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Sample Report of Machine Shop Improvements Resulting From a Value Stream Mapping Analysis

Summary

This report summarises opportunities identified for reducing machined components times as part of the Speed Project aim to increase the speed of ordered parts through the system by 30%.

The critical understanding, on which all else hinges in the machining business, is that value is only added when metal is cut to make first-pass product, in an efficient and effective manner. Every other activity is an expense and a cost. There was plentiful opportunity to save thousands of hours of time annually in manufacturing if the removal of waste from all activities was made a priority.

The information collected and developed during investigations into potential improvement opportunities is enclosed in the body of the report. The recommendations garnered from the investigation are listed in the following Interim Recommendations.

Interim Recommendations

1. Senior management must make a believable plan of how they will achieve the stated aims of the Speed Project. This plan needs to clearly be a Top Management initiative that they are prepared to see through to the end. It is critically important to send the 'right signals' to the work force so they can believe the change is more than another fad.

2. The 'thinking' within the organisation is steeped in 1970's practices and is vastly out of date with best practices now available. This 'thinking' needs to be brought into the present through a well structured and organised change management program that brings best practices into use by the management and people in the operation.

3. The recommended approach to lift 'thinking' to that necessary to achieve the Speed Project aim is to introduce Lean Manufacturing training and the associated methods of waste reduction into the management and workforce. The truth is that the men on the shopfloor know what needs to be done to improve productivity. They only need a management supported and endorsed system that allows the ideas to be developed and implemented.

4. The introduction of Work in Process (WIP) before the need for it should be stopped. No material should be cut earlier than its necessary lead time. This requires far more certain planning/scheduling and parts management practices than are now used, along with a guaranteed means to ensure that necessary raw material is available from Suppliers and the Warehouse when it is required.

5. Extend the Speed Project Scope to cover the time losses and wastes across the entire supply chain process from Customer Purchase Approval to Customer Product Acceptance.

6. Install a 15 Tonne crane dedicated for the High Bay Machine Shop so that little time loss occurs waiting for fabrication to free a crane.

7. Schedule all lifts on Parts that take over 4 hours to the weekend and/or night shift.

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8. At all machining centres place materials on sturdy mobile trolleys with adjustable height to hold a loaded pallet and/or parts so there is no time lost lifting items from/to the floor. At present each lift from floor to working height takes 20 seconds with the jib cranes and 20 seconds to return them to the floor. These 40 seconds per part can be easily recovered and over a year will total several weeks of extra work time.

9. Introduce a 'supermarket' between Power Saws and the rest of the machine shop and only replenish the supermarket when space becomes available as material is drawn from the front (See diagram on last page of this section). To allow this to happen make approved carry cradles that permit Recommendation 8 and into which all cut parts for a job are placed so they can be put into the supermarket for easy retrieval and movement to the work stations throughout the workshop. Change Power Saws' work flow to feed directly into the supermarket and use a Material Handler person to feed from the supermarket to all machining centres and remove finished items from the machining centres to the next stage of production.

10. Change machine layouts to create work flow from one machine to the next machine in the manufacturing process for long lead time items and then level work to the machines by pre-planning which jobs go to which machine so long lead time items are not left standing still in queue.

11. Make it a corporate strategy to replace machine tools within 2 years after they have paid for themselves and so regularly access the latest technology and the most reliable equipment available. With such a strategy the continued use of old equipment, like the two old floor borers, will be done away with and hence not jeopardise the future capability of the organisation.

12. Schedule jobs on the CNC lathes based on tooling set-up and not on machine swing capacity. This will get the maximum number of jobs through with the same tooling set-up and minimise time lost changing-over. The CNC operators are the best people to advise the mix of parts to minimise set-up times.

13. Once people are trained in Lean Manufacturing conduct a thorough investigation into all 7 Lean wastes and categorise them via high-level Pareto and then break the categories down further via a second, low-level Pareto so problems can be identified and removed.

14. Identify how the two large floor borers can be made reliably more robust so deeper, bigger cuts can be made than presently allowed.

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Methodology

Investigations into improvement opportunities were focus on the bolded activities in the Machine Shop SIPOC Diagram of Figure 1. These functions are represented by the thick-edged boxes in the Machined Items Process Flow Diagram. Opportunities to improve overall Speed also exist in other parts of the process.

The methodology adopted to conduct the investigation was the first three steps of the Lean Six Sigma DMAIC process. In which The Define step was the Speed Project goal, the Measuring step involved measuring time wastes in the process by using Value Stream Mapping and Contact Diagrams, the Analyse step produced high-level Pareto charts of time usage. The Analysis step remained to be completed in order to identify all the root causes of time use. The Improve step, where solutions to root cause problems are tested, and the Control step, where changes are introduced into the business systems to prevent problems recurring, also remained undone.

Machine Shop SIPOC Diagram

Suppliers	Inputs	Process	Outputs	Customers
Fabrication Shop	Profiled Steel Plate	**Saw Cutting**	Machined Components	Head Office
Steel, Alloy Steel and Bronze Suppliers	Round and Hollow Bar	**Lathe**		Site Construction
Casting Suppliers	Fabricated Assemblies	**Boring – Horizontal and Vertical**		Fabrication Shop
Purchasing	Pressed Parts	**Milling**		Repair Shop Assembly
Warehouse	Labour	**Hobbing**		Warehouse
Operations	Drawings	**Key Seating**		
Engineering	Consumables	**Fabrication**		
Heat Treatment Shop	Scheduling	Heat Treatment		
		Visual Inspection		

Figure 1 – SIPOC Diagram for Machine Shop

The wastes identified during the Measuring and Analysis steps were any of the seven wastes below:

1. *Waiting Time*: Employees standing about. Inventory at stand-still.
2. *Overproduction*: Producing items before necessary.
3. *Repair Defect*: Making incorrect product.
4. *Movement Unnecessary*: Any wasted motion by man or machine.
5. *Processing More*: Using more steps to produce a product than necessary.
6. *Inventory Non-productive*: Retaining unnecessary inventory between process steps.
7. *Transport Unnecessary*: Moving material unnecessarily or long distances.

