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

Summary

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

The critical understanding, on which all else hinges in the fabrication business, is that value is only added when a flame or arc is burning 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 Fabrication if the removal of waste from all activities wais 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 Velocity 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 The 'thinking' within the organisation is steeped in 1970's practices and is vastly out of date with best practices now available.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 Velocity 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 plate 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 Velocity Project Scope to cover the time losses and wastes across the entire supply chain process from Customer Purchase Approval to Customer Product Acceptance.

6. Relocate two motorised jig cranes from High Bay to Low Bay at the plate joining work station and the rack assembly workstation using people from the workforce and the workshop electrician so sub-two-tonne lifts can be done without need of overhead cranes (See diagram on last page of this section).

7. Move a manual jib crane freed-up from Recommendation 6 to the sub-arc bay so the sub-arc Buggo bench does not need to be lifted by overhead crane (See diagram on last page of this section).

8. Following completion of recommendation No 6 put work weighing more than 500kg and less than 2000kg into workstations with the motorised jib cranes as much as possible so the overhead cranes are not needed so often.

9. Ensure that work on assemblies weighing more than 20kg and less than 500kg is done in the workstations with manual jib cranes so the overhead cranes are not needed so often.

10. Do work on assemblies which can be manually lifted in an area without a jib crane, so the jib cranes are available to use for heavier work.

11. Complete the analysis of the causes of 'non-arc time' identified in the Time Losses of Table 1 for large fabrication and Pareto Chart the causes to target biggest improvement opportunities.

12. Introduce a 'supermarket' between Profile Cutter and the rest of the fabrication 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 heavy duty carry cradles into which all cut parts for a job are placed so they can be put into the supermarket for easy retrieval and movement to work stations throughout the workshop.

13. Get the Profile Cutter flames bevelling function operational and into use, as an automated process will always do more production than an equivalent manually-operated process.

14. Relocate Part sides/top/bottom assembly to beside Bevelling Station to use the 70 – 80% utilised east crane more often (See diagram on last page of this section).

15. Along with Recommendations 14 and 6, relocate Large Leg baffle assembly to beside sides/top/bottom assembly station to use the relocated motorised jib crane and the 70 – 80% utilised East crane more often.

16. Along with Recommendation 15, purchase a spreader bar for 15 tonne lifts so one crane only is used to move assembled Part sides and baffles, and also the joined tops/bottoms.

17. To gain further benefits from Recommendation 16 upgrade the three Low Bay cranes from 12.5 Tonne to 15 Tonne capacity so only one crane is needed to lift all large parts of up to 13 tonne weight.

18. With the right floor layout it would become viable to install tram tracks on which jigs and mechanical rotators are mounted so that Part Legs are assembled, rotated and moved between stations on the tracks and no cranes are used at all.

19. Use jigs for all parts needing to be laid-out and tacked, which are made three or more times a year. The cost of making the jig will be recovered in the on-going times saved from no longer measuring, laying-out and tacking and from the additional time saved in machining because of fabrication distortion and mismeasurement.

20. Schedule all lifts on large parts that take over 4 hours to the weekend and/or night shift.

21. 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 the problems people lived with can be identified and removed.

22. Make it a corporate strategy to replace equipment within 2 years after they have paid for themselves, and so regularly access the latest technology and the most reliable equipment available.

23. Ask Engineering to redesign large itms, and other large fabricated parts that take a long time to make, to totally remove as many fabrication and machining requirements as possible. There are certain to be simpler designs possible once the production issues the company suffers are advised to the designers.

Methodology

Investigations into improvement opportunities were focus on the bolded activities in the Fabrication SIPOC Diagram of Figure 1. These functions are represented by the thick-edged boxes in the Fabricated Items Process Flow Diagram. Opportunities to improve overall velocity 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 Velocity 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.

