Operations Management: Case Custom Molds

Joseph Lynn
A4006828
MBA4
GGSB : LSBF

1. **What are the major issues facing Tom and Mason Miller?**
2. **Identify the individual processes on a flow diagram. What are the competitive priorities for these processes and the changing nature of the industry?**
3. **What alternatives might the Millers pursue? What key factors should they consider as they evaluate these alternatives?**

GRENOBLE ECOLE DE MANAGEMENT Graduate School of Business

Comment Form for Assessed Work

Section One *To be completed by the student* *Please tick as appropriate*

Name (s) Joseph Lynn..

....

....

....

Student ID Number (s) A4006828..

MBA FT ☐ MIB ☐ Undergraduate ☐

MBA PT X MSc ☐ Diploma ☐ Certificate ☐

Specialization Management Consulting..................................

Intake n°Cohort 4...

Grenoble Main Campus ☐ Off site (state which one) X

Subject Operations Management.. London...

Assignment X Oral Presentation ☐ Exam ☐

Title Custom Molds...

I hereby declare that the attached assignment is my own work and understand that if I am suspected of plagiarism or other form of cheating; my work will be referred to the Disciplinary Committee which may result in my exclusion from the program.

Signature Joseph Lynn... Date 09-03-09 ....

Section Two *To be completed by the Professor I lecturer*

Note below your comments on content, structure and presentation. Comments on specific points should be written on the assignment. Enter grade out of **20** on the bottom of this page. Please indicate whether this is a first or a second grading.

☐ First grading…☐ Second grading

Professor's name ....

Signature ....

Date received .... Date returned to student ....

GRADE

Contents **Page**

1. Custom Molds has reached a point in its development where its competitive priorities are changing due to its traditional fabrication market shrinking and its newer parts manufacturing market is growing. It faces two distinct sets of issues requiring different perspectives. Firstly, day-to-day operational issues, waste and delays are mounting up, whilst alongside that, the changing environmental market factors lead to growing strategic dissonance (Burgelman & Grove, 1996).

Major Strategic Issues: The Millers are facing a strategic inflection point (SIP) due to the shrinking size of their core market (Burgelman & Grove, 1996). Their core competencies were traditionally fabrication, but through development of their capabilities in customisation of molds, they took strategic steps to forward vertically integrate into parts manufacture (Prahalad & Hamel, 1990). Through the 1980s, this strategy allowed them to grow, but by 1990, their core fabrication market started shrinking (Appendix A – Fig. 2). Their customers moved towards stronger strategic supplier relationships, rather than backwards integration. Strategic alliances allow customers to rely on their suppliers to develop low cost manufacturing competencies ensuring timely delivery of high quality parts.

These changes in the external environment impact both the fabrication and the manufacturing sides of the business. For fabrication, although the number of orders remained the approximately the same, the market for multiple molds was shrinking, so the absolute number fabricated was reducing. Although it can be assumed that fabrications orders with high order size would have been discounted, the 18% fall in fabricated molds from 722 in 1988 to 591 in 1990 would have significantly impacted revenue generated from the fabrication market. The market for Custom Mold's core competencies of fabricating molds was shrinking and changing the competitive priorities of the company (Appendix A – Fig. 3).

Simultaneously, manufacturing was experiencing massive growth in the number of manufactured parts (Appendix A – Fig. 4). Although the order numbers remained around the same, changes in the demand characteristics of their customers meant that Custom Molds experienced a growth in the number of parts manufactured of 143% between 1988 and 1990. Although a direct association between increased parts manufactured and revenue cannot be assumed due to bulk discounting, it is clear that Custom Molds would have experienced revenue growth in the manufacturing segment. The company achieved these levels of growth, even though the sales team was specifically focusing on limited quantities. This apparently unplanned increase suggests strategic dissonance, since the level of growth of manufacturing department appears to be well outside of expressed strategic intent to target limited quantities for Research and Development efforts. Appendix A – Fig. 5 shows Porter's (2008) five forces analysis of the industry.

Major Operations Issues: On the operational side, due to the vast increase in demand for parts manufacture, Custom Molds experienced difficulties meeting quality and delivery objectives. As demand characteristics increased for manufacturing parts, there was consequent increase in lead time on parts. The theoretical maximum performance of 5000 parts per day from the injection moulding department, shows that even the largest order sizes could be completed within a single day. Furthermore, the annual operating output of 114850 parts in 1990 from the injection moulding department could be completed in 23 days of theoretical optimal operational working time, excluding setup times and other supporting processes. Thus, Custom Molds was suffering from an efficiency issue, rather than a capacity issue.

Bottlenecks were occurring throughout the manufacturing process and quality issues were increasing. These performance issues were likely due to the fact that there was unplanned growth beyond the available capacity given the process issues. There were numerous non-value-adding processes throughout the workflow, including significant delays, many inspection steps, storage and transport. Parts were not being manufactured at optimum speeds and as pressures of late deliveries and mounting backlogs built up, the consequent increased focus on delivery times conflicted with the competitive priority of producing high quality, so quality of finished goods suffered. These operational difficulties required process analysis to streamline and enhance the workflow to deliver greater value to the customer (Krajewski & Ritzman, 2004).

Competitive Priorities		**Fab 1980s**	**Fab 1990**	**Parts 1980s**	**Parts 1990**
Cost	**Low cost operations**	2	2	3	4
Quality	**Top quality**	5	5	2	2
	Consistent quality	4	5	4	5
Time	**Delivery speed**	1	3	3	5
	On-time delivery	3	5	3	5
	Development speed	4	3	1	1
Flexibility	**Customisation**	5	5	1	1
	Variety	1	1	3	4
	Volume flexibility	2	1	3	5

Table 1 - Competitive Priorities (Scale: 1 = lowest to 5 = highest)

