

REPORT TITLE: Low Volume Production Raw Material Storage & Ordering Solution

ASSIGNMENT: APPLYING LEAN TECHNIQUES

MODULE CODE: ACEA6002



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Executive Summary

The following report details a lean six sigma project that uses lean methodology and techniques to make a process more efficient. The report reviews a storage and ordering procedure for a Low Volume CNC machining department, within the company Renishaw at the South Wales plant in Miskin. The report sets about firstly understanding the process and mapping it visually using a value stream map, identifying potential wastes and suggesting and implementing solutions to limit waste.

The project was completed over a 3 month period where data was collected in the form of wasted motion to justify the requirement for lean intervention. Another critical aspect that was identified within the project was a potential health and safety issue with current material storage. The customer ordering procedure was also reviewed with suggestions to make this more efficient. This report gradually begins comparing both a current process state and a proposed future process state, highlighting the benefits of the lean solution.

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Introduction

Lean six sigma is a practice that is employed by a range of industry. In the manufacturing sector, companies are often measured on how lean their processes are and how reliable and reproducible their product is. Lean Six sigma is a combination of six sigma methodology and lean philosophy. Lean strives to eliminate waste such as physical resource, time, effort, and talent with emphasis on ensuring the quality in processes (Kenton, 2023).

Lean six sigma really began in the 20th century with the introduction of Henry Ford's model T production line. Ford really focused on making the best product possible, working tirelessly to eliminate waste and create an efficient workplace. Lean manufacturing was further developed by the Japanese, companies such as Toyota, Nissan and Honda began gaining market leadership during the 1980's. This sudden domination led other market players to invest in understanding and implementing their own lean systems to compete. Some of the techniques included the use of Just-in Time, stockless production and pull systems known as Kanban (Iuga, 2013).

Lean is essential in the manufacturing sector with constant change in customer demand, an unforgiving market environment and the ever increase of competition. Lean helps to combat the unpredictable nature of production reducing cost and improving efficiency as a result (Kovacs, 2017). Meeting customer demand is a key driver in the implementation of lean, maximising processes deemed as "Value Added" and minimising "Non-Value Added" activities ensures customer satisfaction.

Main Body

Lean Project Research

The Seven Wastes

To identify potential lean improvements in the work environment, it is important to understand what are deemed non-lean practices. According to Sheikh-Saradieh (2013) The seven wastes originated in Japan where waste was given the term "muda", developed by Taichii Ohno the "seven wastes" were used as the core of the Toyota Production System. To eliminate waste, it is firstly important to understand what waste is. The seven wastes are as follows:

- Overproduction – Producing excess product that's not ready to be sold.
- Waiting – Waiting for the previous step in the process.
- Defects – Product or service that is out of specification that will require correction.
- Extra processing – Adding value to the product that the customer will not pay for.
- Transportation – Moving items or information that is not required in the process.
- Inventory – Work-in-process not directly related to a customer's requirement.
- Motion – People, Information or equipment that makes unnecessary movement due to workplace layout or ergonomics.

There are also two other forms of waste that are identified as:

- Employees (Knowledge, skills, and abilities) – Not fully utilizing the workforce's job knowledge or skillset.
- Energy and Environment – Using more energy than what is required for the process, this can also lead to the increase of greenhouse gas emissions.

Value For the Customer

Creating value for the customer is the most important part of a business. To be successful, it is critical to listen to the voice of the customer and satisfy needs. Figure 1 show's a diagrammatic representation of the principle and goals of lean, which is critical to create value for the customer.

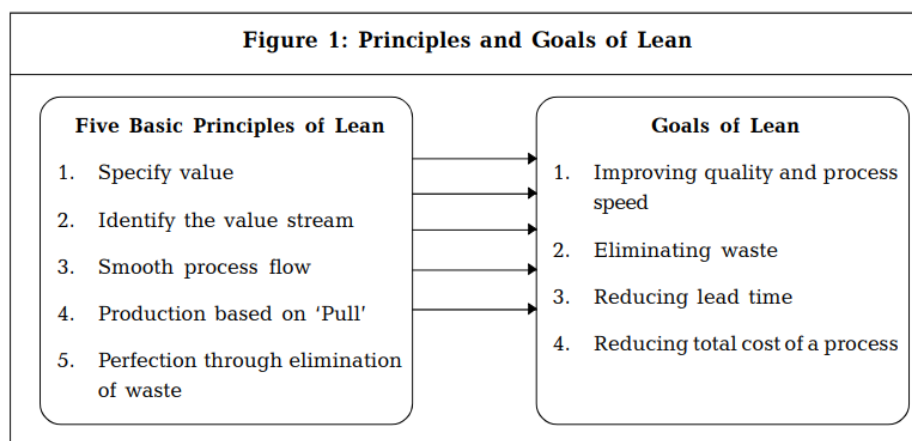


Figure 1 - The principles and goals of lean (Womack, 1996)

Value is the capability to provide the product or process to the customer at the right time. Identifying the value stream and what is adding value and what is not adding value from the customers perspective will also improve the value. Production based on pull so that the process is just-in-time not only creates value but ensures there is no inventory waiting.

Problems With Implementing Lean

There are many problems faced when attempting to implement lean techniques in industry. One of the most common problems as explained by Ulewicz (2016) is the lack of understanding the concept and principles of lean along with tightly limited resources and the affect that has on meeting orders and customer demand.

In larger companies there is also the issue surrounding the financial objectives and expectation in respect to lean implementation (Ulewicz, 2008), many companies become complacent and comfortable when there are still issues within the process. There is often higher staff turnaround which leads to reduced teamwork slowing continuous improvement (Ohno, 2008).