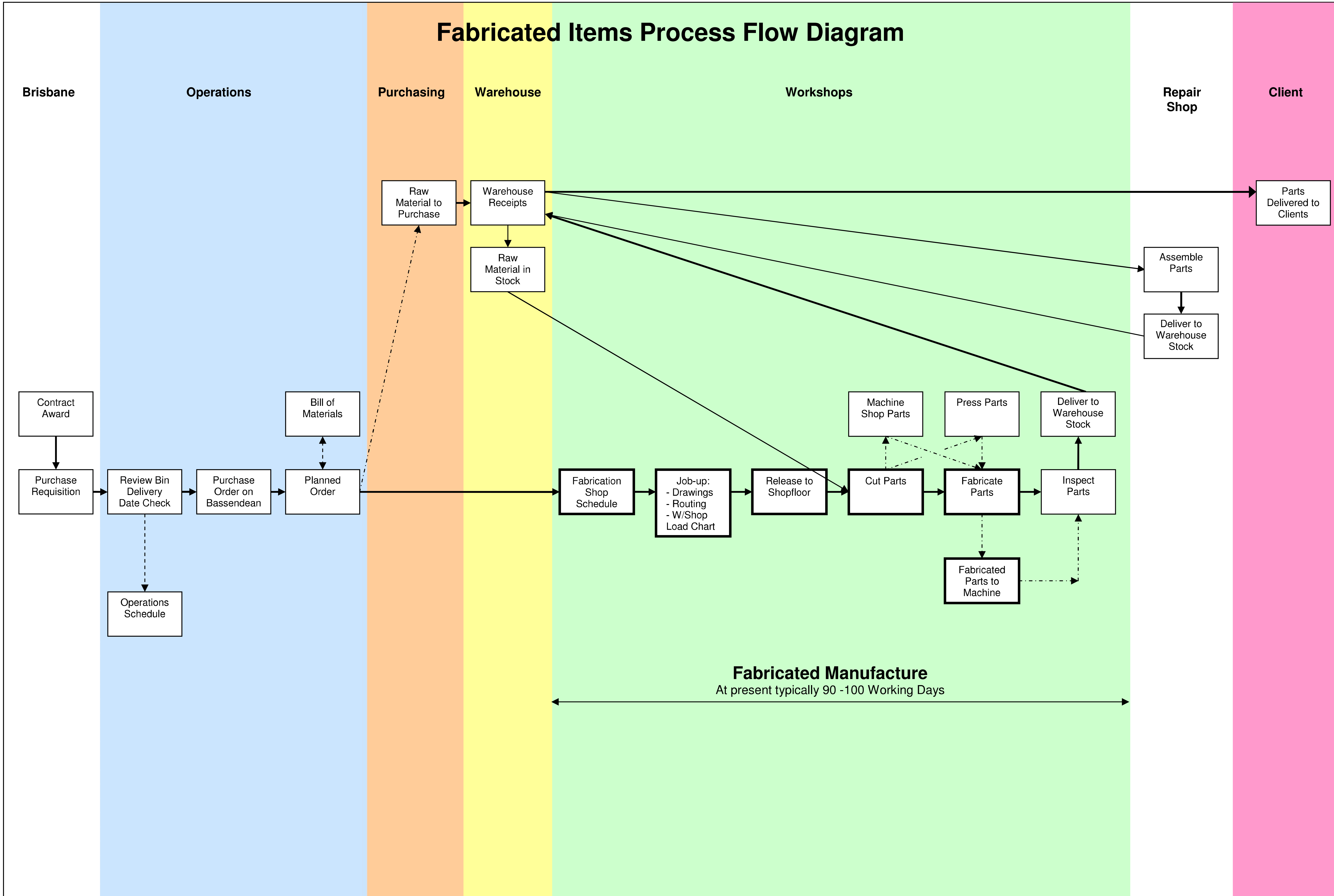
Fabrication SIPOC Diagram				
Suppliers	**Inputs**	**Process**	**Outputs**	**Customers**
Machine Shop Steel Plate Suppliers Steel Section Suppliers Welding Consumable Suppliers Purchasing Warehouse Operations Engineering Press Shop	Steel Plate Pressed Parts Labour Drawings Machined Parts Consumables Scheduling	**Profile Cutting** **Clean-up** **Bevelling** **Set-out** **Assembly** **Welding (Manual)** **Welding (Sub Arc)** **Bore Machining and Facing** Ultrasonic Inspection Visual Inspection	Fabricated Components	Head Office Site Construction Machine Shop Repair Shop Assembly Warehouse

Figure 1 – SIPOC Diagram for Fabrication

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.


Fabricated Items Process Flow Diagram
Brisbane
Operations
Purchasing
Warehouse
Workshops
Repair Shop
Client
Contract Award
Purchase Requisition
Review Bin Delivery Date Check
Operations Schedule
Purchase Order on Bassendean
Bill of Materials
Planned Order
Raw Material to Purchase
Warehouse Receipts
Raw Material in Stock
Fabrication Shop Schedule
Job-up:
- Drawings
- Routing
- W/Shop Load Chart
Release to Shopfloor
Cut Parts
Machine Shop Parts
Press Parts
Fabricate Parts
Fabricated Parts to Machine
Deliver to Warehouse Stock
Inspect Parts
Assemble Parts
Deliver to Warehouse Stock
Parts Delivered to Clients
Fabricated Manufacture
At present typically 90 -100 Working Days