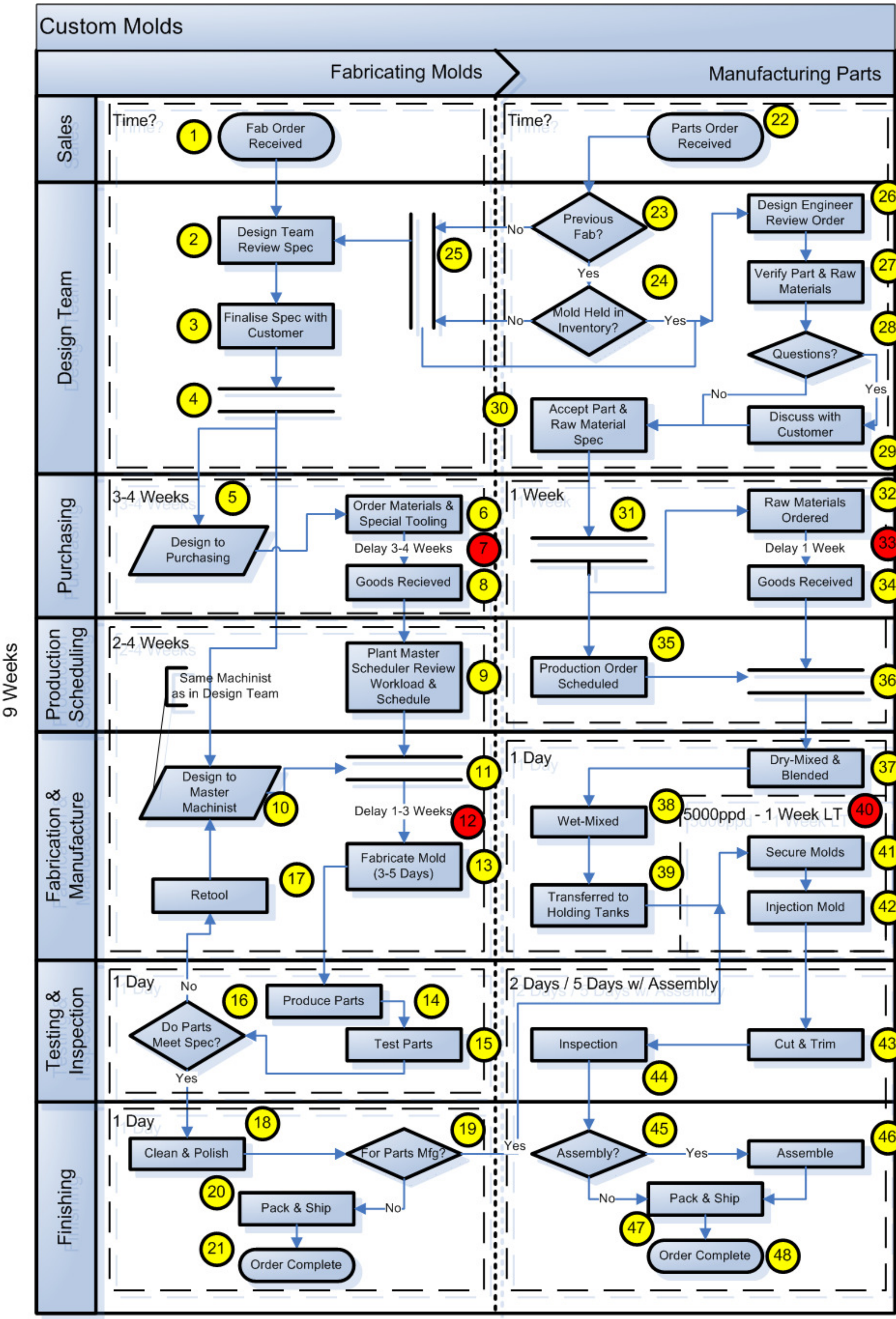


Figure 1 - Flowchart of Custom Mold Processes

2. The flow diagram for individual processes shows a highly convoluted set of processes, many non-value-adding, and many that increase the complexity of the flow through the organisation (Fig. 1). By implementing a process of change to update and enhance these procedures, lead times and cost could be reduced, whilst quality could also be increased. The different numbered stages of the flow chart have been analysed, and recommendations for improvement will be proposed later in this paper. Table 1 displays competitive priorities for the mold fabrication and parts manufacturing industry in the 1980s and 1990. Based on the demand trends in the environment, the market is moving towards parts and away from fabrication (Appendix A).
Competitive priorities for job shop-based mold fabrication are top quality, consistent quality, on-time delivery, customisation and to a lesser extent development speed (Krajewski & Ritzman, 2004). These priorities focus on meeting the requirements of the core processes of order fulfilment, new product development and customer relationship. Cost, delivery speed, variety and volume flexibility are less important, since due to the nature of the bespoke service provided, they are de-emphasised. The industry is moving towards an increased need for speed in delivery and development as customers forge strategic alliances, becoming more reliant on suppliers for timely delivery at consistently top quality. This increases the need for focus on the core process of supplier relationship to reduce lead times for delivery of materials and tooling.
Parts manufacturing has a different set of competitive priorities, which focus on consistent quality, delivery speed, on time delivery and volume flexibility at relatively low cost. Due to the comparatively automated batch processes involved in parts manufacture, speed, cost and flexibility are all achievable competitive priorities. Core processes for parts manufacture are order fulfilment, and to a lesser extent, customer relationship. As the industry moves towards customers forging stronger strategic alliances with and dependencies on suppliers, cost, delivery speed, on time delivery, volume flexibility and consistent quality all become increasingly important priorities. Customers, recognising that developing competencies in non-core areas is costly and inefficient are moving towards a strategic supply chain management approach (Neizen & Weller, 2006). Core processes of supplier relationship and customer relationship become more important to Custom Molds parts manufacture as their Customers became increasingly dependent on timely consistent deliveries at low-cost. Rivals continually adjust to the dynamic environment and would focus on these competitive priorities, so to avoid being out-competed, Custom Molds must also adapt.

3. Through use of process analysis tools, it can be seen that there are several alternatives for the Millers (Krajewski & Ritzman, 2004). When assessing these potential options, it is important to consider the competitive priorities, current metrics and forecast impact on quality, lead time, cost and flexibility. Combined with this, the impact on the core processes of customer and supplier relationships, new product development and order fulfilment also need to be considered. The available alternatives fall into three categories. Short-term, day-to-day operational issues can be resolved with minor incremental process changes that would make immediate performance improvements. Medium-term decisions require more in-depth change. Finally, long-term strategic operational decisions require tight integration with organisational objectives.
Short Term: There are numerous process analysis tools available to interpret the bottlenecks and systemic flaws within the flow chart. From the flow chart, a process chart and string diagram were created, which were used as the basis for Pareto Analysis (Appendix B). Within the fabrication process, the Pareto Charts show that delays dwarfed the operational lead time in the process. Also, there are many non-value adding transport and inspect steps. Steps 7 and 12 drastically increase the length of time it takes to fabricate a new mold. There is a delay of 3-4 weeks for ordering materials and tooling, and a delay of 1-3 weeks due to scheduling issues. The first and quickest step to resolve the initial delay would be to remove the stipulation that the master machinist must be the same as the one involved in the design team. Whilst this could potentially cause difficulties as the machinist would not be as well versed in that particular design, machinists are highly skilled and could understand any design quickly. This would raise pool of available resources from 1 to 13. Despite the delays in manufacturing, there is "excess labour capacity" in the fabrication area, which can be utilised to reduce that 1-3 week wait. Furthermore, the parts manufacturing component could be considerably shortened by improved scheduling of injection molding at Step 40. Scheduling could be improved and bottlenecks avoided by time levelling to balance the task lengths for each step of the process. Whilst all proposed changes need to be evaluated in terms of their impact on resources, competitive priorities and core processes, these initial changes would greatly reduce lead times at minimal cost.
Medium Term: Medium term changes involve enhanced focus on the supplier relationship through supply chain management methodologies, moving towards lean principles through Just In Time (JIT) tactics to eliminate waste, reorganising the plant layout, streamlining the processes and building cultural values of Total Quality Management (TQM). Each of these changes has different costs and benefits for both the organisation and the customer and will be addressed separately (Womack & Jones, 1996).
Developing the supplier relationship through supply chain management methods is a central to meeting the enhanced time-based competitive priorities. In this case, the order fulfilment process is intricately linked to the supplier relationship process. By forging strong strategic alliances with their suppliers, and providing a framework for delivery timescales and expectations by utilising customer guidelines for quality, delivery and reporting procedures, supplier performance can be measured and delivered. This would reduce delays at Steps 7 and 33. Alternatively, by holding raw materials inventory, purchasing lead times could be eliminated.

Having focused on improving supplier relationships, the next steps move towards lean manufacturing principles (Womack & Jones, 1996). By identifying the different wastes that are integral parts of the process, the organisation can address these components within their operations and improve efficiency. As previously discussed, delays can be reduced by improving supplier relationships. Further improvements can be addressed at steps 12 and 40, by reducing waiting time whilst work is scheduled. It appears that currently Custom Molds does all scheduling manually. By investing in an ERP solution, they would be better able to plan their machine and resource time. This would also simplify their supply chain management processes, predict supplier lead times, and streamline the inventory and stock ordering procedures. This would allow JIT supply of inventory, ensuring timely delivery of raw materials, and reducing waste inventory. By addressing these issues, much of the time-based waste would be reduced.