The identification of these wastes provides opportunity for their removal, often at little cost.

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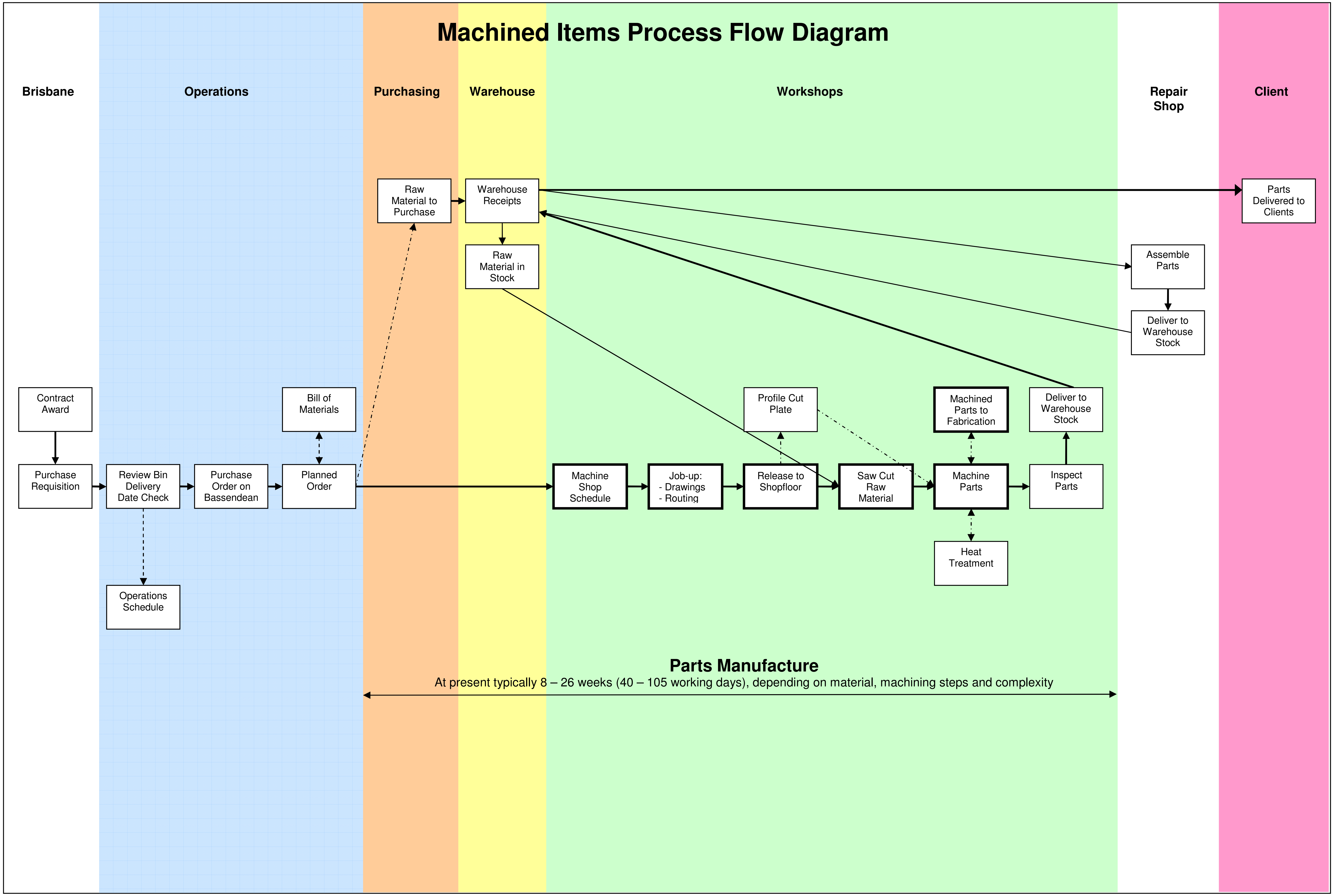


Investigation of Machined Parts Manufacture

DEFINE

The project aim was to increase manufacturing speed through the machining facility by 30%. This was interpreted as reducing time in the Machine Shop by 30%.

MEASURE

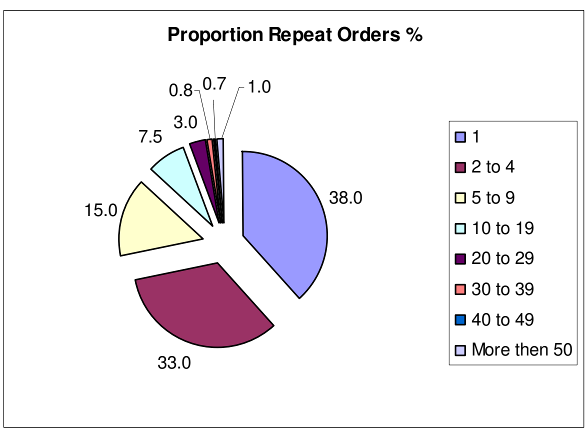
Data on standard machining times and parts' orders was collected from the MRP system that had been in use for 15 years, prior to the SAP introduction in February 2007. Most of the machining work was component parts for mining equipment. Some parts for blast-hole machines were also made from time to time.

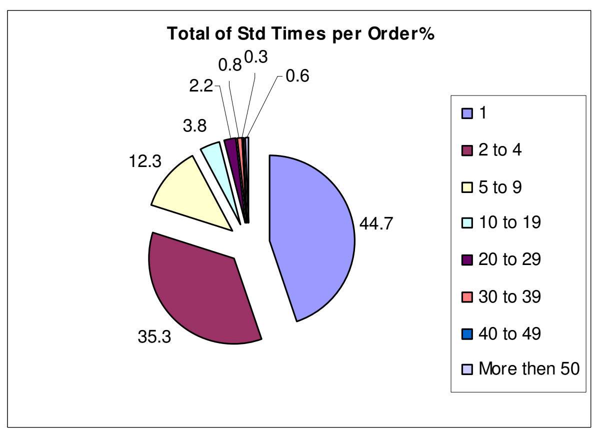
Over the 15 years of the MRP system the facility had made 8054 part numbers, 44,001 orders had been placed and 243,193 items had been made. The high variety of parts made in the facility introduced complexity, which was defined as the number of types of different products and options required. Table 1, and its associated pie charts below, indicate the complexity in the operation.