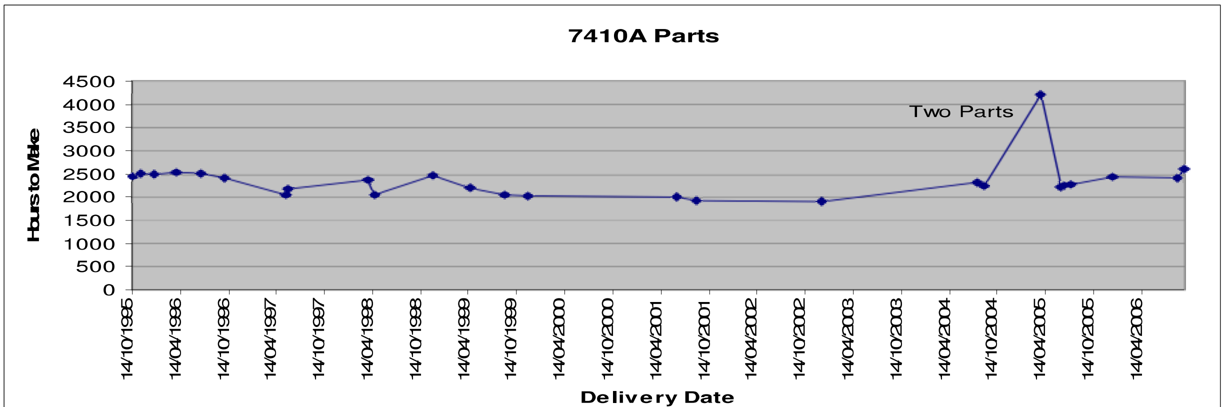
Investigation of Part Manufacture

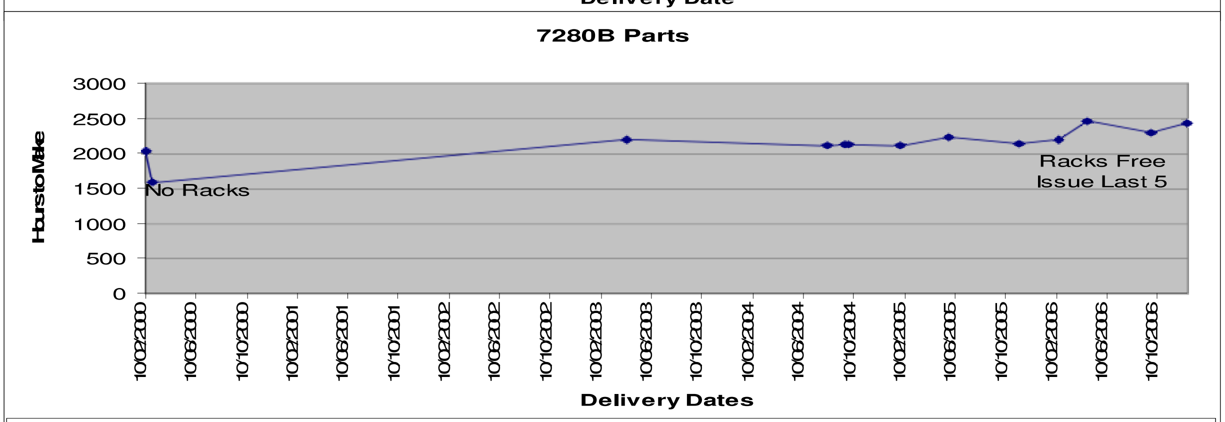
DEFINE Velocity Project

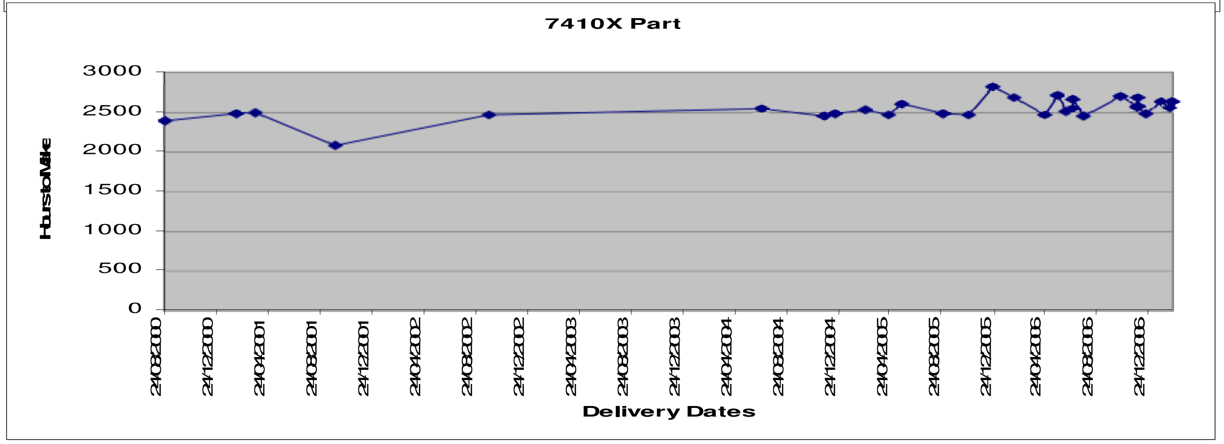
The project aim was to increase manufacturing speed through the fabrication facility by 30%. This was interpreted as reducing fabrication time by 30%.