Based on the string diagram of the factory plant and the estimated transport distances within the organisation, there is a considerable amount of waste transport (Appendix B, Fig. 6; Quality Tools, 2007). By considering which processes are necessary to add value to the customer, and the path that most products will take through the plant, there is scope to rearrange the plant layout to better utilise resources. By rearranging departments in a way that reduces transport with greater emphasis on the manufacturing side of the organisation, due to the changing environment, many unnecessary movements can be removed.

By assessing the processes involved in the flow chart, several innovative changes can be made to remove non-value adding inspection steps (Womack & Jones, 1996). Steps 14-17, 26-30 and 43-44 are all inspection steps of various types. By instilling a quality culture through job enrichment and forming quality teams, many of these wasteful steps can be removed. This requires time, effort and support from the top of the organisation to champion the roll out of TQM. By aiming for continuous process improvements, and embedding quality into the core of the organisation, the processes can be streamlined.

Appendix C shows a proposed Flow Chart, Process Chart, Plant Layout and String Diagram for Custom Molds once the innovative process changes have been implemented. Through these changes, the increased competitive priority of time-based competition will be met, as will, through elimination of waste, the increased focus on low cost operations. By installing an ERP system, scheduling and capacity will be improved, leading to improved variety and volume flexibility. Implementing TQM will ensure that even though the testing and inspection steps are removed, quality objectives and competitive priorities within both processes can still be met. Based on the forecast performances metrics in terms of lead time, number of waste processes and distance travelled, along with concurrent assumptions of enhanced quality and reduced cost through process improvement, the proposal should positively impact all three key metrics of quality, lead time and cost.

Whilst these Medium Term changes do not require a change of strategy, some of the more long term decisions should be taken sooner since the future strategic vision for the organisation determines the short and medium term operational decisions[1]. Installing an ERP system incurs significant costs and changing the core organisational values and culture is a complex task, which must be built around a specific vision.

Long Term: From a strategic perspective, there are four possible alternatives for Custom Molds. They could establish a plan for more controlled growth, refocus the company on custom mold fabrication only, refocus the organisation on the growing parts manufacturing market or recognise the different requirements of the two separate processes and establish two entirely separate lines. Each of these options has different costs and benefits to the organisation, its suppliers and its customers.

By establishing a plan for more controlled growth, the company is able to remain tapped into its core competencies, its brand and reputation and also retain access to the extremely fast growing parts manufacturing sector. However, this means that resources are spread between the separate processes and if the demand continues to fall for fabrication at its current rate, Custom Molds will be investing in a doomed market segment. It may be better to harvest and divest (Marketing Teacher, 2008).

Another option would be to leverage their core competency and aim to become highly specialised, premium mold fabricator. Through this process, they could retain high margins, and potentially stay profitable, but, again, there are significant risks involved in relying too intently on a shrinking market segment.

The third strategic choice would be to divesting the fabrication component of the business in order to focus more directly on the growing manufacturing market segment. This might be hardest to do, due to the considerable change in strategic intent and core values that would be required. The Millers would have an emotional attachment to the successful mold fabrication business, and that would feed into the culture of the organisation. Also, fabrication is the core competency of the business. However, given the industry structure and apparent likelihood of continued growth in the manufacturing sector, it may also be the best choice.

The final option is to establish separate lines for each process. The processes are currently separate, but this might include moving one of the processes out to a separate location. Whilst this would ensure that both revenue streams were retained, it would also have a considerable cost impact, and with the shrinking fabrication market, it may mean too great a commitment of resources.

The external environment is changing for Custom Molds. As industry competitive priorities change, strategic decisions must be taken based on the market need and linked in with operational design. Thus, with strong enough leadership and vision, the preferred option would be to move solely into the manufacturing market.

---

[1] Many of these recommendations would be valid no matter what the long term strategic decisions are, but the more specific proposals in Appendix C assume no significant changes in strategy, or establishing a plan for more controlled growth.

Bibliography

Burgelman, R. A. & Grove, A. S. (1996). Strategic Dissonance, *California Management Review*, Vol. 38, No. 2, Winter, pp.8-27.

Krajewski, L. J. & Ritzman, L. (2004). *Operations Management: Processes & Value Chains (7th Ed.)*, Prentice Hall.

Market Teacher (2008). *The General Electric (GE) Business Screen.* [Online]. http://www.marketingteacher.com/Lessons/lesson_general_electric_business_screen.htm [Accessed on 21 March 2008].

Neizen, C. & Weller, W. (2006). Procurement as Strategy. *Harvard Business Review*, September, pp. 22-24.

Porter, M. (2008). The Five Competitive Forces That Shape Strategy, *Harvard Business Review*, January, pp. 79-93.

Prahalad, C. K. & Hamel, G. (1990). The Core Competence of the Corporation, *Harvard Business Review*, May-June, pp. 79-91.

Quality Tools (2007). *String Diagram*. [Online]. Quality Tools. http://syque.com/quality_tools/toolbook/String/string.htm [Accessed 05 March 2009].

Womack, J. P. & Jones, D. T. (1996). Beyond Toyota: How to Root Out Waste and Pursue Perfection, *Harvard Business Review*, September-October, pp. 140-158.

Appendix A – Industry Analysis

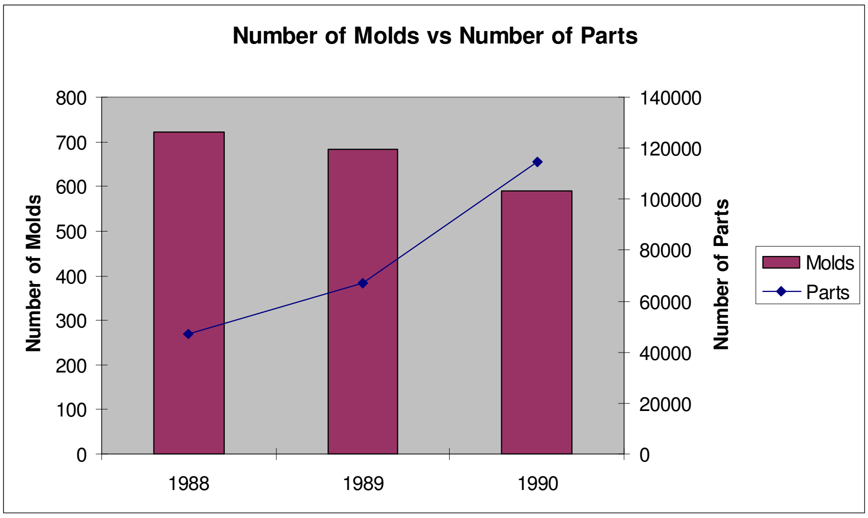
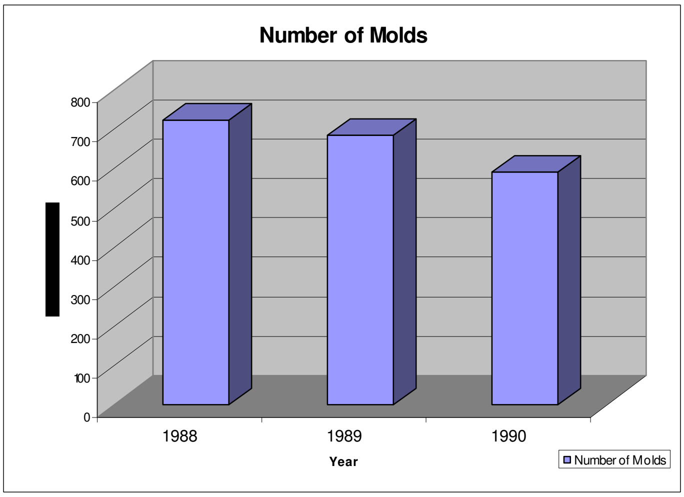