Items per Order	Proportion of Total No of Orders %
10 or less	93.0
5 or less	85.0
4 or less	82.0
3 or less	72.0
2 or less	62.0
1	31.0

Number of Orders	Proportion Repeat Orders %
1	38.0
2 to 4	33.0
5 to 9	15.0
10 to 19	7.5
20 to 29	3.0
30 to 39	0.8
40 to 49	0.7
More then 50	1.0

Table 1 Complexity of Machined Parts





The tables highlight that 85% of orders received over the 15 years were for 5 or less items. 86% of orders over the 15 years were repeated 9 or fewer times. In fact 71% of orders were repeated 4 times or less in 15 years (a repeat order about every 4 years). 38% of orders were issued only once. The tables and charts clearly indicate that the vast proportion of work in the facility was jobbing shop work and there were negligible mass-production quantities.

Table 2, and its bar chart below, indicate the spread of times required to complete the orders processed through the facility.

Total of Standard Times per Whole Order		Proportion of Total of Orders Times	No of Different Part No's	No of Orders
Minutes	Hours	%		
500 or more	8.5 or more	94.7	3091	19030
1000 or more	17	88.8	1905	10396
5000 or more	83	67.5	422	1821
10000 or more	167	57.7	223	888
20000 or more	333	46.3	105	337
30000 or more	500	41.7	79	162
50000 or more	833	34.3	49	83
80000 or more	1333	25.4	28	50
100000 or more	1667	22.4	23	28
150000 or more	2500	11.1	9	11

Table 2 Range of Standard Times to Fully Complete Orders

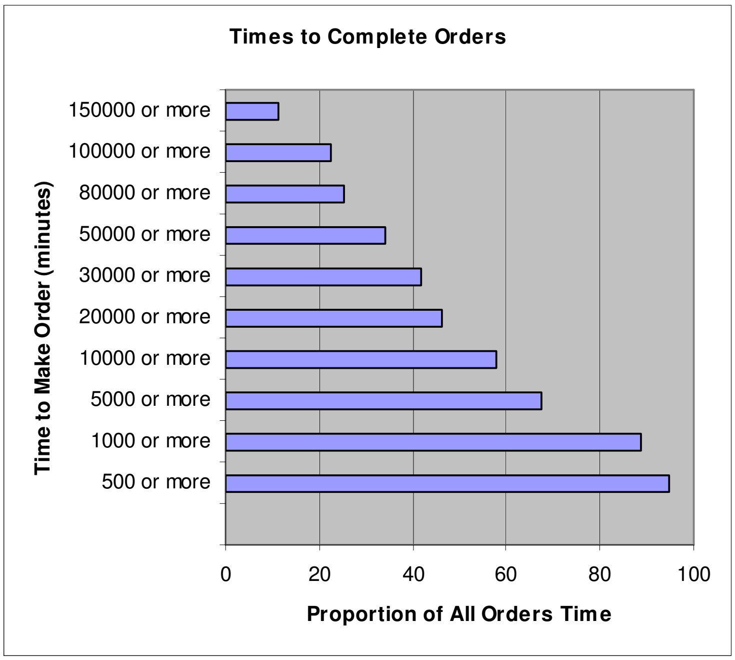


Table 2 and its bar chart highlighted that nearly 95% of orders took more than a shift of machining time. About 58% took 17 shifts of machine time and over 25% of orders took over 133 shifts to machine. For most parts there were at least three operations required, and often four. Each operation was physically separate from the prior step. This meant the parts were moved often between machining stations, sometimes over a hundred meters away. When the Machine Shop was viewed in whole, not only was there high variety and complexity in the many infrequent orders placed on the facility, but most orders used multiple work stations and the amount of material to remove and configurations to cut into the parts took many shifts of machining to complete.

Value Stream Mapping

Current State Value Stream Maps were developed from the MRP standard times for five typical parts made in the Machine Shop. An example of one is shown below for a Pilot Dipper Trip. The proportion of value-add time across the time the parts were being machined ranged from 6.5% at best to 2.5% at worst. This figure would be much lower if the entire manufacturing lead time was used to calculate the true system value-add proportion. Table 3 overviews the process flow and time use for the five parts.