MEASURE

To focus the project, and in recognition of future work scheduled through the Shop, it was decided to examine large parts fabrication. Data collected by the Technical Clerk over the previous decade was converted into graphs of the three most often made parts. It was evident that fabrication times had risen recently.

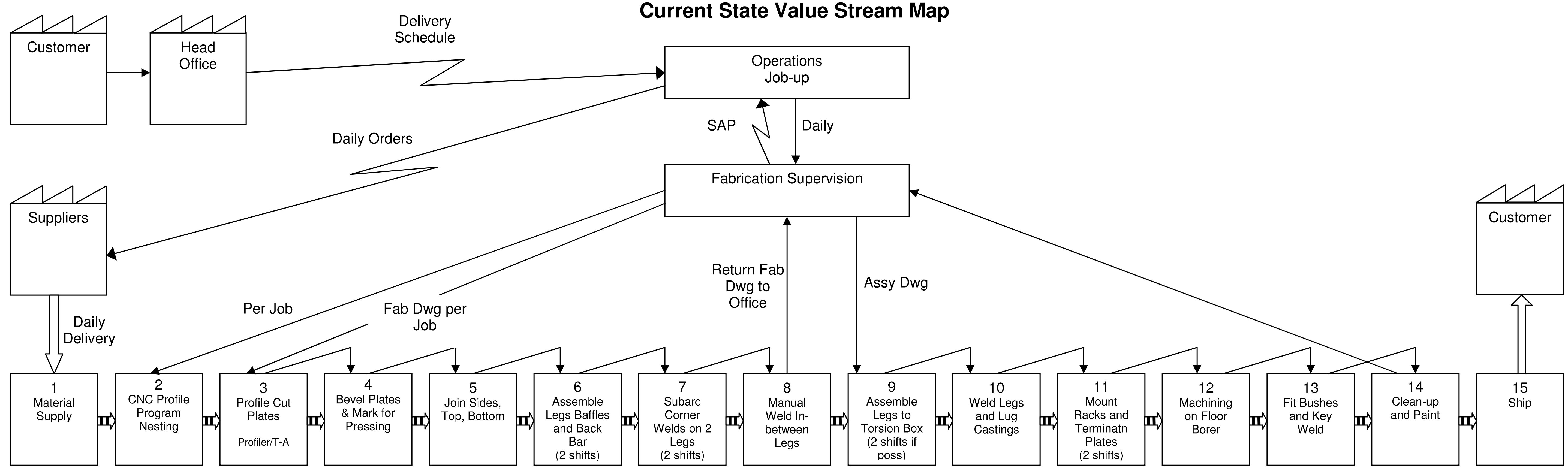






The Parts Current State Value Stream Map shown below was developed from the historic times. The Value Stream Map indicated that of the 2333 hours needed to make a Part, 55% of fabrication time was value-add and 45% was non-value-add. A value-add task was defined as one that advanced the product to a more complete state. Closer investigation for improvement opportunities was required in both categories to identify where and how the time was used.

Current State Value Stream Map



DATA BOX	DATA BOX	DATA BOX	DATA BOX	DATA BOX	DATA BOX	DATA BOX	DATA BOX
Lot: 23	Lot: 55	Lot: 55 / 23	Lot: 55	Lot; 16	Lot: 60	Lot: 2	Lot: 2
CT: 2-12wk	CT:	CT: 5 day	CT: 10 day	CT: 8 day	CT: 22 day	CT: 10 day	CT: 8 day
NL: 23 (6 min)	NL:	NL: 150+ (6min)	NL: 120 (3 min)	NL: 20 (30 min)	NL: 35 (20 min)	NL: 10 (30 min)	NL:8 (20 min)
Man: 1	Man: 1	Man: 2	Man: 1	Man: 2	Man: 2.5	Man: 4	Man: 3
Time: 15 hr	Time: 25 hr	Ti: 32 / 35 hr	Time: 80 hr	Ti: 180 hr	Ti: 550 hr	Ti: 480 hr	Time: 270 hr
ST: 5 hr	ST:	ST: 20 hr	ST: 5 hr	ST:	ST: 6 hr	ST: 5 hr	ST: 5 hr
Rwk:	Rwk:	Rwk:	Rwk:	Rwk: 5 hr	Rwk:	Rwk 1 hr	Rwk:
LT:	LT: 5 hr	LT: 5 hr	LT: 5 hr	LT: 8 hr	LT: 22 hr	LT: 10 hr	LT: 10 hr