The Process

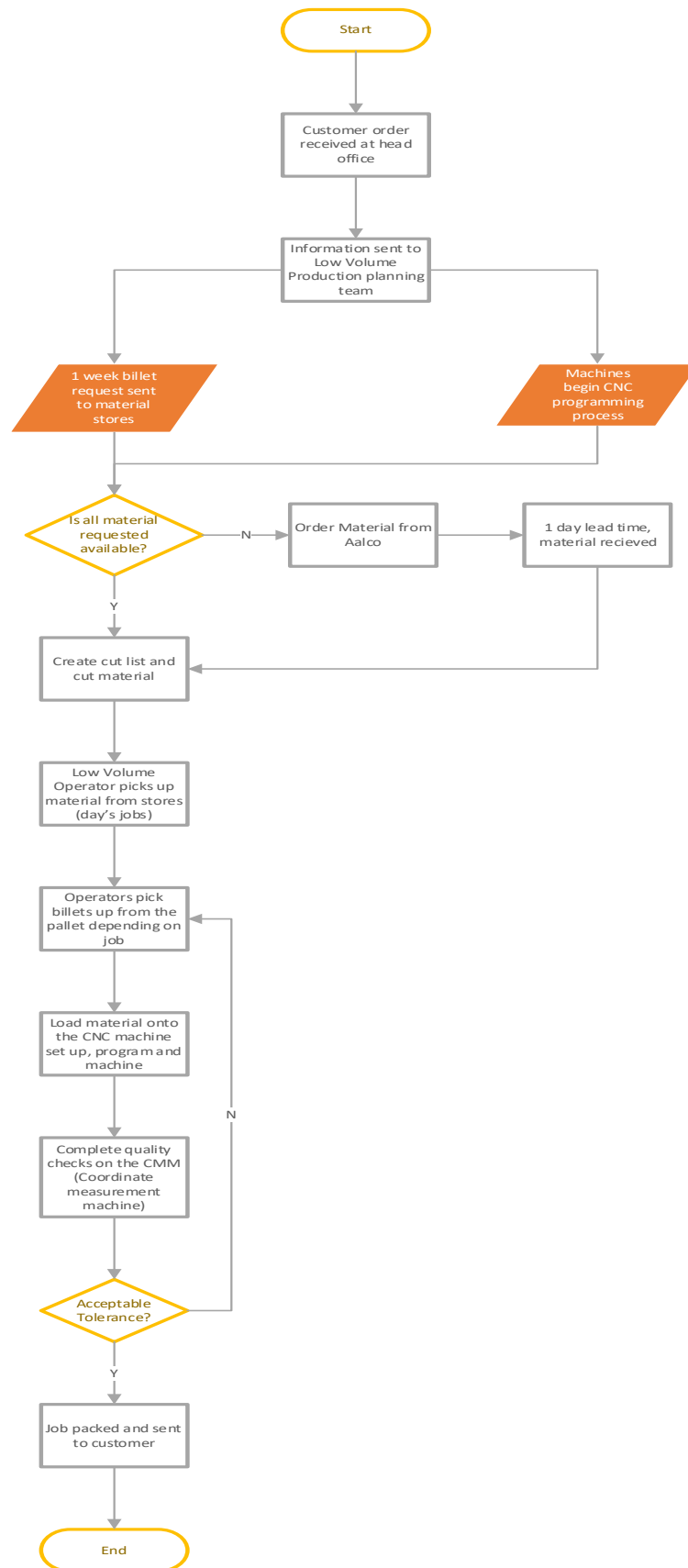
Low Volume Production (LVP) is a low volume CNC (computer-numerical control) machining department within Renishaw. The department deal with the manufacture of complex machining jobs that are requested both by external customers and internal customers (different product divisions within Renishaw). This department has been highlighted by senior management as a potential area for improvement via the implementation of lean methodology. A part of the process that was immediately reviewed was the lack of storage strategy for raw billets that were used by the operators for machining purposes. These billets were stored on the shop floor as shown in Figure 2. Not only is this time consuming for the operator to pick raw material from the pallet, but there was also a health and safety concern with the unmarked pallet storage.



Figure 2 - Current raw material storage at LVP

Current Process Map

The first step was to understand the process, a process map was established this is shown below:



Brief process description:

The process starts when the customer order is received at Renishaw headquarters, this information is then transferred to the planning team at Low Volume Production. At this point a billet request form is sent from LVP to the raw material stores at Renishaw and jobs are planned and assigned to the CNC machines. The raw material stores order any material that is not stocked from the material supplier (Aalco).

Material stores begin cutting the raw stock into billets that have been requested. An operator from LVP then takes a pallet truck and picks up the material from stores and brings it back to the department. Operators pick the material from the pallet depending on what job has been planned and program, tool, and machine the billets to the parts requested. The parts are then quality checked for tolerance on the CMM (Coordinate Measurement Machine) before being packed and shipped to the customer.

The process was reviewed with the section leader for clarity and following on from this a current value stream map was drafted to further understand where the waste was occurring.