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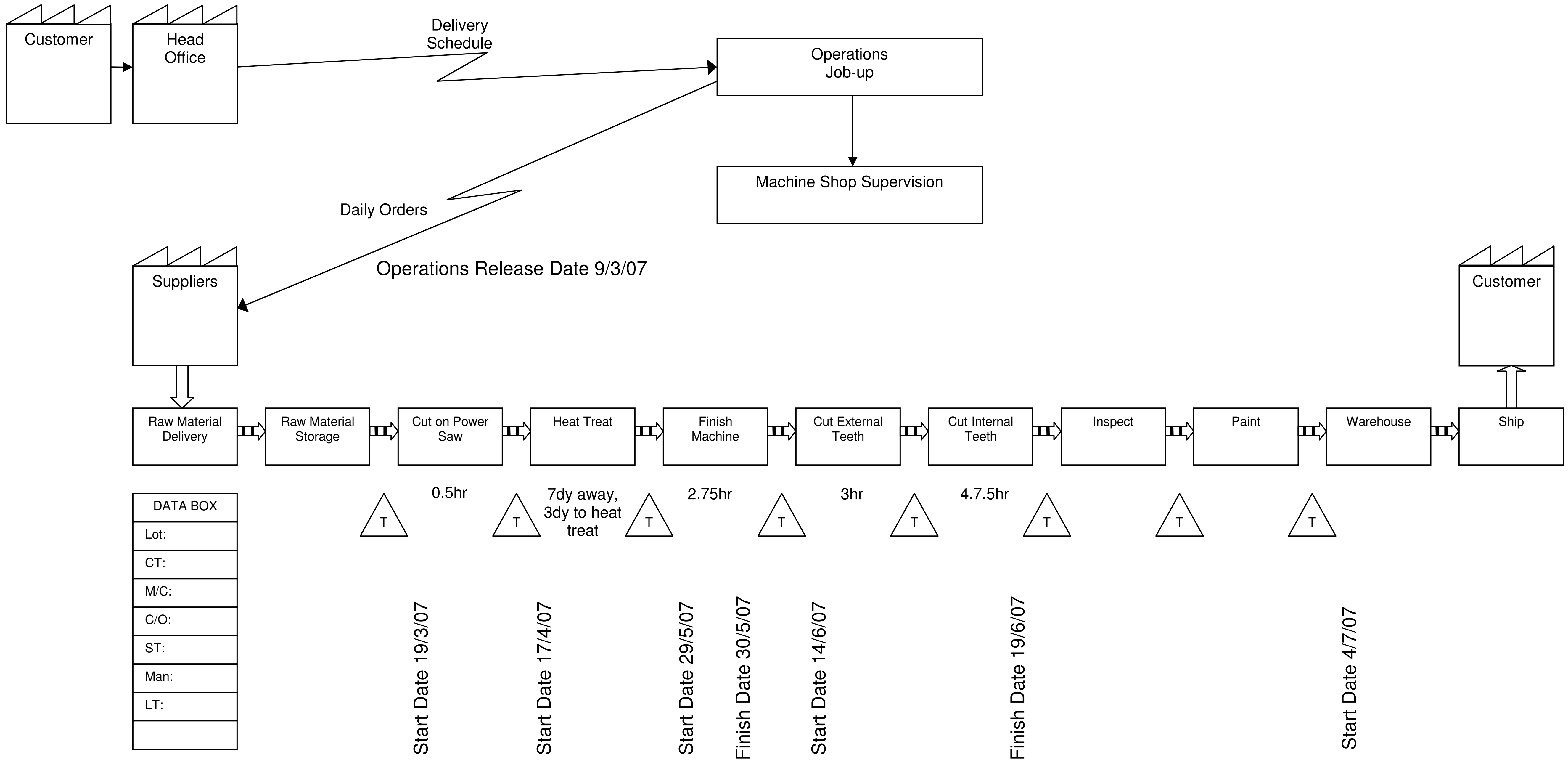
Current State Map – Pilot Dip Trip – Part No. 10P1391



DATA BOX LEGEND
Lot – No parts per job
CT – Cycle Time
M/C – Machining Time
C/O – Change Over Time
ST – Set-up Time
Man – Manning level
LT – Lost time

T Time Delay

Value-Add Ratio = Time Value Added to Product / Total Time to Make Product
= 5.5 days / 85 days
= 6.5%

	Process Steps															
Part No & Description	Ops Release	Warehouse Issue	Cut Raw Material	Fabricate	Rough Turn	Heat Treat	Finish Turn	Mill	Finish Machine	Cut Teeth / Spline	Fitting	Inspect	Warehouse Receipt	Total Order Std Times	Total Process Time	% Value Add
10P1391 Pilot Dip Trip	X	X	X			X	X			X		X	X	103hr	16.5wk	6.5%
235P9D4 Bushing (Steel)	X	X	X		X	X	X							77hr	14wk	5.5%
7811J30F1 Rear Assembly	X	X	X	X				X			X			18hr	16.5wk	2.5%
713R59D1 Bushing Pin	X	X			X		X		X		X	X	X	105hr	20.5wk	5%
23510 D1F1N503 Shaft Trip	X	X	X			X	X			X	X	X	X	82hr	19wk	4.5%

Table 3 Proportion Value-Add for Five Parts

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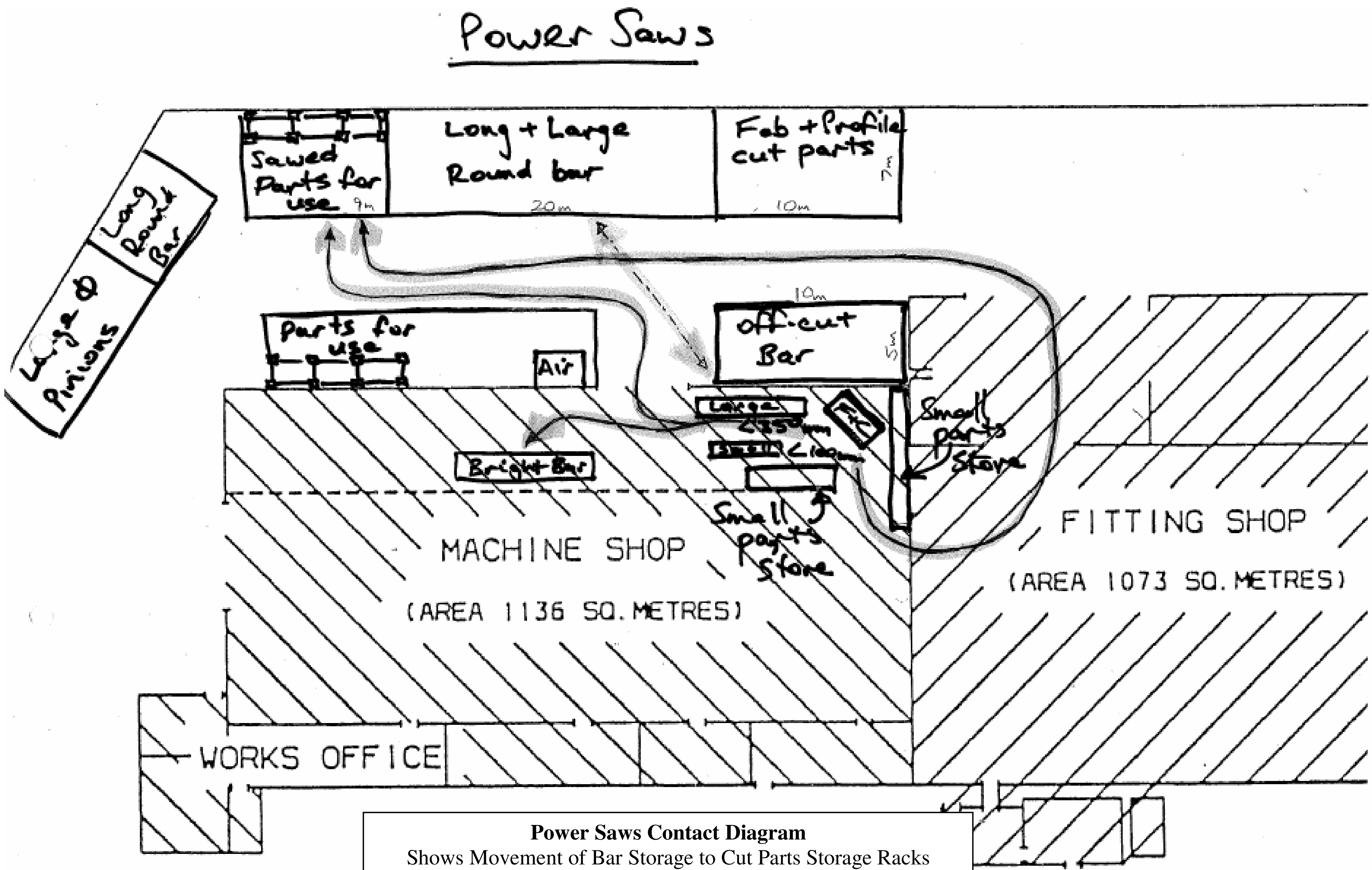
The Value Stream Maps confirmed that time was lost at every step of the production process. As each stage of manufacture was completed the parts waited in queue for their turn on the next work station.