DATA BOX	DATA BOX	DATA BOX	DATA BOX	DATA BOX	DATA BOX	DATA BOX
Lot: 3	Lot: 3	Lot: 6	Lot: 1	Lot: 8	Lot: 1	Lot: 1
CT: 3 day	CT: 6 day	CT: 10 day	CT: 8 day	CT: 3 day	CT: 3 day	CT: 1 day
NL: 3 (30 min)	NL: 16 (30 min)	NL: 12 (20 min)	NL: 2 (30 min)	NL: 4 (15 min)	NL: 1 (30 min)	NL: 1
Man: 2	Man: 2	Man: 2	Man: 1	Man: 1	Man: 1	Man: 2
Time: 60 hr	Ti: 120 hr	Ti: 385 hr	Time: 75 hr	Time: 30 hr	Time: 20 hr	Time: 8 hr
ST: 2 hr	ST: 6 hr	ST:	ST: 8 hr	ST: 2 hr	ST:	ST: 2 hr
Rwk:	Rwk: 3 hr	Rwk: 5 hr	Rwk:	Rwk:	Rwk:	Rwk:
LT: 3 hr	LT: 6 hr	LT: 0 hr	LT: 8 hr	LT:	LT:	LT:

Add Value = 1278 hr

Non-Value = 1055 hr

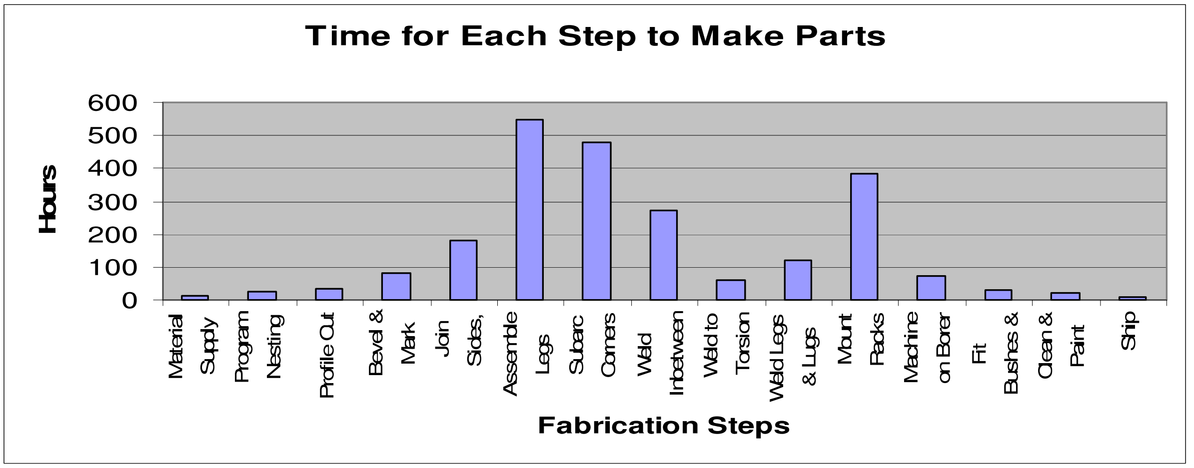
Arc Time ~ 60% of Time to Complete

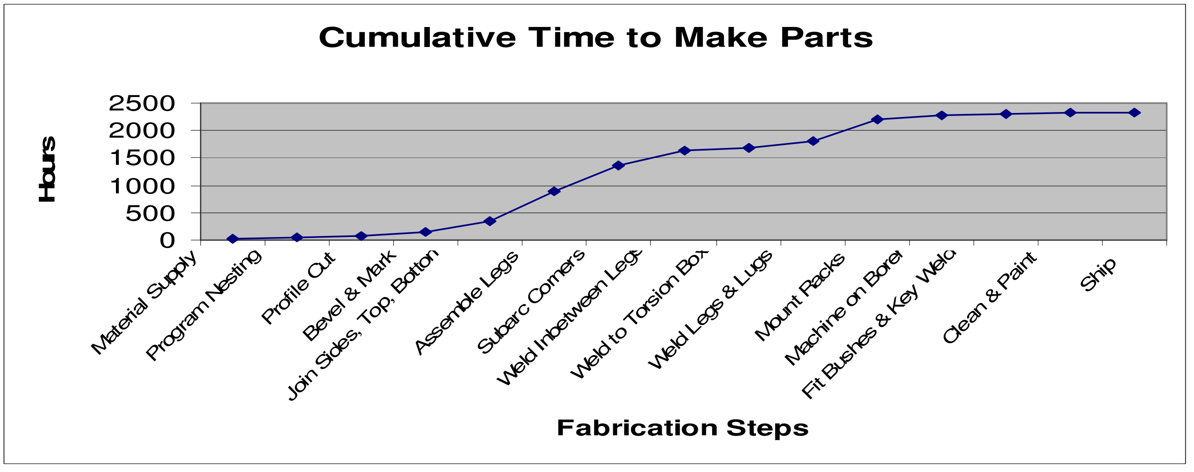
DATA BOX LEGEND
Lot – No of parts handled
CT – Cycle Time
NL – No of lifts
Man – Manning level
Time – Time to complete
ST – Set-up Time
Rwk –Rework Time
LT – Lost time

$$\text{Percent VA} = \frac{1278}{1278 + 1055} = \frac{1278\ \text{hr}}{2333\ \text{hr}} = 55\%$$