Current Value Stream Map

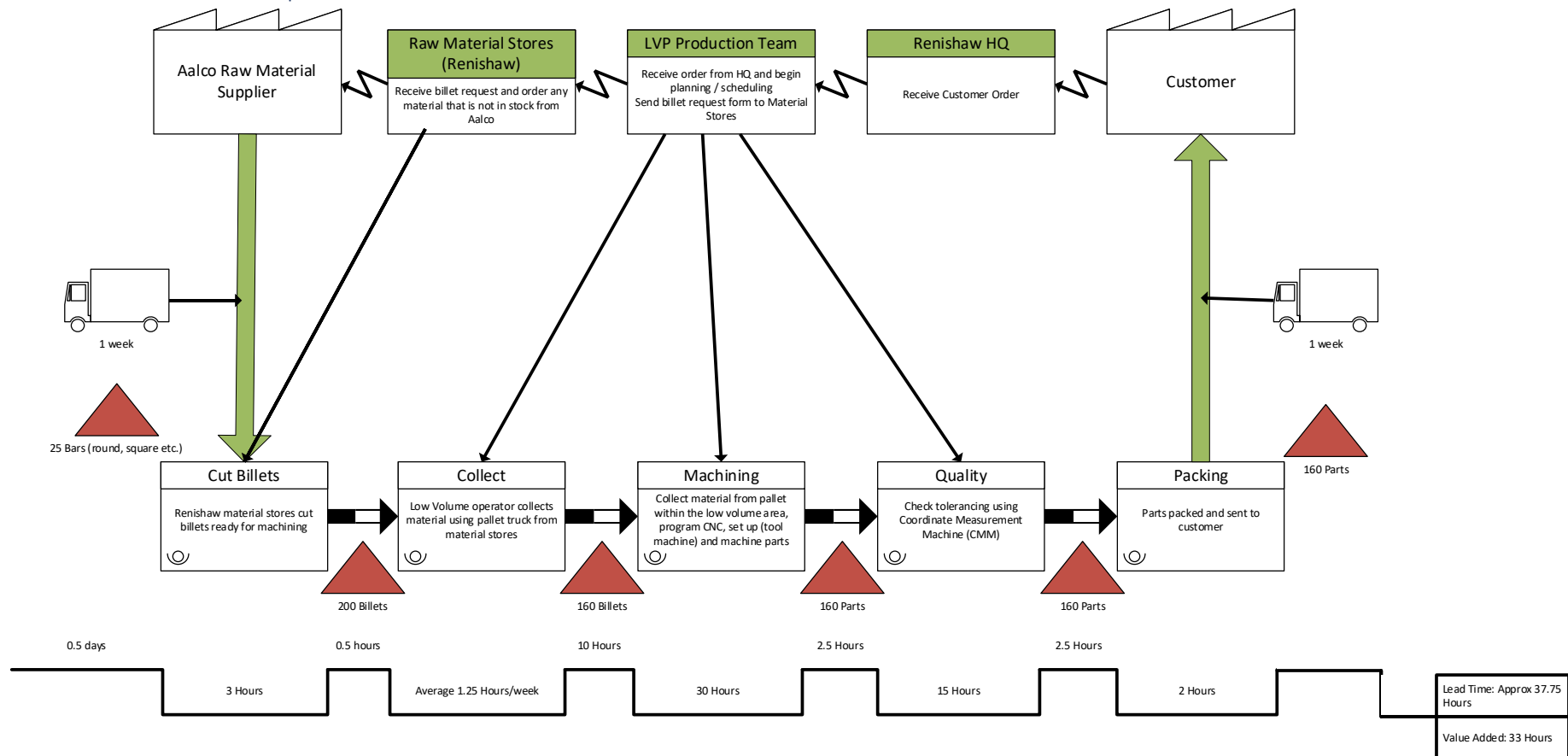


Figure 3 - Current Value Stream Map

There are 8 operators that work in LVP over 7.5 hours every day. There's approximately 60 working hours available per day, Jobs are often low quantity on average 2 parts per job (these range in intricacy). Each operator often uses 3-4 billets to machine each job to allow for a first off run and scrap allowance. 32 Billets are used per day or 160 per week as shown in the value stream map, 25 bars are delivered weekly by Aalco ranging in shape, this makes around 250 billets. The department output approximately 160 parts per week. Having calculated the lead time at 37.75 hours; senior management would like to reduce this figure.

Brief analysis of current Value Stream Map:

Takt Time – How often parts need to be made to meet demand:

Total Production / Customer Demand:

8 Operators:

(8 Hours – 0.5 Hours (Break) x 5) working days x 8 Operators = 300 Hours / 160 Parts = **1.87 hours/parts** To meet demand.

Cycle Times

Operation	Value Added (Hours)	Non Value Added (Hours)	Total (Hours)
Material Delivery and Cut Billets	3	4	7
Collect and Store LVP	0	3	3
Store and Machine	30	10	40
Store and Quality Check	0	17.5	17.5
Store and Pack	0	4.5	4.5
Total	33	39	72 (Some OT)

Process Efficiency

Value Added Time / Total Time = $(33/72) * 100 = 46\%$ adding value

Raw Material Wait Time

14.5 hours total

Total Inventory Time

19.5 hours total

Looking at the current value stream map, it is quite clear that firstly, there is too many steps to transfer information at the start of the process (Transportation). Secondly, Motion is another potential waste which includes both the distance travelled by the LVP operator to collect the material, as well as the movement to retrieve billets from the euro pallet. Thirdly, There is potentially waste in inventory, there appears to be more stock sitting in inventory than that required by the customer. Having reviewed the current process with key stakeholders, there was need to gather more data to understand the impact of these potential wastes. The main area of focus was the distance required to collect material and the method for storing the material within the department.