Contact Diagrams

Contact Diagrams were made for raw materials cutting at the Power Saw, for a fabricated Greenhorn and for materials movement in/out of the Machine Shop. These are shown in the drawings below.

Non-bright-steel bar parts moved about 300 meters in the process of being manufactured and shipped. In a typical month about 500 orders were competed by the Machine Shop with an average of 4 - 5 items per order. The cumulative distance moved for the parts on each order was in the vicinity of 0.5 kilometres, and for 500 orders it was 250 kilometres per month. Over 12 months this equated to a trip across Australia each year at a forklift speed of 10 km per hr, for a total time of 300 hours, or 8 working weeks.

Fabricated parts which were then machined, if the five parts were average examples, they were moved over 500 meters per order.



Power Saws Contact Diagram
Shows Movement of Bar Storage to Cut Parts Storage Racks

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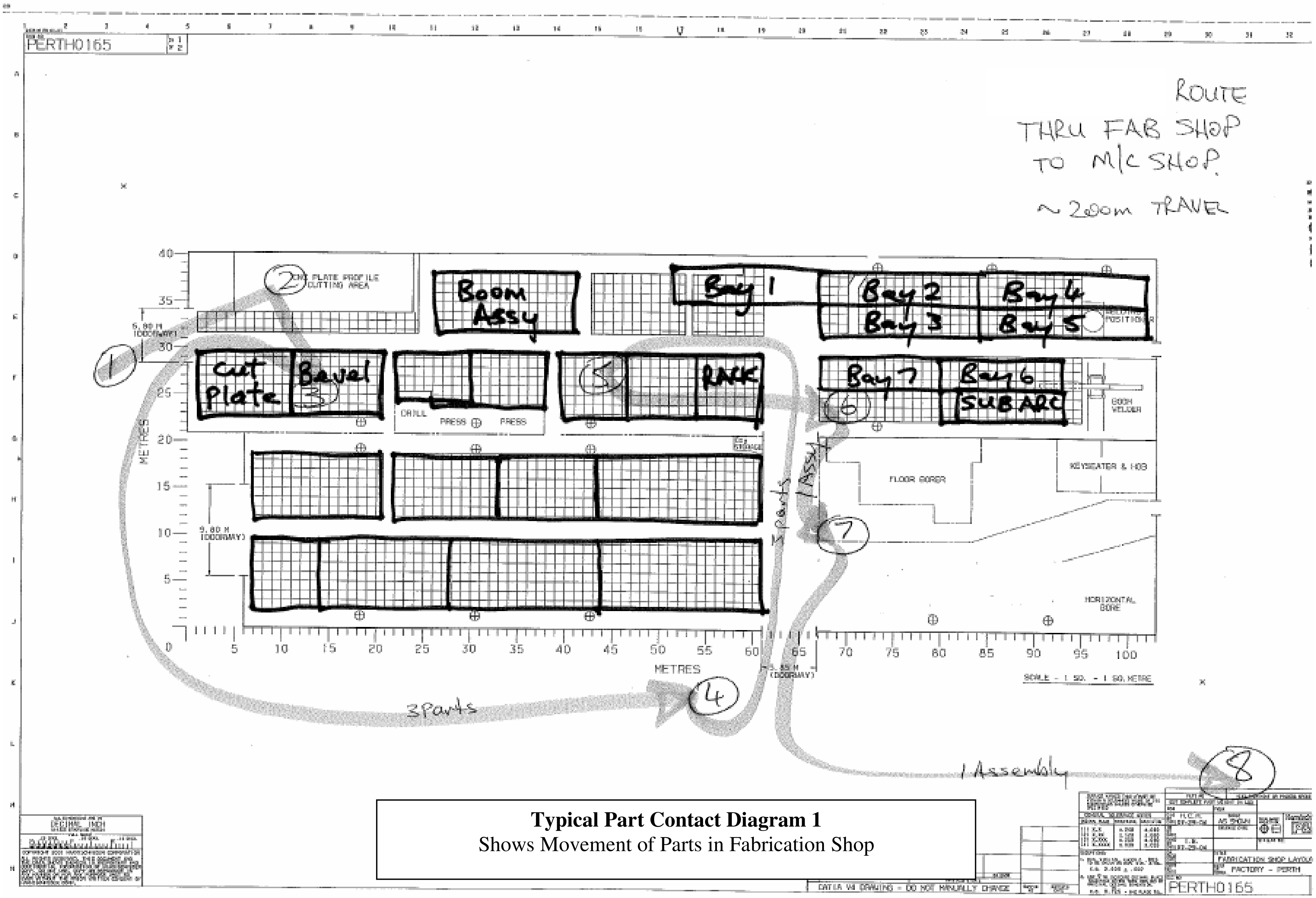