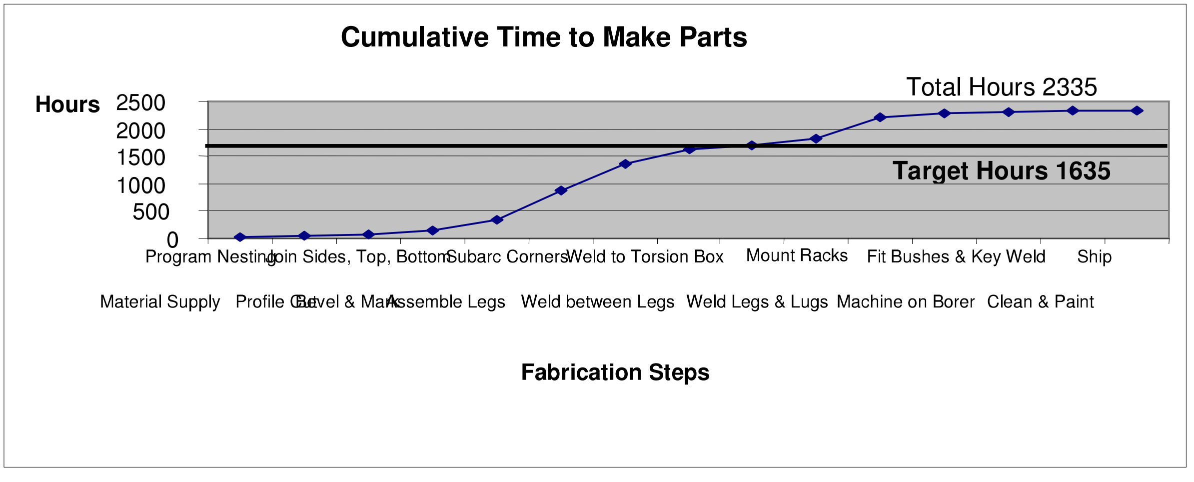
ANALYSIS

The fabrication step times were displayed as a bar chart (see below) in order to identify those steps taking the most times, on the expectation that they had the greatest potential for time savings.





Historic times for manufacture were used to set the Velocity Project 30% reduction target. From the current 2333 hours expected to make a part, a 30% reduction of 700 hours was the time to be removed from the fabrication process. The target was to bring Part fabrication down to 1635 hours.

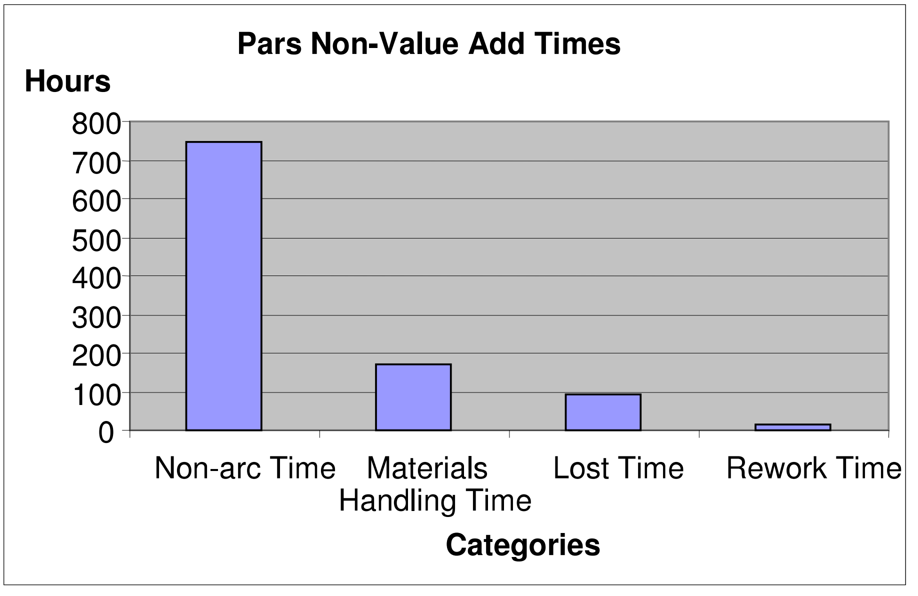


Root Cause of Time Losses

The Value Stream Map identified the time losses categorised in Table 1.