Current Process Layout Review

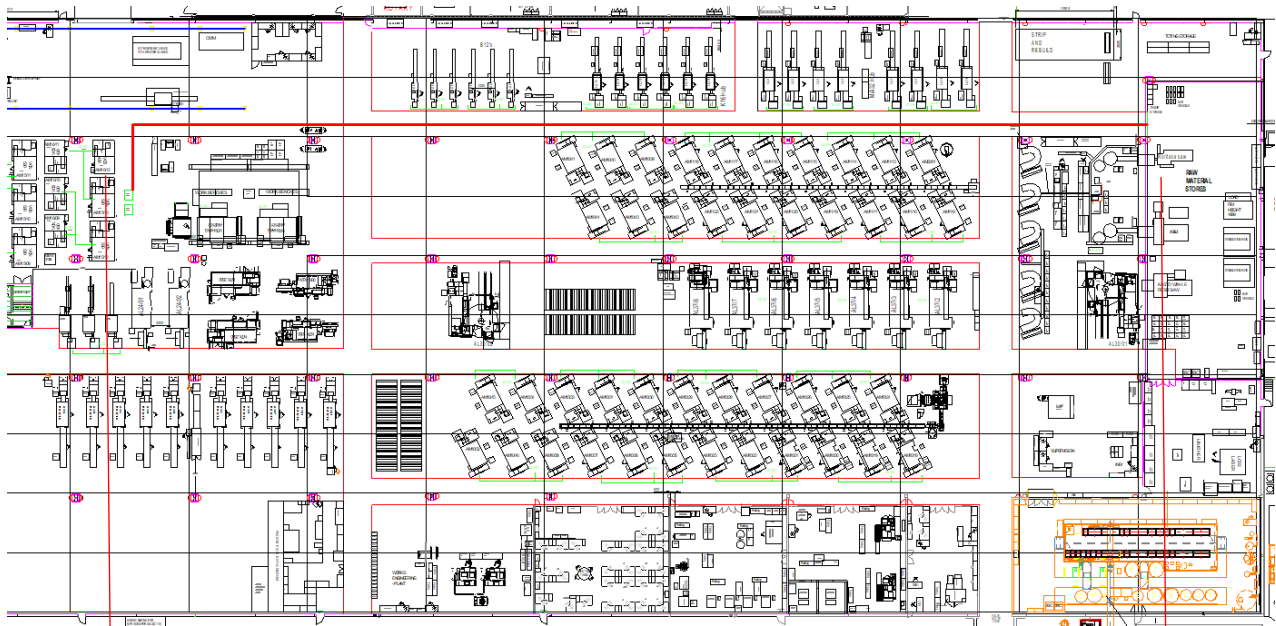


Figure 4 - Renishaw Hall 2 Layout

Low Volume Production

Raw Material Stores

Figure 4 shows the current layout of Hall 2 at Renishaw (Miskin site), The raw material store is to the right hand side of the figure, the material stores supplies all of the machining operations within hall 2. In an ideal world if there was only Low Volume and Stores then it would be simple to re-configure the layout to move LVP closer to Stores or vice-versa. A big issue (that is quite clear from the image) is the distance required to travel which is approximately 150m (Highlighted by the red distance line).

Closer Layout Images:

CMM used for quality checks

8 x Nexus CNC Machines (1 used only for prove out jobs)

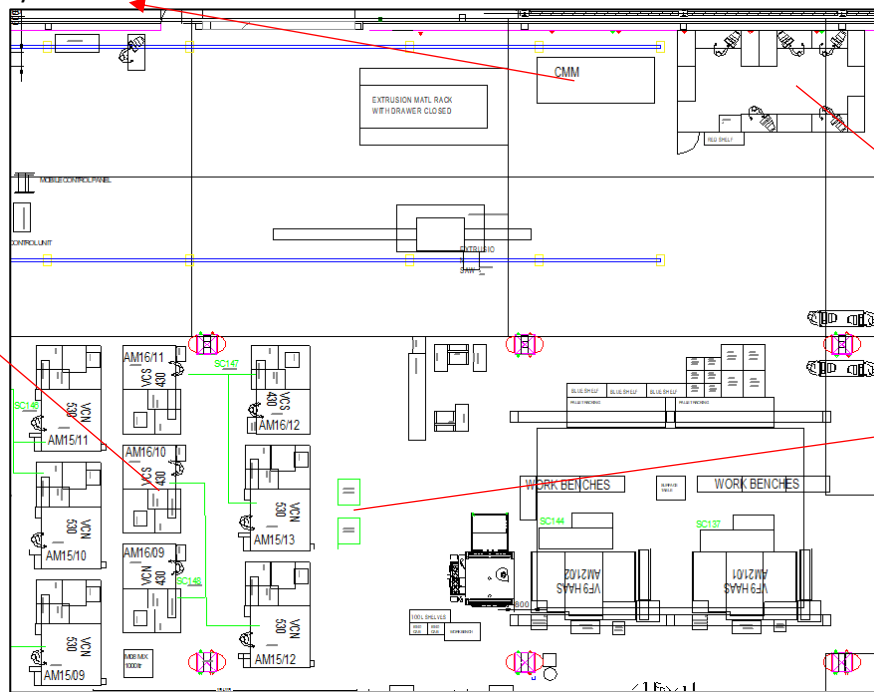


Figure 5 - Low Volume Production

Kastowin Saw for cutting bar into billets

Noritake Saw for cutting bar into billets

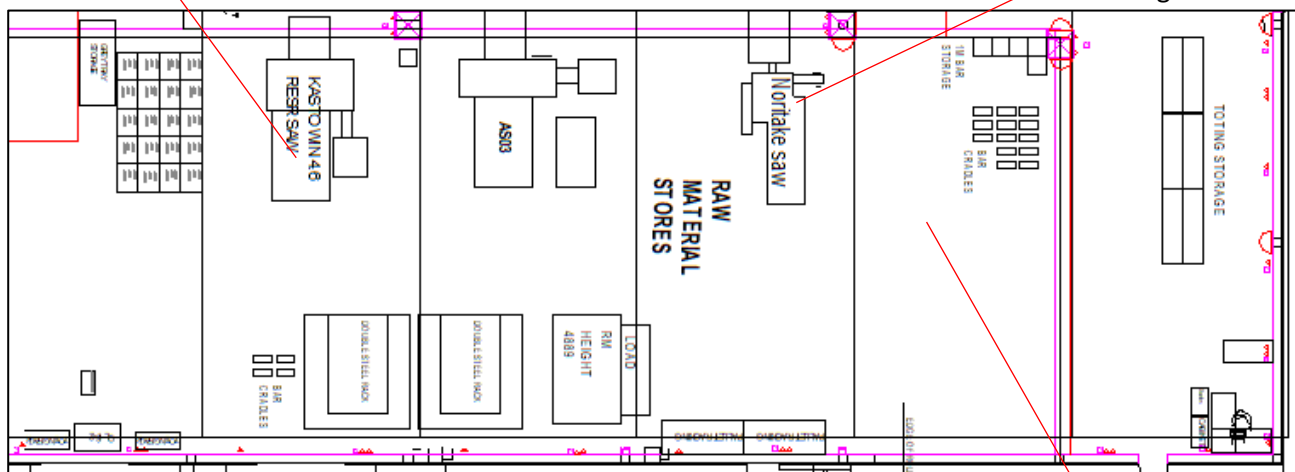


Figure 6 - Material Stores

Area where Low Volume raw material is stored for pick up.

Data Collection

There are eight operators in LVP that walk 150m to collect two euro pallets from stores (Figure 4). They cover the 150m journey four times every day. Below is a data collection plan to calculate the impact this has on the process.