Figure 2 - Volume of Molds compared to Volume of Parts by Year



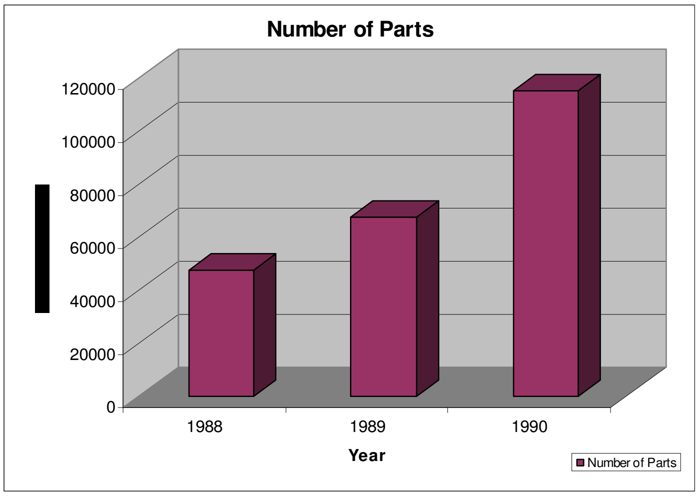


Figure 3 - Number of Molds Fabricated by Year

Figure 4 - Number of Parts Manufactured by Year

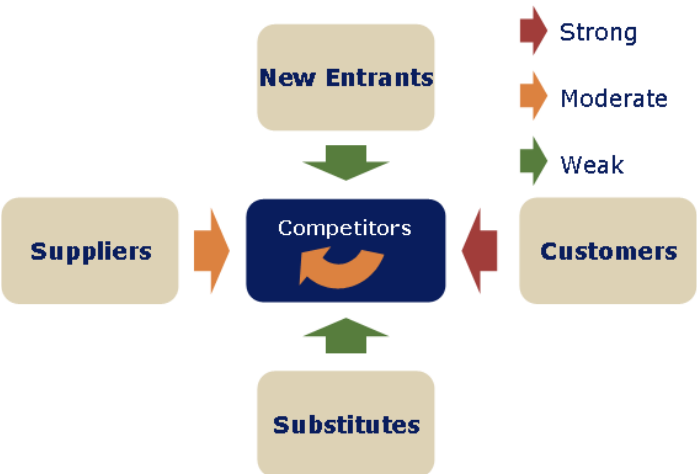


Figure 5 - Porter's Five Forces Industry Analysis[2]

[2] Bargaining power of customers is high as customers demand on reliable delivery times and quality. Bargaining power of suppliers and competitive rivalry is moderate since Custom Molds are reliant on suppliers, but they can utilise their customer demands as leverage, and it can be assumed that there are a fair number of competitors. The threat of new entrants and substitutes is low because there are high capital costs, and few other options for customers

Appendix B – Current Situation

Process Chart[3] – Fabricating Molds
Process: Fabrication
Subject: Fabricating Molds
Beginning: Fabrication Order Received
Ending: Fabrication Order Completed

Summary

Activity	Symbol	No. Steps	Time (days)	Distance (ft)
Operation	○	3	4.5	155
Transport	⇨	7	0.5	245
Inspect	☐	6	1	70
Delay	D	3	27.5	30
Store	S	-	-	-

No	Time (Days)	Distance (ft)	○	⇨	☐	D	S	N/A	Activity
1	?	20		⇨					**Fab Order Received**
2	?	10			☐				**Design Team Review Spec**
3	?		○						**Finalise Spec with Customer**
4	?							N/A	**Parallel Processing**
5	?	20		⇨					**Design to purchasing**
6	?	N/A		⇨					**Order Material & Special Tooling**
7	15 to 20					D			**Delay**
8	?	125		⇨					**Goods Received**
9	?				☐				**Master Scheduler Review & Schedule**
10	?	40		⇨					**Design to Master Machinist**
11	?							N/A	**Serial Processing**
12	5 to 15					D			**Delay**
13	3 to 5	150	○						**Fabricate Mold**
14	0.5	15			☐				**Produce Parts**
15	0.5	45			☐				**Test Parts**
16	?				☐				**Do Parts Meet Spec?**
17	?	30				D			**Retool**
18	0.5	5	○						**Clean and Polish**
19	?				☐				**For Parts Manufacturing?**
20	0.5	35		⇨					**Pack and Ship**
21	?	5		⇨					**Order Complete**
Total	**25-42**	**500**							

Process Chart – Manufacturing Parts
Process: Production
Subject: Producing Parts
Beginning: Parts Order Received
Ending: Parts Order Completed

Summary

Activity	Symbol	No. Steps	Time (Days)	Distance (ft)
Operation	○	4	5	355
Transport	⇨	7	0.5	450
Inspect	☐	11	1.5	215
Delay	D	1	5	-
Store	S	1	4	-

[3] Assumptions – 5 day week and 22000 sq ft factory

No	Time (Days)	Distance (ft)	○	⇨	☐	D	S	N/A	Activity
22	?	20		⇨					Part Order Received
23	?	15			☐				Previous fab?
24	?				☐				Mold Held in Inventory?
25	N/A	N/A						N/A	Fabricate Mold
26	?	10			☐				Design Engineer Review Order
27	?				☐				Verify Part & Raw Materials
28	?				☐				Questions?
29	?				☐				Discuss with customer
30	?				☐				Accept Part and Raw Material Spec
31	?							N/A	Parallel Processing
32	?	N/A		⇨					Raw Materials Ordered
33	5					D			Delay
34	?	100		⇨					Goods Received
35	?				☐				Production Order Scheduled
36	?							N/A	Serial Processing
37	0.5	30	○						Dry-Mixed & Blended
38	0.5	30	○						Wet-Mixed
39	?	75		⇨					Transferred to Holding Tanks
40	4						S		Stored In Holding Tanks
41	?	70		⇨					Secure Molds
42	1	120	○						Injection Mold
43	1	110			☐				Cut & Trim
44	0.5	80			☐				Inspection
45	?				☐				Assembly?
46	3	175	○						Assembly
47	0.5	160		⇨					Pack & Ship
48	?	25		⇨					Order Complete
Total	**17**	**1020**							

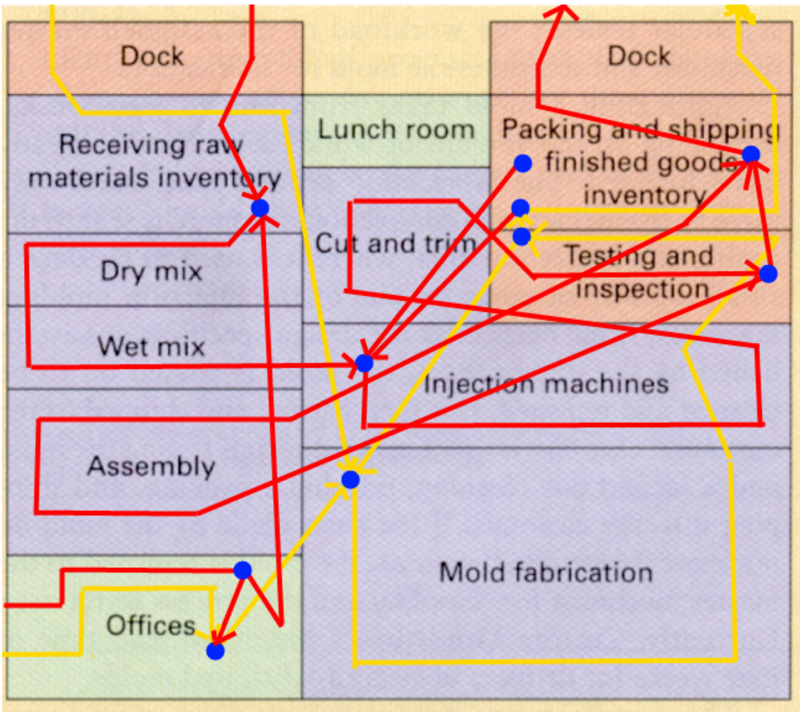


Figure 6 - String Diagram (Yellow: Fabrication Order, Red: Manufacturing Order)