Typical Part Contact Diagram 1
Shows Movement of Parts in Fabrication Shop

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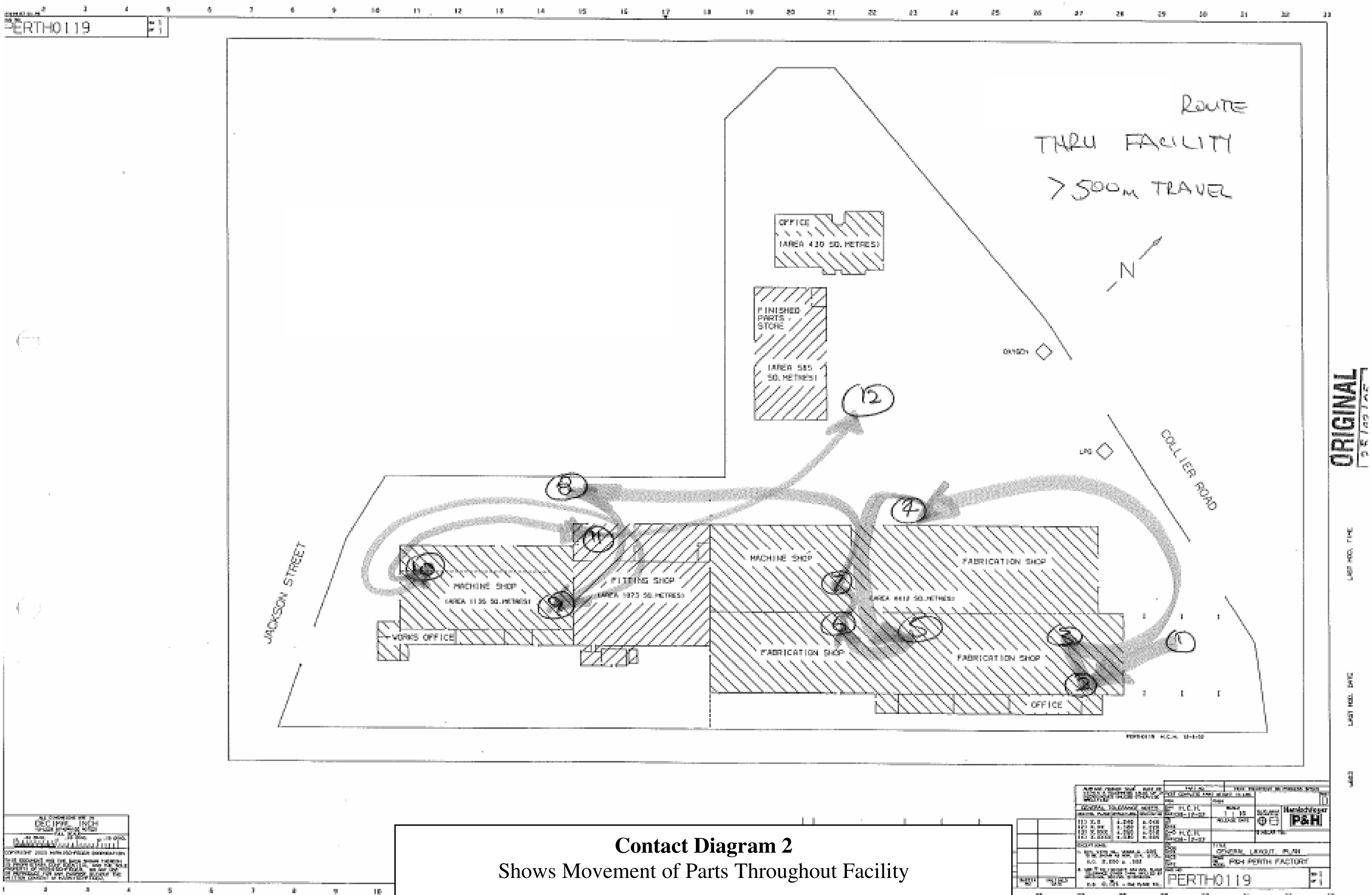