Figure 7 - Marker For Data Collection

Data Collection					
Measure Title	Data Type	Definition	Stratification	Sampling Notes	Responsibility
Time Taken To Collect Material	Seconds – Continuous	The amount of time taken by an LVP Operator to pick up the daily material from material stores that is required by Low Volume Production.	This will be measured by an individual every morning using a stop watch and marked out distance lines as shown in Figure 7.	Taken every day for 8 weeks.	Ryan Harris – Process Development Technician

The raw data collected over the eight weeks is illustrated in Appendix 1. Below are two graphs that display the data. The average cost per week across the eight weeks was equal to £48 and the average time taken per week 8922 seconds or 2.5 hours spent collecting material. These figures don't include the time spent searching for the material on the euro pallet or the distance travelled to the machine. This information was fed back to senior management and key stakeholders who decided that the process required lean Implementation.

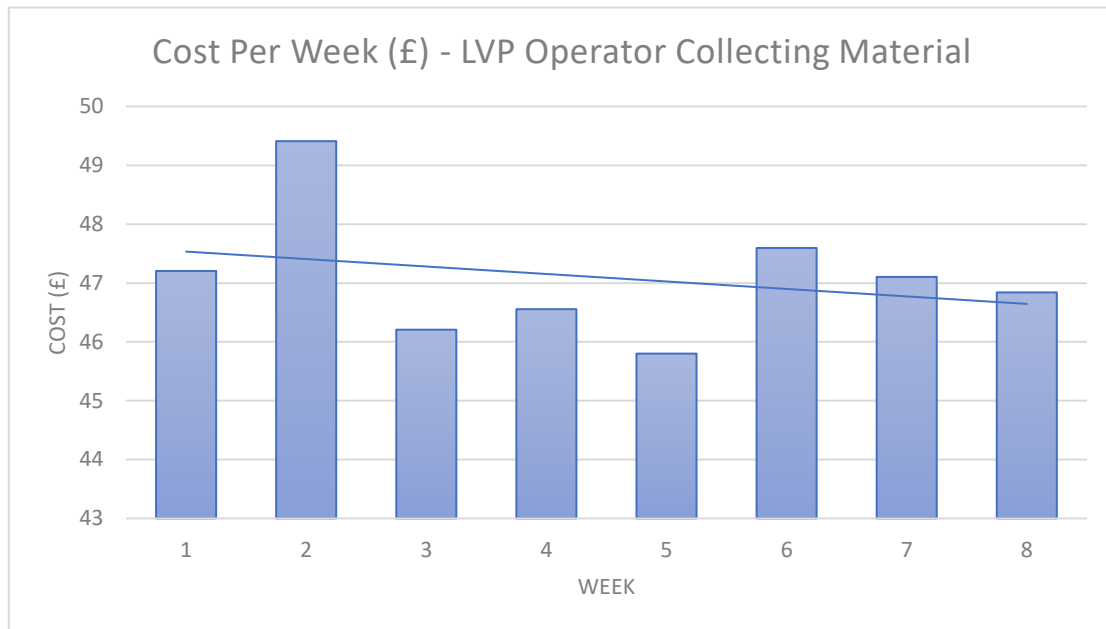


Figure 9 - Cost per Week Collecting Material

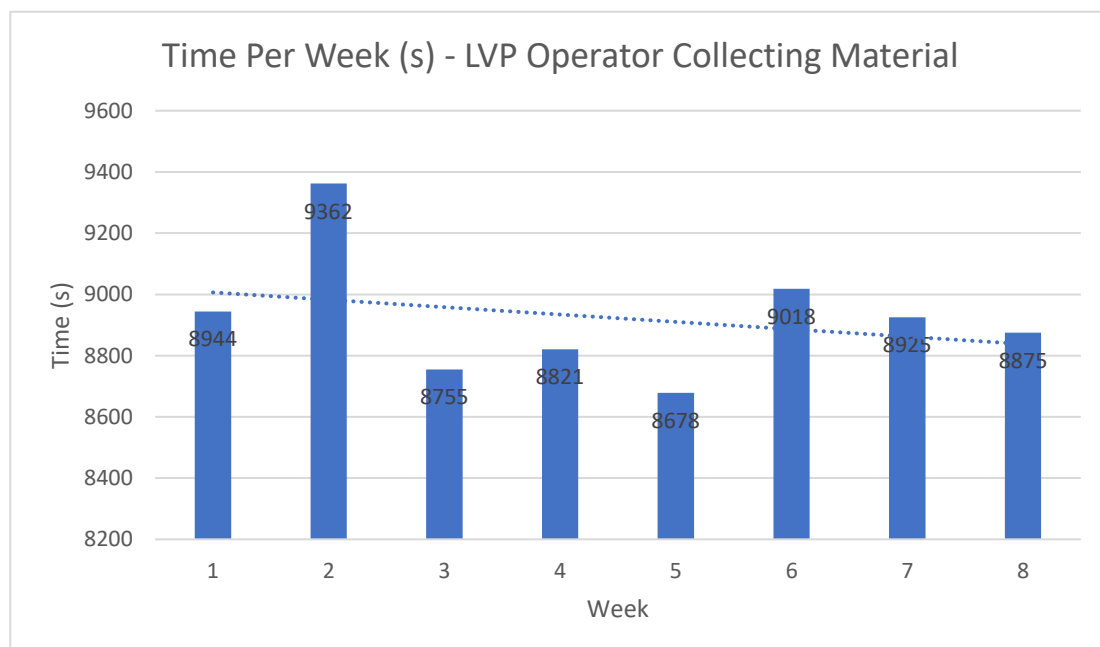


Figure 8 - Time Taken per Week Collecting Material

Lean Implementation

The raw material was previously stored on pallets; some material was in metal trays. There was no identification to what material was required for each job. Using the 5S process, the following shelving was introduced (Figure 10). As stated by Lista (2014) 5S refers to five steps sort, set in order, shine, standardize and sustain. These are the five pillars of a visual workplace, the biggest positive for implementing this for the material storage is to make the operator picking procedure far more efficient. Each billet is labelled to match the job sheet to improve the picking efficiency as shown in Figure 11.