Time Loss Categories	Time
	Hr
Non-arc Time	746
Materials Handling Time (Getting parts and cranage)	170
Lost Time (Wait crane, breakdowns)	92
Rework Time (Quality defects)	14
Total	**1022**

Table 1 Time Losses Identified by Value Stream Map



The largest category by far was the 'Non Arc Time'. Such time included time spent on toilet breaks, getting drinks, washing-up and other such breaks, time spent measuring dimensions, time spent marking-out, time spent fitting parts in-place, time spent moving parts into required alignment, time spent interpreting drawings and getting information, time spent searching for parts, time spent extracting parts from under other parts, time spent moving materials to clear floor congestion or to make space to work, along with other activities required to do the task, but not actually advancing the product to completion.

Unfortunately no measuring was able to be done of the non-arc time make-up to identify the sizes of the various categories

Table 2 shows the results of a crane usage survey conducted mid-June 2007. It identified 3 hours crane waiting time for every 45 hours worked in the Low Bay. This equated to 120 hours lost per part in the Low Bay alone waiting for cranes, which was more than the 92 hours estimated by Value Stream Map. The survey result was from actual observation and was expected to be the more reliable count of crane waiting times. If 20 parts were built per year, the lost time waiting for cranes at the hourly recovery rate would amount to $168,000 per year in the Low Bay alone. To this would need to be added the cost of time lost in the High Bay waiting for cranes.

Crane Location	**Utilisation**	**Less then 2T Lifts**	**Man Waiting Time**
Low Bay	% of Time Used	% of Lifts	Minutes
East	70 - 85%	40 – 50%	30
Middle	80 - 95%	20 – 40%	110
West	80 – 90%	25 – 50%	30
High Bay			
East	50 – 90%	10%	0
West	50 – 90%	25%	0

Table 2 Crane Usage Summary During 6.5 Hours of Observation

The Contact Diagram below identified some five (5) kilometres of parts transportation per Part.

Parts Contact Diagram
Shows Movement of Parts

Wastes Identified

Table 2 below records wastes identified at each step in the 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.

	Manufacturing Steps														
Waste	Material Supply	Program Nesting	Profile Cut Plates	Bevel and Mark Plates	Join Sides, Top and Bottom	Assemble Legs Baffles and Back Bar	Subarc Corner Welds	Manual Weld between Legs	Assemble Legs to Torsion Box	Weld Legs and Cast Lugs	Mount racks and Termination Plates	Machine on Floor Borer	Fit Bushes and Key Weld	Clean-up and Paint	Transport and Ship
Waiting Time: (Employees standing about. Inventory at stand-still)			A great deal of non-moving plate material was kept in storage racks	Finished bevelled parts sat on pallets awaiting next production step	Time lost waiting for cranes to bring bevelled parts to the work station and to move joined sections to floor stack	Time lost waiting for two cranes to become available to lift assembly Time lost waiting for machined baffle plates	Time lost waiting for two cranes to become available to lift leg assembly or welded leg. Workshop interviews indicated that sub-arc equipment breakdowns caused regular time loss.		Time lost waiting for cranes. Time spent waiting for machined torsion box.		Time lost waiting for crane	Time lost waiting for cranes	Workplace interviews indicated that bushes had been supplied late at times in the past		
Overproduction: (Producing items before necessary)			At times cut material was not needed for up to three months. In the majority of cases profiled shapes were not required for days.	Once cut all profiled parts sat on the floor or out in the yard waiting for next process step	Stacks of joined sections left waiting along side centre walkway	Assembled legs sat on floor awaiting next production step									Parts awaiting shipping were stored off-site to clear floor and make space for another Part
Repair Defect: (Making incorrect product)					Not observed, though advised by ultrasonic test (UT) inspector that welds had failed in the past	Not observed, but advised during workplace interviews that backing bar gap was excessive at times and that assembled leg was occasionally bowed beyond design specification							A concern was expressed during an interview that a key weld was high		
Movement Unnecessary: (Any wasted motion by man or machine)			The vast majority of lifts were single items ranging from tens of kilograms to several hundred kilograms. Removing small off-cut parts one at a time into the off-cut bin took crane time from other crane users.		Joined plates were removed from stack and separately laid-out on the floor for UT then re-stacked	Power leads and cables continually being moved or relocated Searching for the correct baffles for the Part Leg	Lift the sub-arc buggy stand away from a finished leg and onto each new leg								
Processing More: (Using more steps to produce a product than necessary)						Not observed as varying from procedure, but all mark-out was by hand measurement and parts held in-place by tacking and then squared-up									
Inventory Non-productive: (Retaining unnecessary inventory between process steps)								Three legs stored on floor awaiting next process step							
Transport Unnecessary: (Moving material unnecessarily or long distances)			Many profiled parts were stored up to one hundred and fifty meters from next point of use.	Bevelled parts stored sixty meters from next point of use	Bevelled parts stored sixty meters from next point of use	Not observed as varying from procedure, but all rotations required two cranes					Parts moved about High Bay several times to make space for other work			Parts moved about High Bay several times to make space for other work	

Table 2 Wastes Identified in Manufacturing Process (The table does not show all wastes, only those noted at times of observation.)