Contact Diagram 2
Shows Movement of Parts Throughout Facility

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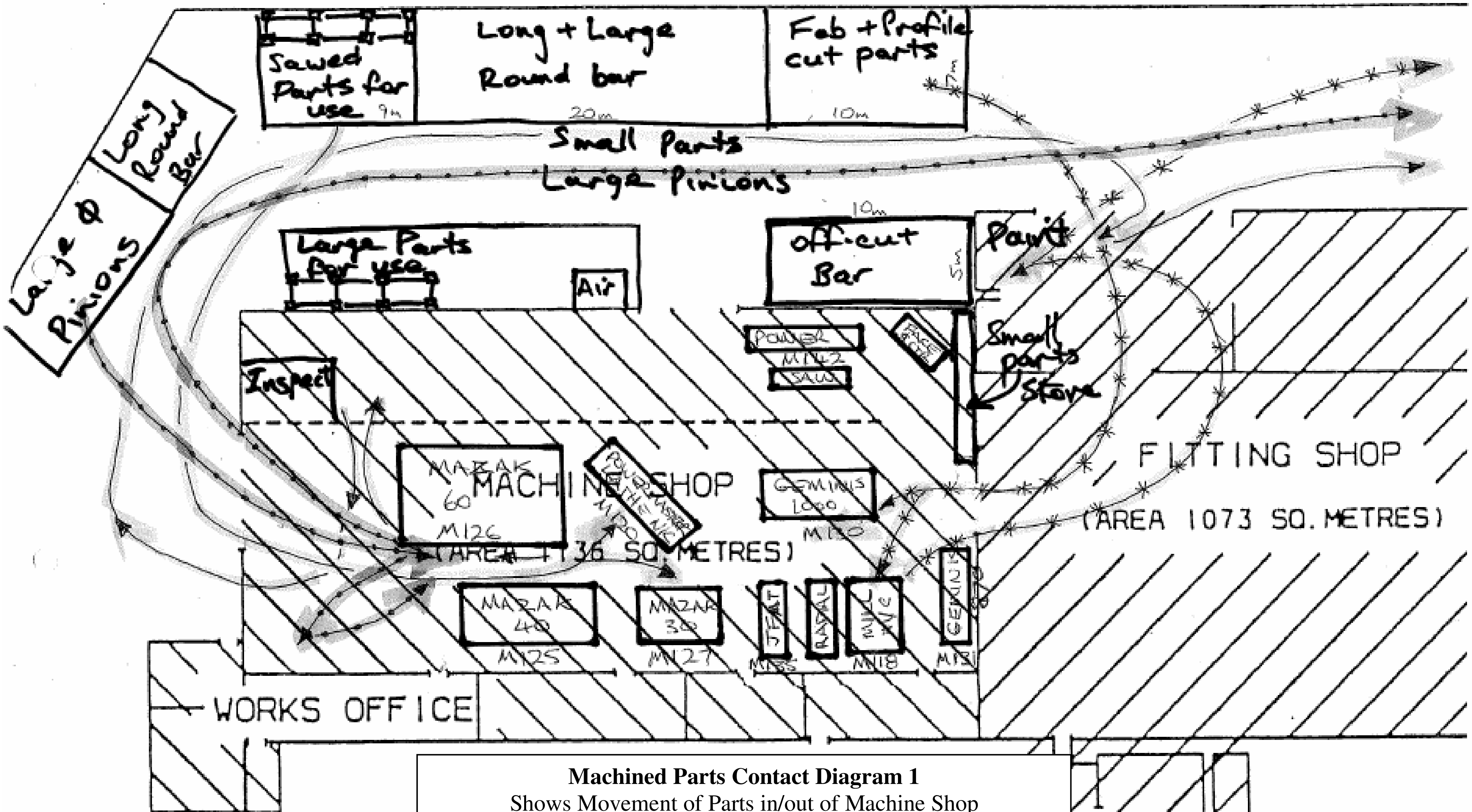

Machined Parts Contact Diagram 1
Shows Movement of Parts in/out of Machine Shop

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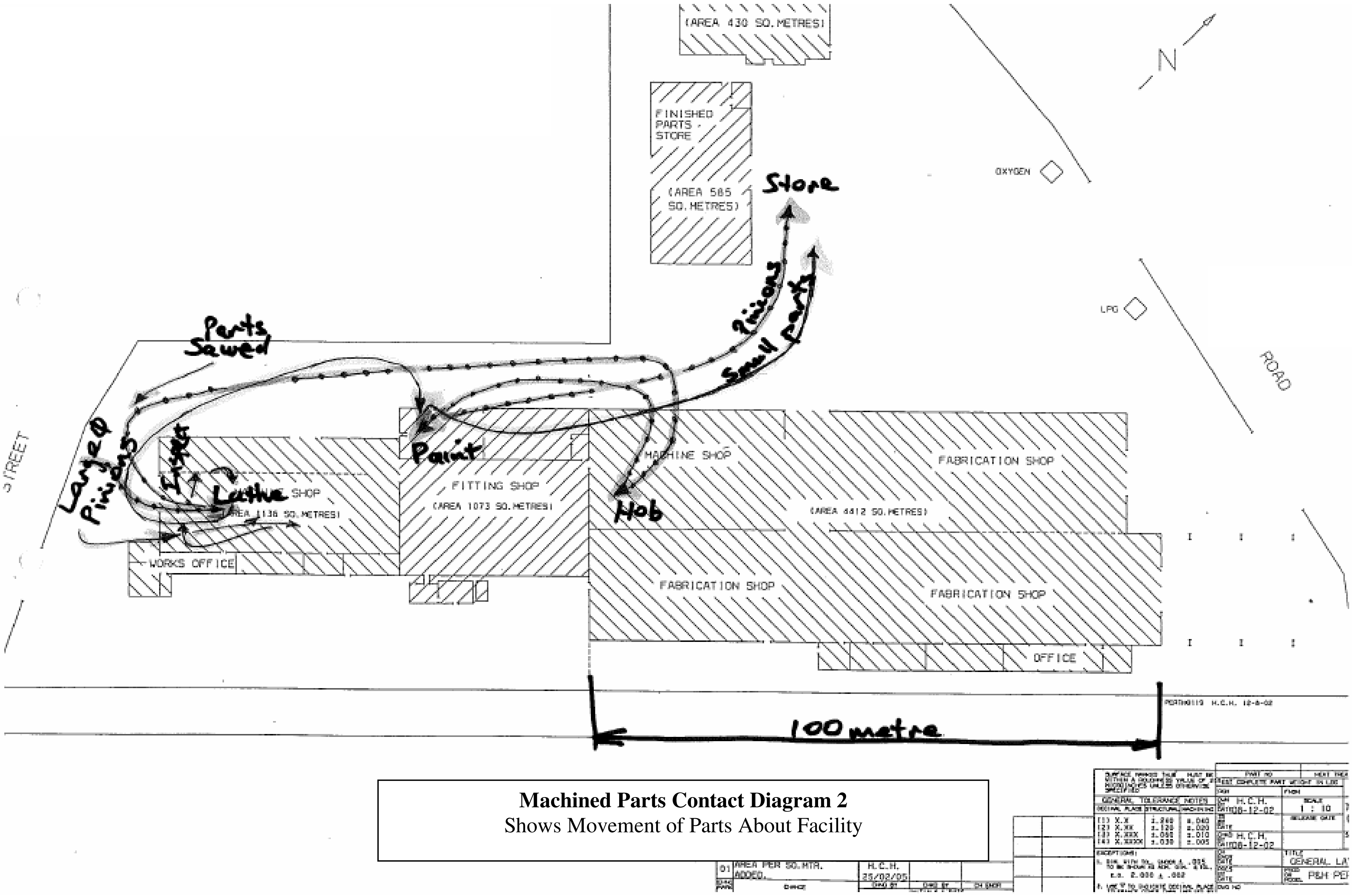
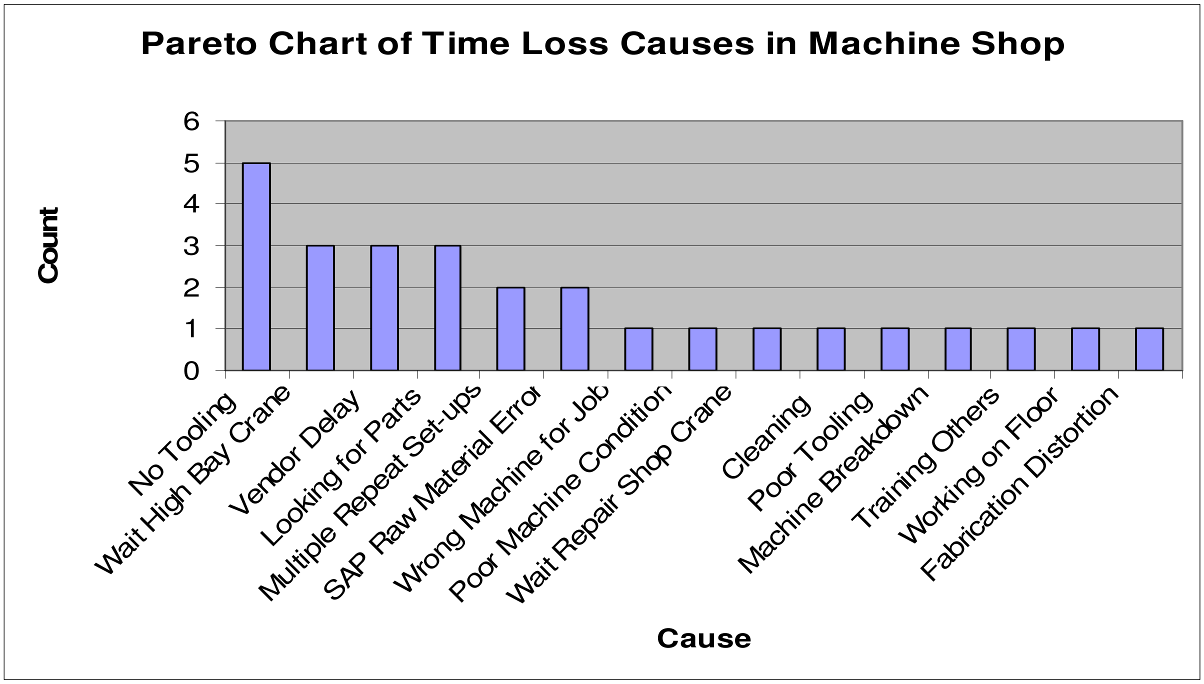