Figure 10 - 5S Material Shelving



Correct UDL shelf weight to adhere to

Each material sectioned and labelled

R Coding (Renishaw Material Identification) labelled relating to operator job sheet

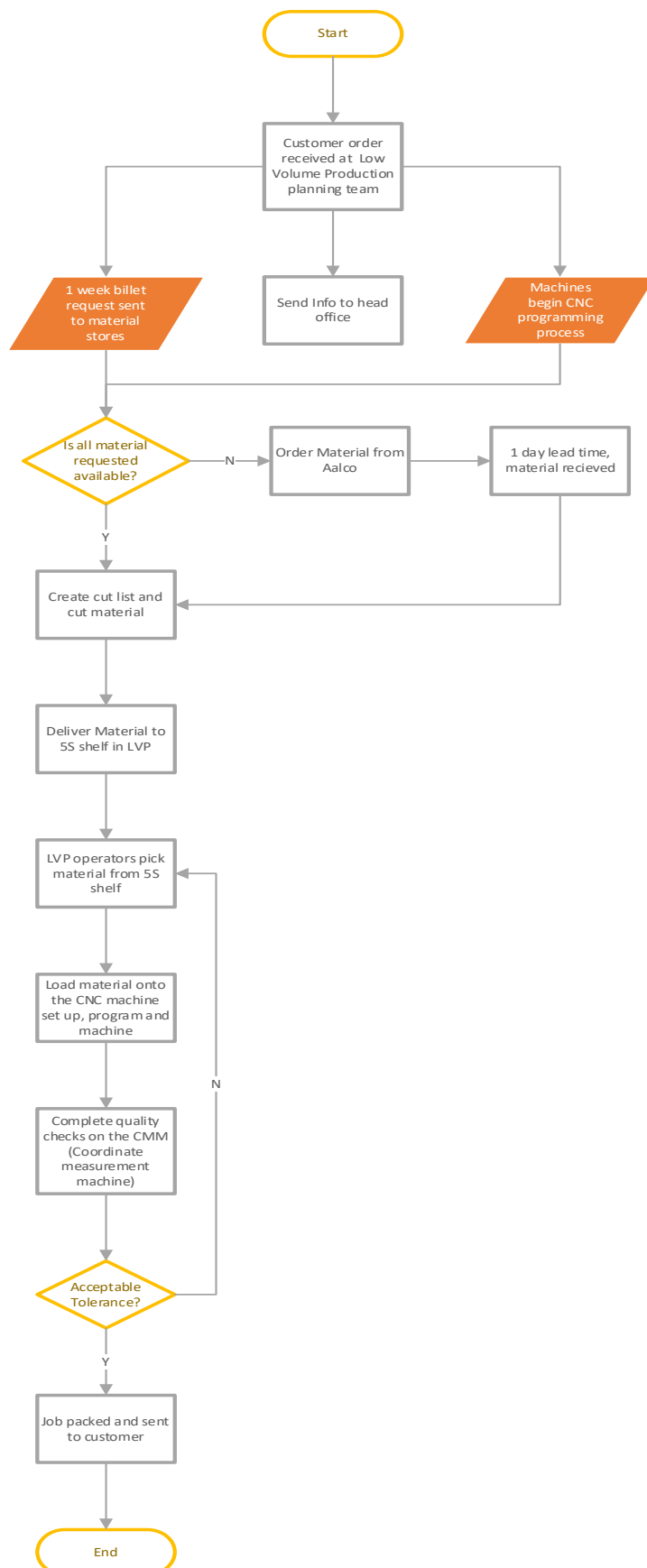
15/11/2018 12:37:28		Item Current Routing		Page 1 of 2		
M-5103-4188-03 Revision C-01   SIDE COVER RH						
Eng Doc Ref L0588/99118 Planner Code S05 Planner Desc TW134282-MILLING LOW VOLUME Item Status PP Serial Flag N		Notes				
 Op. 10		AM15S AM15 NEXUS 510 SET		SET MACHINE Setup Time 2.000 CUT BILLET 196mm LG, 1 BILLET Run Time MAKES 1 COMPONENT.		
Location	Qty to Pull	Qty Pulled	SN	Item	Description	Sensitivity
STOCK	0 UN	Other	N	QS-05514-01	Side Cover RH Op10 QS	N
S-003-3-B-03 S-003-BH1-4	217.778 MM	Orderless Rep	N	R-2022-5897	127mm x 25.4mm AL ALLOY 6082 T6 Qty Per: 196.000 MM	N
 Op. 11		AM15 AM15 NEXUS 510		MACHINE FIRST OP TO DRAWING Setup Time Run Time 0.500		
Location	Qty to Pull	Qty Pulled	SN	Item	Description	Sensitivity
STOCK	0 UN	Other	N	M-5799-0052-W	VF TOTOING - 4 PKT SQUARE - White	N
S-003-01	0 UN	Ref Only	N	P50070	TOTETRAY 600x400x75mm) GREY	N



Figure 11 - Job Sheet Reference

Future Process Map

As well as improving the material storage, the author also proposed improvements to the process.



Brief future process description:

The process starts when the customer order is received at Low Volume Production. At this point a billet request form is sent from LVP to the raw material stores at Renishaw and jobs are planned and assigned to the CNC machines. LVP then alert headquarters of the order. The raw material stores order any material that is not stocked from the material supplier (Aalco).

Material stores begin cutting the raw stock into billets that have been requested. And deliver the material to the material shelf. Operators pick the material from the pallet depending on what job has been planned and program, tool, and machine the billets to the parts requested. The parts are then quality checked for tolerance on the CMM (Coordinate Measurement Machine) before being packed and shipped to the customer.

In this format, the process is skipping the double handling of information. This in turn speeds up the customer order received at LVP to allow for faster product conversion. The material is now also delivered to the department on time by the raw material stores and stored in an efficient fashion.