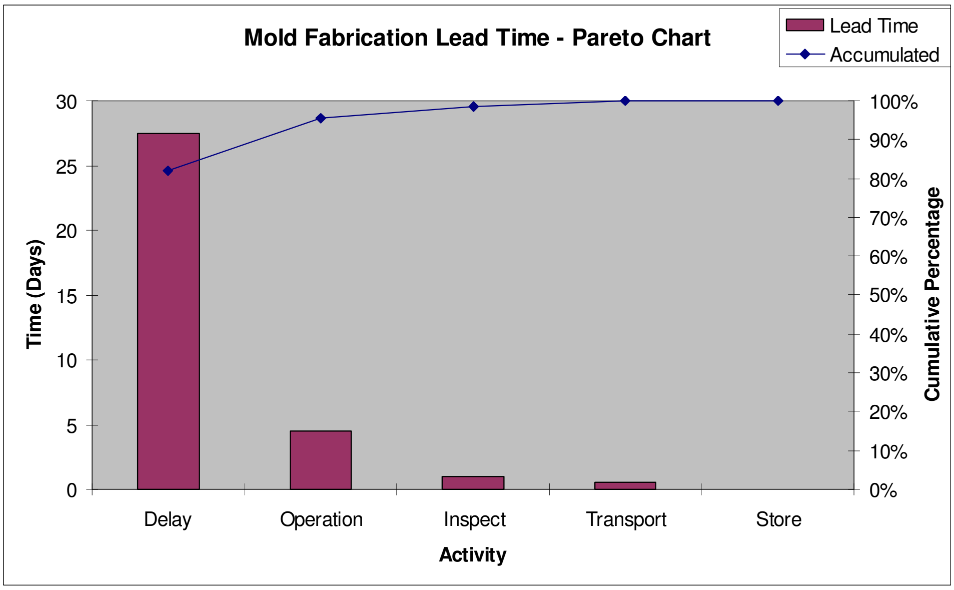


Figure 7 - Mold Fabrication Lead Time

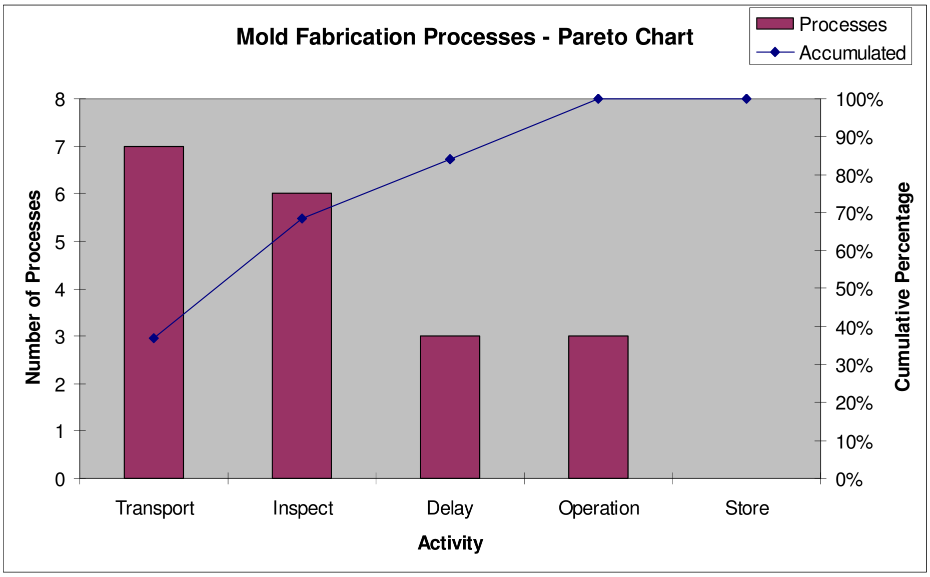


Figure 8 - Mold Fabrication Processes

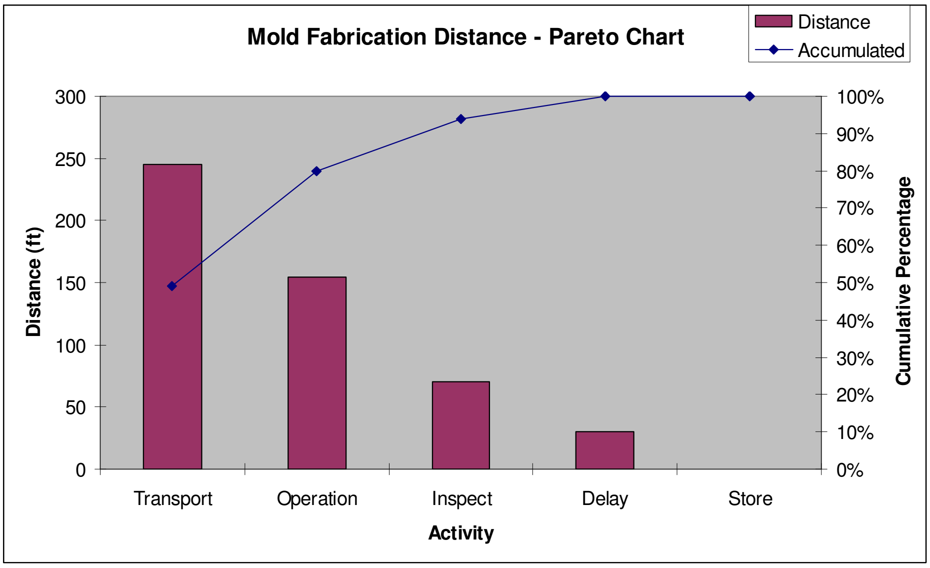


Figure 9 - Mold Fabrication Distance

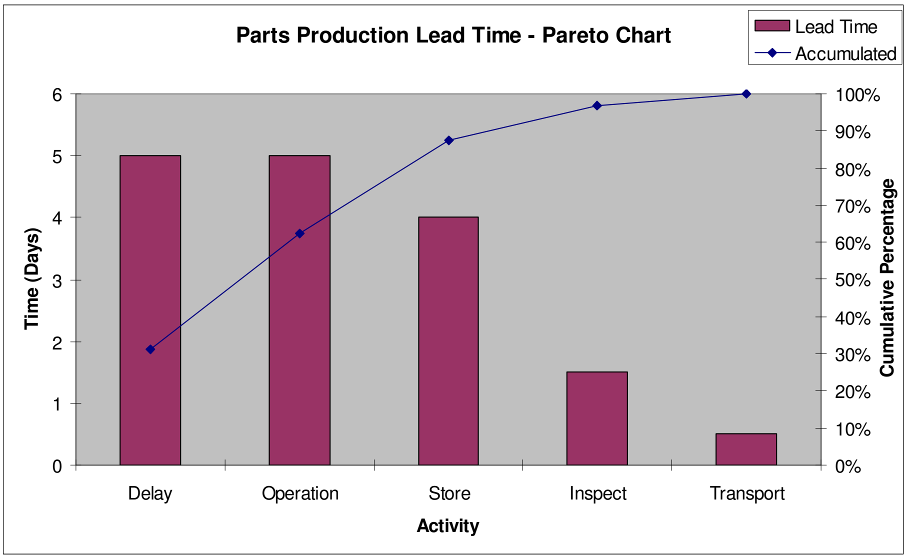


Figure 10 - Parts Manufacturing Lead Time

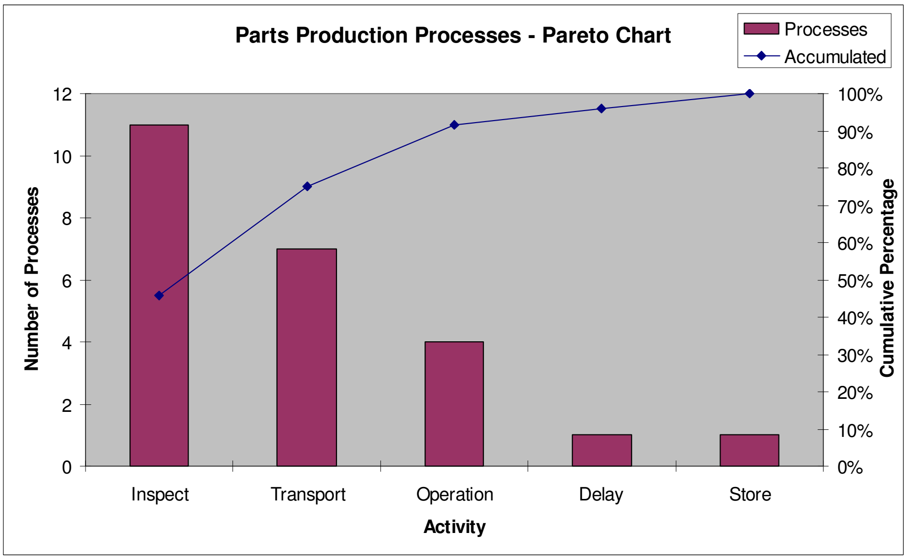


Figure 11 - Parts Manufacturing Processes

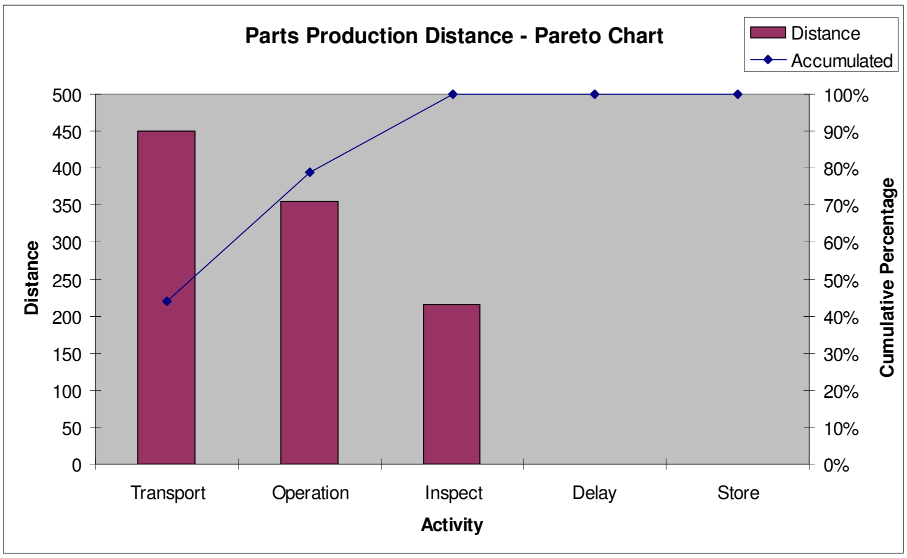


Figure 12 - Parts Manufacturing Distance

