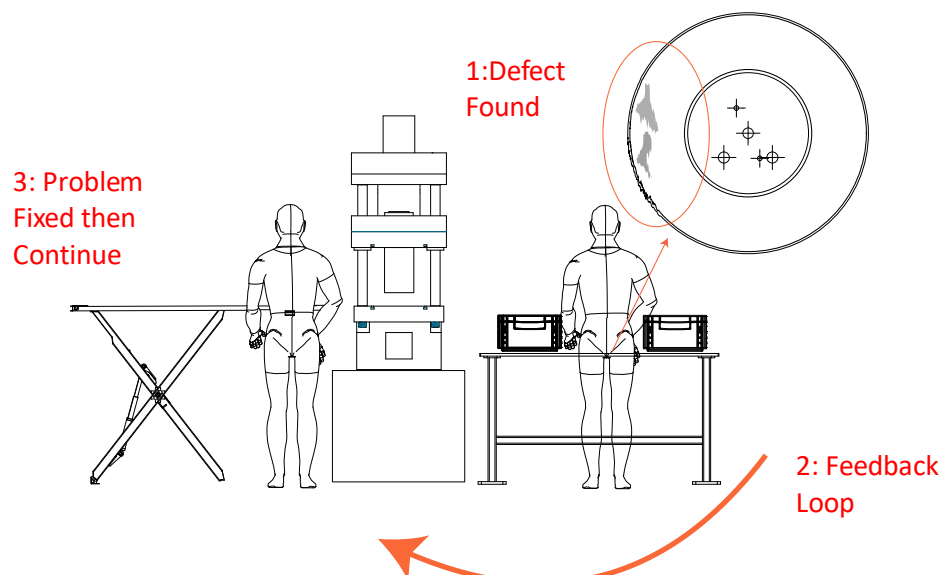
Figure 6.5 Control Plan Showing What Needs to be Monitored.

Controlling Quality: Component Inspection

The control on the parts stored in the kanban, also needed evaluation to avoid poor quality parts being integrated into the kanban system. Components created internally, as seen on the process map, needed to have the correct inspection procedure to avoid any problems. This was important when considering the kanban system runs at lower volume, potentially putting the company at higher risk of delays in final delivery. Furthermore, this would result in customer dissatisfaction and compromising efforts in process improvement.

The example chosen was the dial face of the gauge on the Plus Six speedometer. This was created through cold press tooling within the company plant. The aluminum blank component was formed into the profile of the dial and inspected using a sampling method, also referred to as judgment inspection by Shingo, S (1885). This method had the advantage of low costs to the company but could prove insufficient for the high value product. The sampling method also had the risk of making the wrong decision on whether it would be accepted or not regarding its quality, causing further problems in production. This is mentioned by Throat, S (2023) who also suggests another disadvantage of sampling would be having less information on the quality of the product rather than inspecting the entire quantity.

An alternative method of inspection, suggested by Shingo, S (1885) is to inspect each component by another member immediately following the part being pressed. This meant that as soon as a defect appeared in the component, the process would be halted and fixed immediately, limiting the number of rejects being produced. This method of controlling the quality could be introduced to any of the internal components that required attention to detail. Some components would not require as much resource in inspection due to their nature. such as fasteners which prove impractical to individually check due to the quantity required.



End of line inspection

Another area of interest was the end of line procedure. This involved checking quality after the product has been assembled and could prove a vital step in the process and ensure that customer expectations on quality are met. This could be an addition to the kanban board, with the inclusion of a inspection section. This section would mean that the product is waiting to be inspected by the quality engineer and once approved, signed off for shipment.

One of two methods of inspection could be introduced to the company end- of- line procedure, the first being manual inspection. This procedure would involve a worker inspecting the product when assembled, using checking procedures and referencing images or models of the product. One negative aspect of this is that it could cause excessive strain or fatigue in the employee which would hinder the process. This then could lead to further problems if defective goods are dispatched by mistake. Another negative is that it could slow down production when manually inspecting at a higher volume. This method could prove feasible by reducing the time needed in inspection and directing the worker to concentrate by finding only unavoidable defects during assembly such as dust particles or scratch marks from fastening. All other defects having been inspected prior to assembly.

The alternative was to use a vision system to speed up the process and not rely on human intervention to spot errors. Visual scanning systems like lumitrax by Kayance (2024) are programmed to identify patterns in products and can detect if there are any imperfections like scratches or dust that may be visible. The Lumitrax system compares the inspected component to a non-defective sample by referring to its pixelated image as featured in Figure 6.7. The benefit would be that the operator could cut down inspection time by introducing an automated system. This, however, is a more costly method of inspection, requiring training and the backing of stakeholders.