Future Value Stream Map

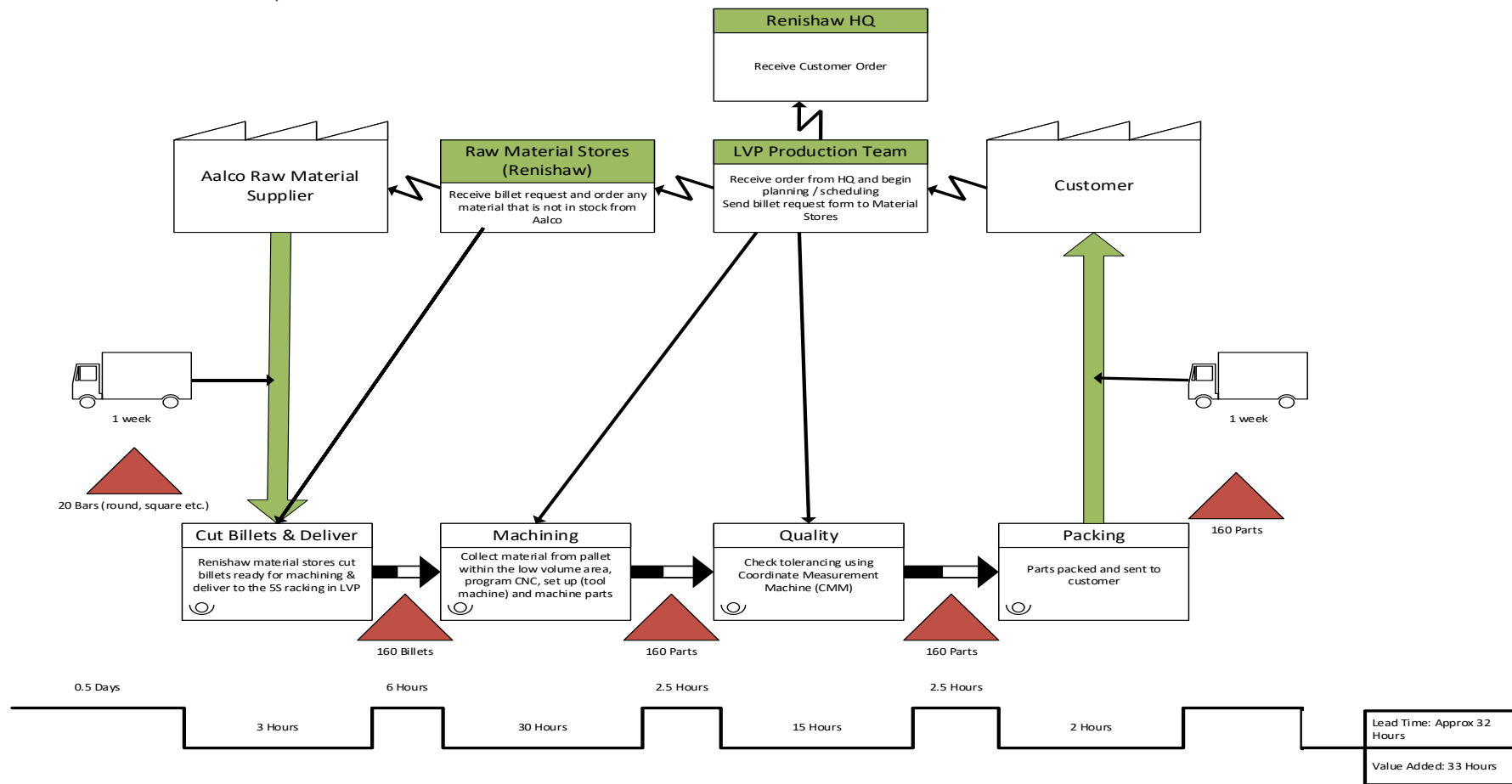


Figure 13 - Future Value Stream Map

This is the future value stream map for the process. The customer order is now direct to LVP which in turn relay the information to headquarters. This way the customer order can be processed far quicker. The collection process has been removed as raw material stores now deliver the billets. The inventory waiting for machining has been reduced by 4 hours as picking the material is far more quicker with the 5S material shelf. Lead time has been reduced by 5.75 hours making the process far more lean.

Brief analysis of future Value Stream Map:

Takt Time – How often parts need to be made to meet demand:

Total Production / Customer Demand:

8 Operators:

(8 Hours – 0.5 Hours (Break) x 5) working days x 8 Operators = 300 Hours / 160 Parts = **1.87 hours/part** To meet demand.

Cycle Times

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Store and Machine	30	6	36
Store and Quality Check	0	17.5	17.5
Store and Pack	0	4.5	4.5
Total	33	32	65

Process Efficiency

Value Added Time / Total = $(33/65) * 100 = 51\%$ adding value, 5% more efficient