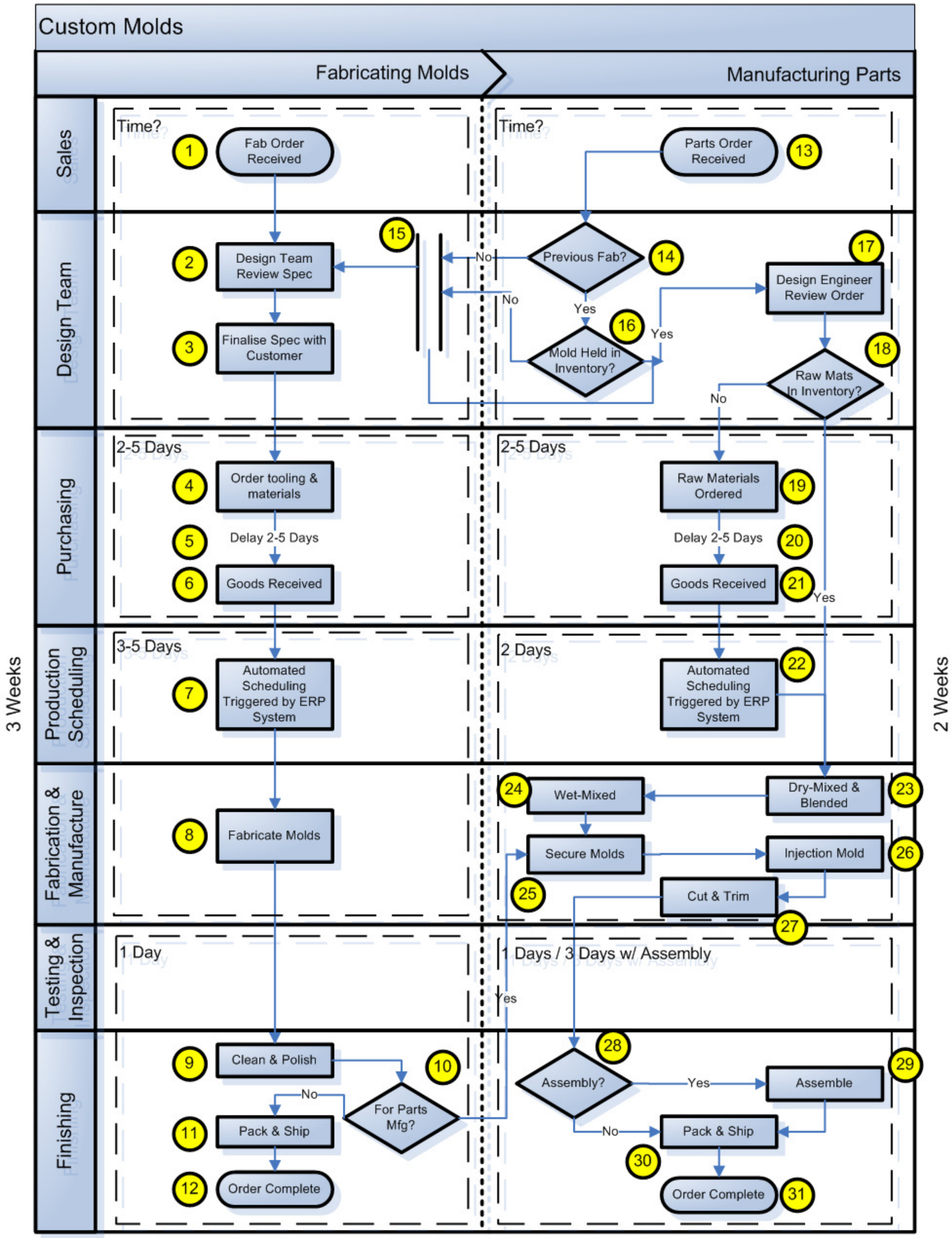


Figure 13 – Proposed Flow Diagram of Custom Mold Processes

Appendix C – Proposed Situation

Fig. 13 displays proposed flow chart

Process Chart – Fabricating Molds
Process: Fabrication
Subject: Fabricating Molds
Beginning: Fabrication Order Received
Ending: Fabrication Order Completed

Summary

Activity	Symbol	No. Steps	Time (Days)	Distance (ft)
Operation	○	3	4.5	150
Transport	⇨	5	0.5	165
Inspect	☐	3	?	-
Delay	D	1	3.5	-
Store	S	-	-	-