Machined Parts Contact Diagram 2
Shows Movement of Parts About Facility

ANALYSIS

Machine Shop Survey

In order to identify where time delays were occurring, an anonymous survey was conducted in the Machine Shop. The following Pareto Chart identified the frequency that problems were reported by the Machine Shop personnel.



The Pareto Chart clearly indicated the top issues the Workshop personnel considered took them away from working. Those items identified two or more times were:

No Tooling covered situations were machine tools had to be searched for and if not found then had to be ordered and the job delayed until the tools were found or became available.

Wait High Bay Crane was those situations where machinists had to wait for fabrication personnel to free the crane. The survey was conducted before the two Vertical Borers were moved from the Repair Shop to the High Bay and the situation would now be worse.

Vendor Delay was if parts or raw material delivered from suppliers could not be identified, or the paperwork was wrong.

Looking for Parts was for time spent searching for raw materials, or fabricated parts, for the next job people had been given to do.

Multiple Repeat Set-ups were those situations where the same part was made on two different orders within days of each other. One example was where a part needing 1.5 hours of set-up time was made one week and again made on the Wednesday following on a different order.

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Wastes Identified

Table 4 below records wastes observed at each step of the machined part manufacturing process. A blank cell indicates that the waste was not identified during site observation, but it does not mean that it did not occur.

Waste	Material Supply	Power Saw	CNC 60	CNC 40	CNC 30	CNC Lathes	Milling	Hob/Keyseater	Floor Borer	Horizontal Borer	Vertical Borer	Assembly	Transport and Ship
Waiting Time: (Employees standing about. Inventory at stand-still)		Waiting for Forklift	Waiting for Forklift	No person manned machine for several days	No person manned machine for several days			Waiting for crane	Waiting for crane	Waiting for crane	Waiting for crane		
Overproduction: (Producing items before necessary)		Parts cut 4 – 6 weeks ahead and stored in racks and on shelves											
Repair Defect: (Making incorrect product)		Power Saw blades wander as they cut					Distorted fabricated items	Splines incorrectly machined					
Movement Unnecessary: (Any wasted motion by man or machine)		Time spent looking for raw material in storage bays or at warehouse	Repeated set-up for same parts in a short time period	Repeated set up for same parts in a short time period	Repeated set up for same parts in a short time period							Component parts left in boxes on pallets remote from work area	
Processing More: (Using more steps to produce a product than necessary)			Breaking down set-ups to process rushed order	Breaking down set-ups to process rushed order	Breaking down set-ups to process rushed order								
Inventory Non-productive: (Retaining unnecessary inventory between process steps)	Pallets of heat treated parts sitting on floor for days Bronze raw material sitting on floor for days		Finished parts sitting on floor for days	Finished parts sitting on floor for days	Finished parts sitting on floor for days								
Transport Unnecessary: (Moving material unnecessarily or long distances)		A great amount of forklift movement occurs to get material to saws Material from the back of storage bays requires that at the front to be moved	Much forklift movement occurs before finished item is warehoused	Parts craned up and down from a pallet on floor	Parts craned up and down from a pallet on floor	Parts craned up and down from a pallet on floor			Jib crane located in an unusable spot for less than two tonne loads				Finished parts stored all over yard

Table 4 Wastes Identified During Parts Machining

IMPROVE

This step required the root causes of problems/issues to be identified and proposed changes trialled. It was still to be done.

A proposed floor layout change for discussion was developed, as shown below.

CONTROL

This step required the Improvements to be finalised before making necessary changes to the business processes in order to maintain and sustain the changes. It was still to be done.

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