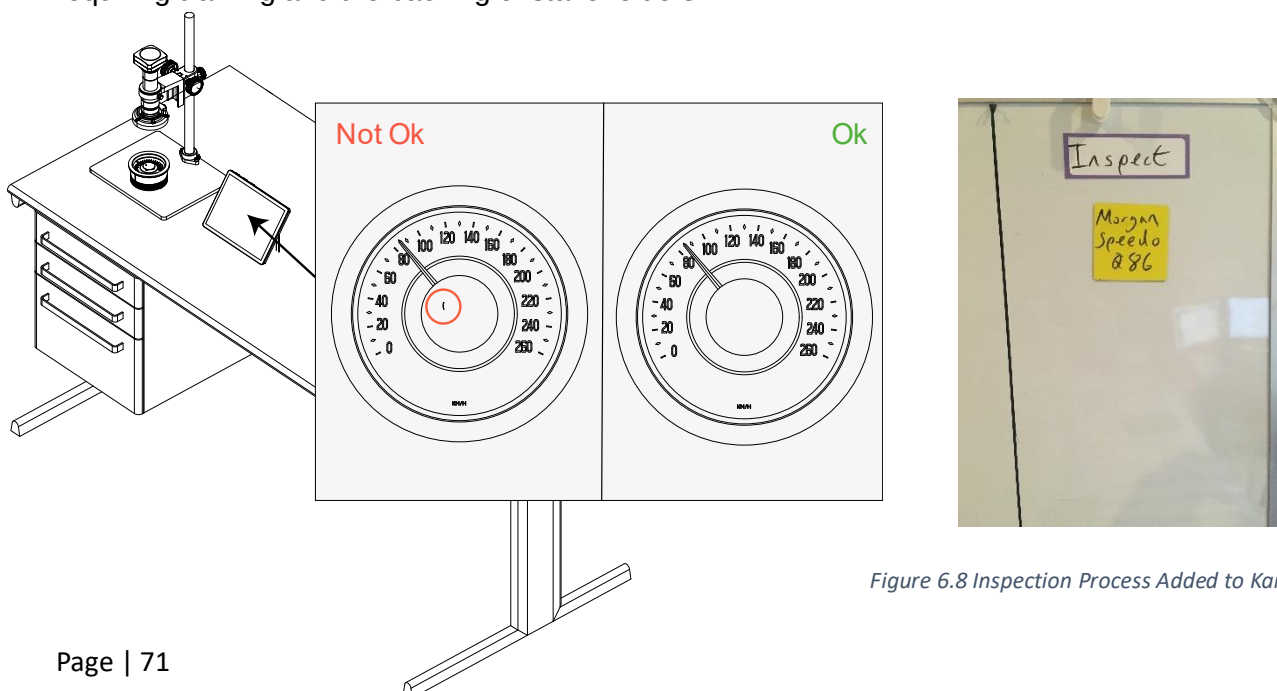


Figure 6.8 Inspection Process Added to Kanban System

Figure 6.7 Inspection Process Using a Vision System

Conclusion

The central theme explored in the project concerned process improvement in an industrial environment and focused on identifying more efficient methods to make existing processes faster, more reliable, and efficient. Process improvement aimed to find a problem within an organization and apply a solution that would benefit the company. The practice of process improvement is important in industry which relies on workflow to deliver service to customers on time. The effectiveness of operations within an organization impacts negatively on the customer when processes are disjointed and can also affect the company and hinder potential growth.

The problem presented in the report was the delay in delivering products to the customer on schedule. The collected data highlighted that up to 18% of products were considered delayed and suggested the providing company were responsible. The impact of delayed production was demonstrated to also not only affect the customer but the company's financial health and sustainability. Research further concluded that when companies effectively solve issues early in product manufacturing this can suppress any negative impact on timeframe in comparison to companies who leave it too late.

The objective was to create a permanent solution that could benefit the company long term. Furthermore, to be able to suggest better workflow to company procedures whilst enabling the company to grow in productivity and financially. Moreover, to identify where the true cause of the delays occurred within the company and further implement a solution.

The method chosen was DMAIC format due to it being useful in previously researched problems. The results indicated that when understanding the customer's needs and following translating them to the process characteristics, the definition of the problem was more precise and manageable for the project team. This identified the cause as being from errors in the manufacturing process.

The data provided further evidence that changes to the product were made after it was released into the production process. This knowledge directed the team towards gathering data on the assembly section of the organization. Finally, the last section of data collected proved that the bill of materials was associated with the leading problems faced by the company.

Further analysis suggested that the root cause of the problem was inefficiencies in the system used to create the product when the goal was to reduce the production time.

The action taken by the team was to create a solution that was feasible for the company. This involved all duplication methods to be removed from the MRP system and then attempt to reduce the bill of materials down to a more manageable size.

The long-term solution was to suggest removing the MRP and adding a kanban system. This was proven by using the Plus six method. Results for the trial showed that the kanban system reduced the time needed to create the product and thus reduced the cost.

Results in lean methodology implemented proved to have a positive impact during trial and following agreement with stakeholders, could be implemented to one product at a time until MRP is no longer required. Due to the variation of the CAI products, implantation of kanban would need large investments in resources and funding.

Control was also an important consideration as it was necessary to address any possible quality issues from suppliers or from other pre manufacturing processes such as pressing and finishing.

The study concluded that when considering a large problem within manufacturing, it is necessary to assess through sequence procedure to gain the true cause and reach the correct solution. After examining the data regarding the initial problem, the team could deduce that the manufacturing system was the root cause of the problem.

It has been shown that to thrive in a manufacturing environment, modern systems make product creation more efficient and reduce production time. Through process improvement methodologies, the company can develop its workflow and productivity, while reducing its costs and increasing customer satisfaction.

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