No	Time (Days)	Distance (ft)	○	⇨	☐	D	S	N/A	Activity
1	?	20		⇨					Fab Order Received
2	?				☐				Design Team Review Spec
3	?		○						Finalise Spec with Customer
4	?	N/A		⇨					Order Material & Special Tooling
5	2 to 5					D			Delay
6	?	125		⇨					Goods Received
9	?				☐				Automated Scheduling Triggered By ERP System
10	3 to 5	100	○						Fabricate Mold
18	0.5	50	○						Clean and Polish
19	?				☐				For Parts Manufacturing?
20	0.5	15		⇨					Pack and Ship
21	?	5		⇨					Order Complete
Total	**6 to 11**	**315**							

Process Chart – Manufacturing Parts
Process: Production
Subject: Producing Parts
Beginning: Parts Order Received
Ending: Parts Order Completed

Summary

Activity	Symbol	No. Steps	Time (Days)	Distance (ft)
Operation	○	5	6	160
Transport	⇨	6	0.5	220
Inspect	☐	6	-	40
Delay	D	1	3.5	-
Store	S	-	-	-

No	Time (Days)	Distance (ft)	○	⇨	☐	D	S	N/A	Activity
13	?	20		⇨					Part Order Received
14	?				☐				Previous fab?
15	N/A	N/A						N/A	Fabricate Mold
16	?				☐				Mold Held in Inventory?
17	?	10			☐				Design Engineer Review Order
18	?				☐				Raw Materials held in inventory?
19	?	N/A		⇨					Raw Materials Ordered
20	2 to 5					D			Delay
21	?	100		⇨					Goods Received
22	?				☐				Automated Scheduling Triggered by ERP System
23	0.5	15	○						Dry-Mixed & Blended
24	0.5	15	○						Wet-Mixed
25	?	30		⇨					Secure Molds
26	1	100	○						Injection Mold
27	1	30	○						Cut & Trim
28	?				☐				Assembly?
29	3	30	○						Assembly
30	0.5	50		⇨					Pack & Ship
31	?	20		⇨					Order Complete
Total	**5.5-11.5**	**420**							

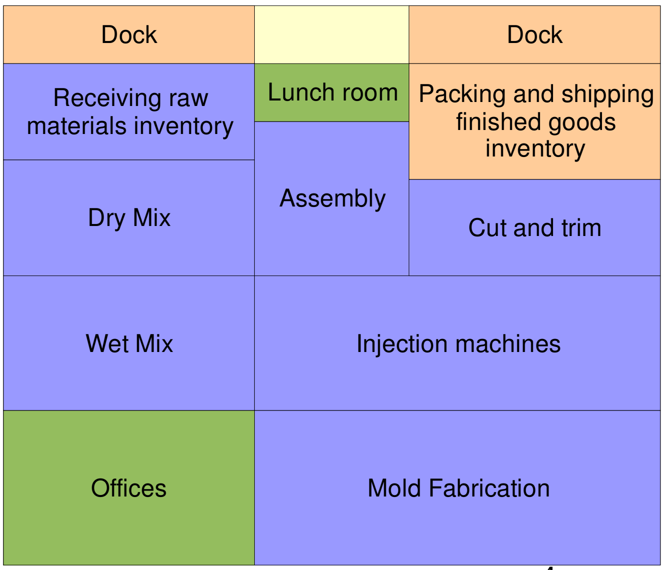


Figure 14 - Proposed Plant Layout[4]

[4] There is less space devoted to the Fabrication areas and more to the part manufacture area compared to the original layout, because that better reflects the realities of capacity requirements given the changing nature of the industry.