Raw Material Wait Time

10 hours total reduced by 4.5 hours

Total Inventory Time

14.5 hours total reduced by 5 hours

Future Process Layout Review

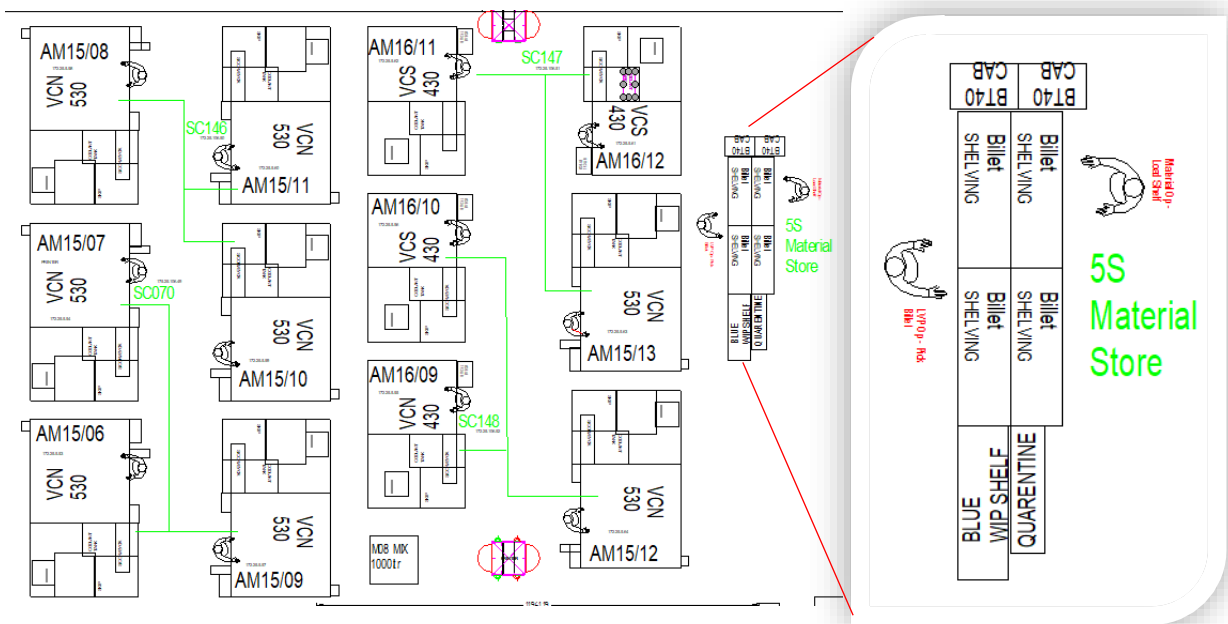


Figure 14 - Future LVP Layout

In the future layout as illustrated in Figure 14, the 2 euro pallets full of material is replaced by a well organised 5S shelf that will order billets by size, material code and quantity. This will make the material picking process far more lean, this is illustrated in Figure 10. Also the raw material operator will load the material from the back of the shelf, creating a pull system (Kanban). A kanban system as described by Kanbanize (2023) is a work management technique that originates from lean, using visual signals to indicate when items should be replenished. A future goal would be to introduce this system to further streamline inventory wait time.

Controlling Change & Problems with Lean Implementation

There is always a resistance to change during the implementation of any project that alters the way employees work, Elaction (2023) state that "Resistance can come from people who are chronically upset with their working conditions". The new process proposes that the material stores operators will now have to deliver the material to the shelving thus reducing the need for LVP operators to make the journey. Luckily, the material stores manager welcomes the change and can see the cost saving benefits for the solution, this also means that pallets of raw billets are no longer cluttering the area.

To ensure that the process is adhered to, the author decided to draft an audit that will be completed to ensure that the lean solution is being used correctly. This will tie in with all internal audits that are carried out within Renishaw.

RENISHAW MSD - Low Volume Machining Material Audit			
Use for ALL Assembly Processes		Ref:	RA001
Auditor(s):		Date:	
1 Materials		Pass	Comment
1.1	Is appropriate toting / Material racks being used? Is it clean?		
1.2	Are any suspect items clearly identified and clearly separated from 'good' product?		
1.3	Is all material labelled within a totting bin?		
1.4	Is WIP stored & identified appropriately?		
1.5	Are reject Materials Identified clearly?		
1.6	Are quarantine items dealt with promptly (where possible, within 2 weeks)?		
1.7	Are materials / parts identified with R number and stored in correct locations?		
Health & Safety - Observation Only (will not effect the product quality)		Pass	Comment
2.1	Are safety & PPE requirements adhered to? Is the correct PPE signage in place?		
2.2	Are all items stored in a safe & proper manner?		
2.3	Is there a COSHH folder, is it up to date (within 1 calendar month / is it updated regularly)?		
2.4	Sample check substance(s) in the cell - Are they ref'd in the COSHH folder? - Make note of substance(s) checked:		
2.5	Are there any special H&S procedures required in the cell? If so, are they complied with?		
3 Housekeeping - Observation Only		Pass	Comment
3.1	Is the workstation / area tidy & organised?		
3.2	Is all product stored OFF the floor?		
3.3	Is there evidence of any spills or leakages?		
3.4	Are any <u>non-essential</u> personal items stored in the cell?		
3.5	Is the lighting adequate and working correctly?		
3.6	Audit waste bins in the area and check visually for incorrect waste		
0			
Notes			
Is there any issues found that are not highlighted on this audit?			

Figure 15 - Internal Audit

Conclusion & Recommendation

Implementing a lean project always comes with its difficulties, whether management will be onboard, if there will be resistance from employees or whether there is resource available. However, lean implementation is critical in manufacturing to ensure that companies can react to such unsteady market conditions. Implementing lean successfully means that the processes are as efficient as possible. It is crucial to instil lean mentality within the organisation and to encourage employees to seek the most efficient way to complete processes.

The lean project set about to improve the storage and ordering procedure for Low Volume Production, as well as make the customer ordering process far more efficient by reducing the amount of information steps required.

The current process took a total of 72 hours with 39 hours of non-value added time, the future layout was reduced to 32 hours of non-value added time. The total cost saving from having stores operators deliver the material was £2,600 per year, but the Low Volume department has now gained this time from having operators available for an extra 7 hours. This time equates to £3,640 per week over eight operators which is quite the saving. This time can now be spent starting to machine new jobs.

The new visual management system with the use of 5S shelving has allowed for a more efficient material picking process, as well as, allowing for future kanban system implementation. If the author was to complete the project again, more data would be gathered to further justify time taken. This would allow for a far more accurate cost saving calculation. The author would also use techniques such as JIT (Just In Time) to allow for material to be ordered when required to limit inventory wait time.

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Appendix

Appendix 1 – Raw Data Collected

		Total Time Taken Daily - Material Collection (s)						
Week	Date	Monday	Tuesday	Wednesday	Thursday	Friday	Total Per Week	Cost Per Week
1	01/05/2023	1893	1768	1679	1901	1703	8944	47.20444444
2	08/05/2023	1852	1834	1876	1902	1898	9362	49.41055556
3	15/05/2023	1598	1678	1789	1834	1856	8755	46.20694444
4	22/05/2023	1809	1703	1876	1890	1543	8821	46.55527778
5	29/05/2023	1543	1876	1752	1765	1742	8678	45.80055556
6	05/06/2023	1745	1754	1762	1867	1890	9018	47.595
7	12/06/2023	1893	1642	1763	1754	1873	8925	47.10416667
8	19/06/2023	1732	1842	1843	1654	1804	8875	46.84027778

Average Per Week (s)	8922.25
Cost (£)	47.08965278

Operator Wage Annual After Tax (£)	34200
Monthly	2850
Weekly	712.5
Daily	142.5
Hourly	19
Minute	0.316667
Second	0.005278