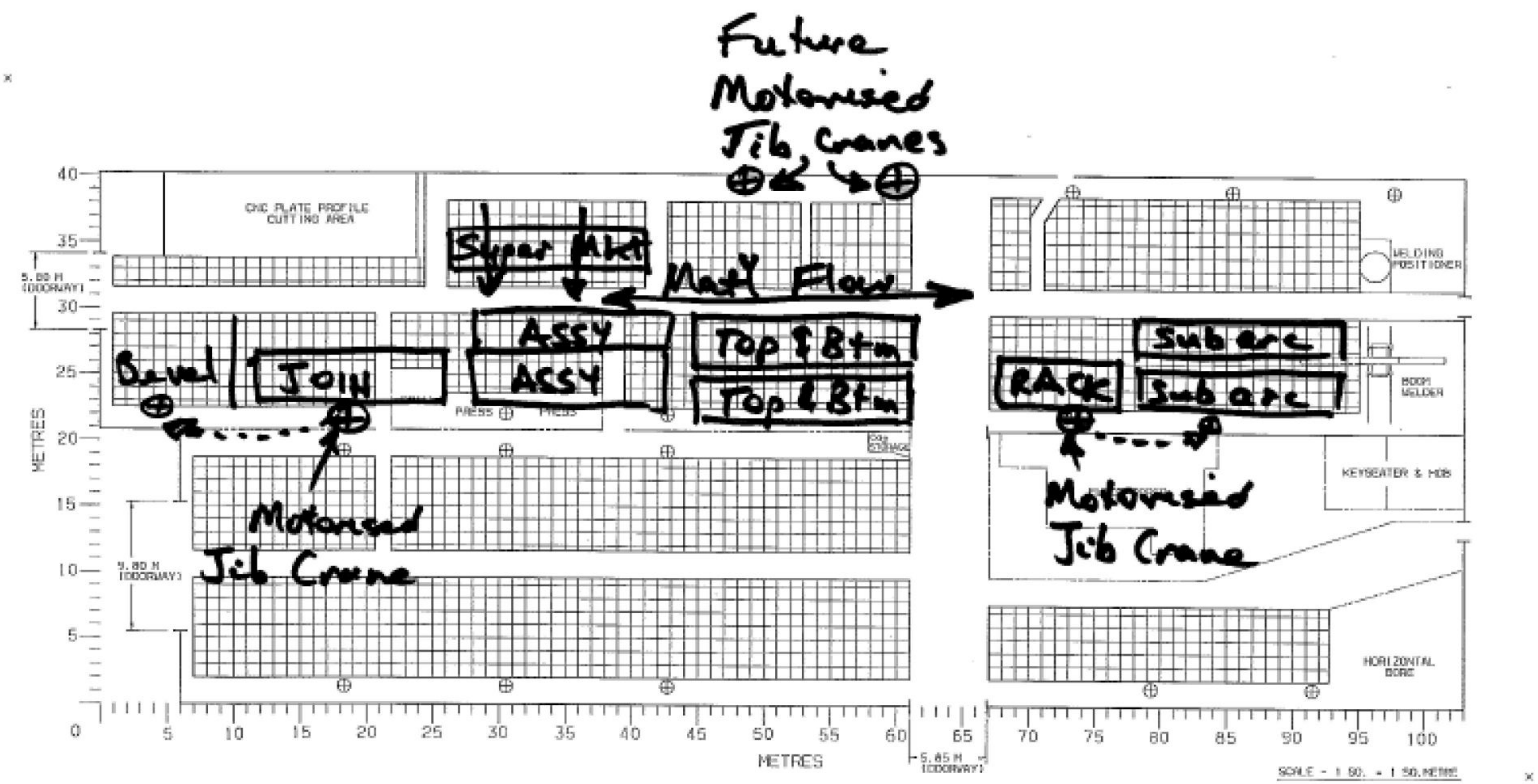
IMPROVE

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.



Future Motorised Jib Cranes
CNC PLATE PROFILE CUTTING AREA
Sypar Mkt
Mat'l Flow
ASSY
ASSY
Top & Btm
Top & Btm
Bevel
JOIN
PRESS
Motorised Jib Crane
RACK
Sub arc
Sub arc
Motorised Jib Crane
WELDING POSITIONER
BOOM WELDER
KEYSEATER & HOB
HORIZONTAL BORE
5.80 M (DOORWAY)
9.80 M (DOORWAY)
5.85 M (DOORWAY)
METRES
METRES