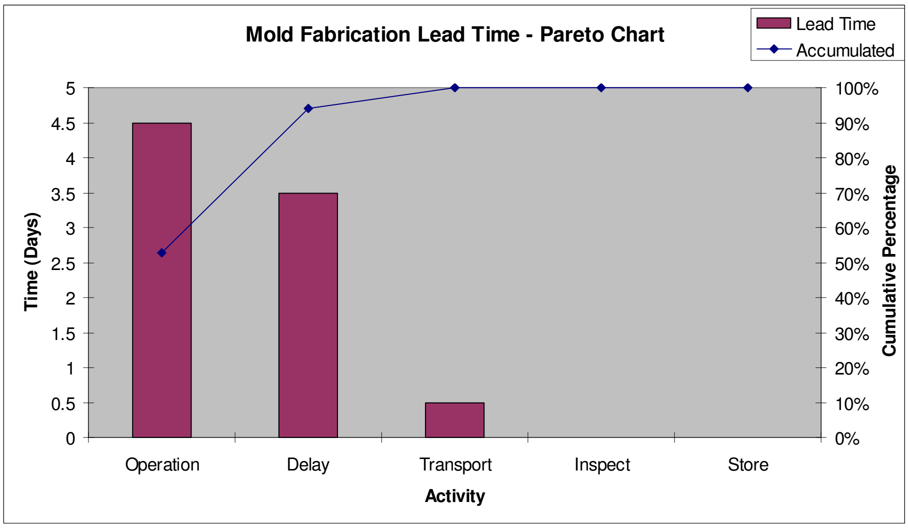


Figure 15 - Mold Fabrication Lead Time Forecast

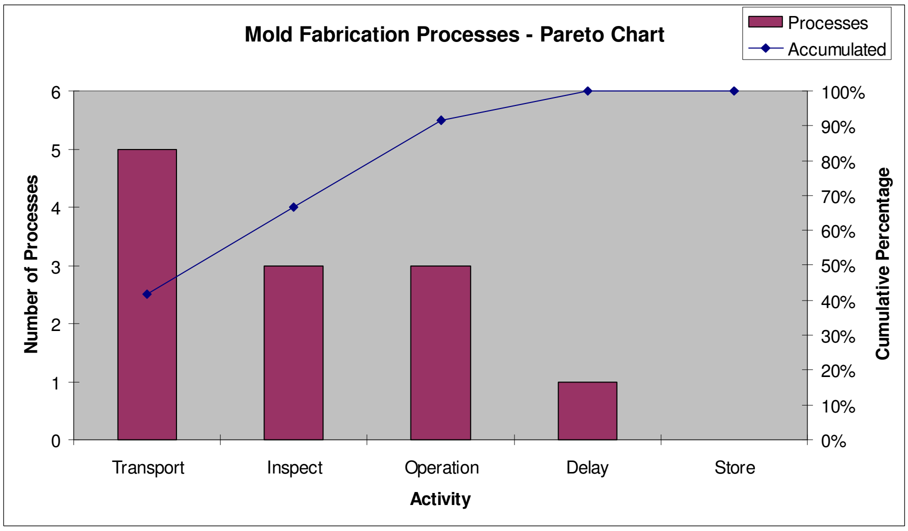


Figure 16 - Mold Fabrication Processes Forecast

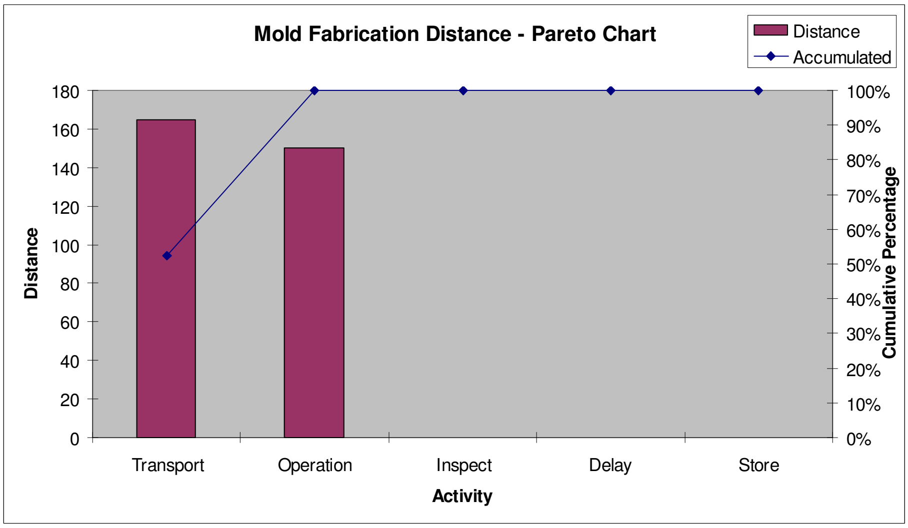


Figure 17 - Mold Fabrication Distance Forecast

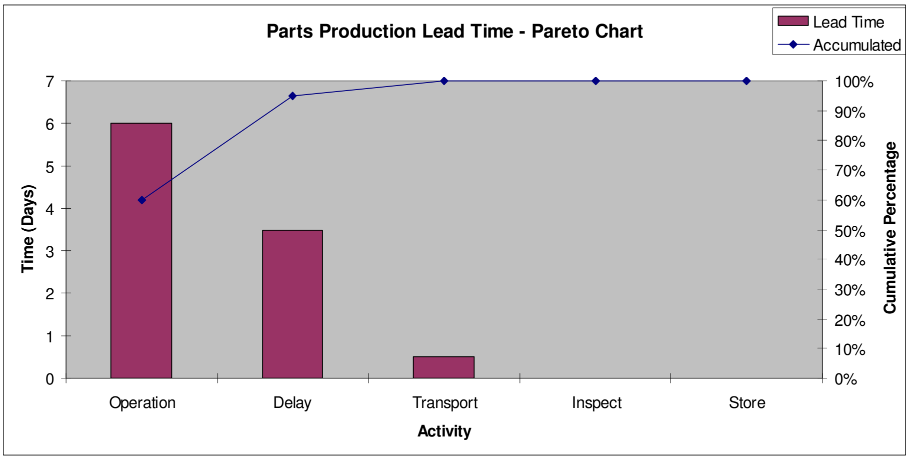


Figure 18 - Parts Manufacturing Lead Time Forecast

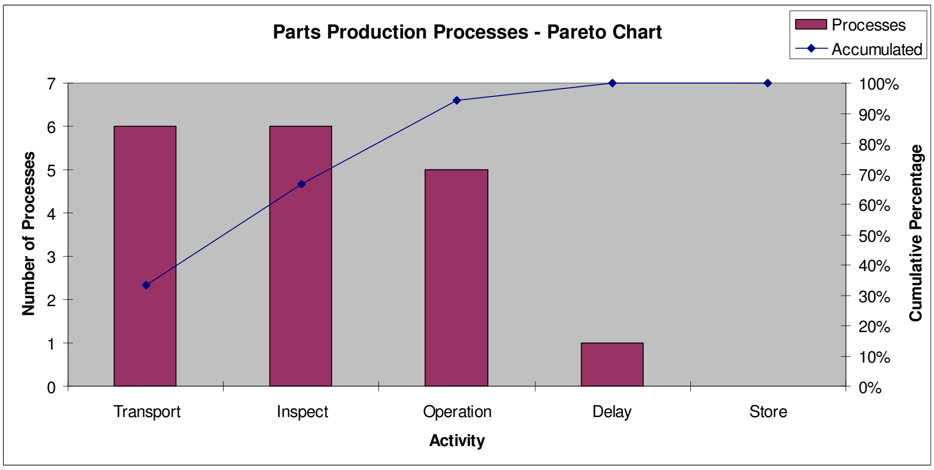


Figure 19 - Parts Manufacturing Processes Forecast

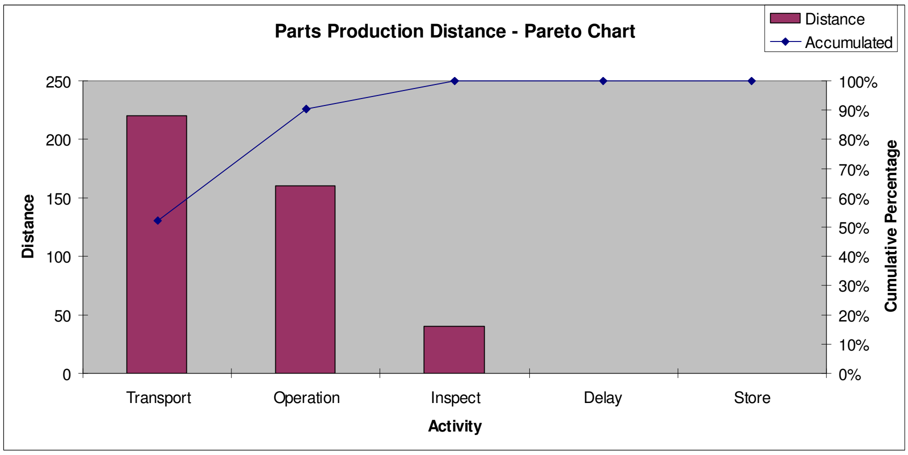


Figure 20 - Parts Production Distance Forecast

In this proposed medium term solution, the lead time, number of processes and the distance has been substantially reduced for both Fabrication and Manufacture. Whilst there are still more transport and inspection processes than operations, the differential has been reduced. Also, many of the inspection processes involve much shorter timeframes than other steps so measuring just on number of processes may not offer a true reflection of the benefits of the solution. Nevertheless, over time, as the organisation moves into lean and TQM, many of these remaining processes could be removed. Equally, transport processes still take up most distance, but this is an interim solution, and even given that, the total distance moved has been greatly reduced and, looking at the String Diagram (Fig. 20), it is clear that there is much less unnecessary movement and the process is much more streamlined. Furthermore, through the long term goals of implementing lean, reducing waste and continuous improvement, the outstanding wastes will be eliminated.

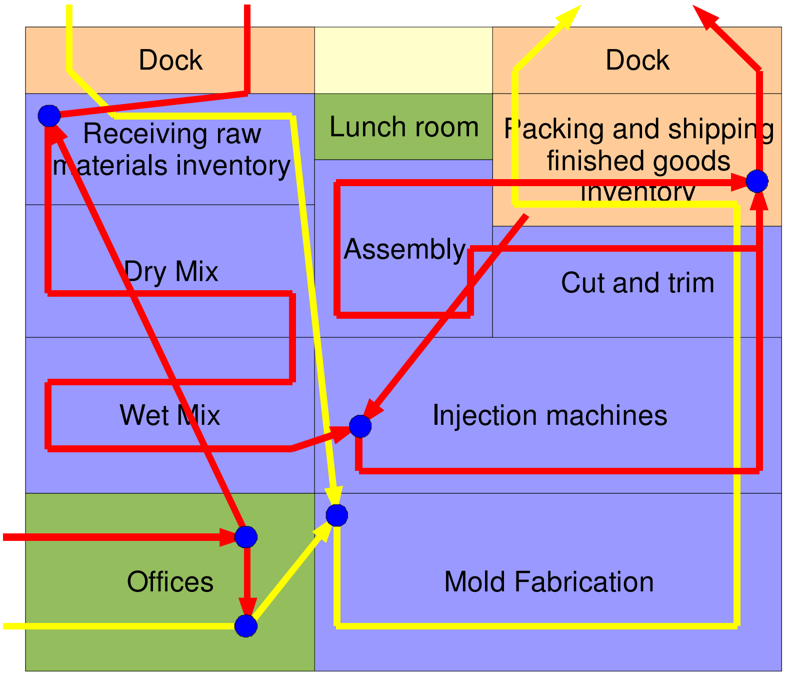


Figure 21 - String Diagram Forecast
(Yellow: Fabrication Order, Red: Manufacturing Order)