

Development of a Robust Supply Chain for Dynamic Operating Environment

Shilan Li*, Ivan Arokiam[^], Peter Jarvis*, Wendy Garner[^], Gazelleh Moradi* and Stuart Wakefield*

Abstract—Development of a Robust Supply Chain for Dynamic Operating Environment as we move further into the twenty first century, organisations are under increasing pressure to deliver a high product variation at a reasonable cost without compromise in quality. In a number of cases this will take the form of a customised or high variety low volume manufacturing system that requires prudent management of resources, among a number of functions, to achieve competitive advantage. Purchasing and Supply Chain management is one of such function and due to the substantial interaction with external elements needs to be strategically managed. This requires a number of primary and supporting tools that will enable the appropriate decisions to be made rapidly. This capability is especially vital in a dynamic environment as it provides a pivotal role in increasing the profit margin of the product. The management of this function can be challenging by itself and even more for Small and Medium Enterprises (SMEs) due to the limited resources and expertise available at their disposal.

This paper discusses the development of tools and concepts towards effectively managing the purchasing and supply chain function. The developed tools and concepts will provide a cost effective way of managing this function within SMEs. The paper further shows the use of these tools within Contechs, a manufacturer of luxury boat interiors, and the associated benefits achieved as a result of this implementation. Finally a generic framework towards use in such environments is presented.

Keywords—Lean, Supply Chain, High variety Low volume, Small and Medium Enterprises.

I. INTRODUCTION

MANY researches have been done in purchasing and supply chain area and many efficient tools and techniques have been developed. However, most of the tools and techniques are developed for high volume and relatively low variety industries. SMEs like Contechs with low volumes and extremely high variety product do not find the use of tools and techniques straight forward as compared to other standard manufacturing environments.

This paper presents the problems associated with these types of organisations and the approaches taken to solve some of these problems. The paper is written with hopes that these strategies, tools and techniques used by Contechs can help other SMEs with low volume and high variety with their purchasing and supply chain management to reduce non value added activities and increase efficiency.

II. BACKGROUND

A. The Company

Contechs is an SME supplying soft trimming service to large boat manufacturers and select bespoke automotive OEM's. Contechs makes an average 3 ~ 5 boats a week which contains about 250 different component parts. Most of the boats have different designs, colour and specifications depending on the request of the end customer.

With growth in demand, Contechs initially struggled with purchasing of raw materials on time. Due to complex planning requirements for each product group, making it impossible to schedule efficiently. Compounded by limited Material Planning Software existing in the market, that supports low volume, high variety production.

In early 2008, Contechs applied to become a Knowledge Transfer Partner with support from Coventry University to employ graduate students to carry out a research to make Contechs more efficient.

B. Problems in Dynamic Manufacturing Environments

As we move further into the twenty first century, it is necessary for organisations to operate optimally due to increasing competition and/or operating costs. This phenomenon has been recognised for well over two decades within the standard manufacturing arena where customers increasingly insist on high quality products, delivered on demand at a competitive cost. To achieve this in a dynamic operating environment, organisations have to operate extra efficiently as minor issues can greatly affect the performance and is in line with [1]. This is even difficult when the variations can be customized [2]. This will have an even greater impact in SMEs due to the limited resources available at their disposal [3]. Dynamic manufacturing environments present challenges to both shop floor as well as the supporting functions. Some of the main problems from the purchasing related business function include:

Planning – in High Variety Low Volume environment, materials can't be planned and ordered until the customer has decided and placed his order, whereas in mass manufacturing environment plans their materials well in advance.

Lead Time – customers usually pay a higher premium and would want the goods or services as soon as possible. Generally the process may involve design to customer specification and engineer it to make it manufactureable before being passed on to purchasing to plan the materials. Then consider the lead time suppliers required to produce the

* Production Planner: Contechs Ltd, email: Sli@contechs.co.uk

[^] Senior Lecturer: Coventry University, email: I.Arokiam@coventry.ac.uk.

parts for the project. In Contechs case this can be about 2/3 of total project lead time. Whereas mass manufacturers would receive customer order and put in production with the materials they have in stock with same machinery, it's only a matter of increase production, doesn't involve design, engineering and sourcing processes.

Sourcing engineered products – Designers generally make the idea of a product more fancy and engineers generally makes the product more complicated, but for purchasing and production, the simpler and easier the better. But purchasing still have source the parts that is engineered which is not an off the shelf item. It cost great time to search the market to find someone to make it and at most occasion it's specially made by suppliers (the problem in here is that it cost a great deal of set up charge and not a lot of suppliers can complete the job at the given lead time). Also there is a general lack of integration of supply chain with the facility and is in line with that mentioned in [4] which points out the lack of supply chain among SMEs.

One of the key routes used towards achieving a competitive advantage within this sector has been to adopt agile and lean practices [5]. The standard manufacturing sector is therefore a step ahead in the application of these tools. Despite this, most of the applications have been targeted at the shop floor type areas. While such steps have increased the operating efficiency, greater improvements can be achieved as a number of the office based supporting activities are overlooked. This could be because of the unavailability of an approach to apply in such an environment where there is little or no standardisation. This mimics high variety low volume environments where also there is a lack application of the manufacturing concepts or is currently at a virgin state spotted across these environments. Although the need for improvement in each of these areas may vary from one to another, the approach to analysing and solving the problems would possibly lie along the same path due to their operational similarities.

C. Methodology

Work in this organization has been aligned and carried out exploiting key lean concepts. Value stream type process maps were used towards identifying vital issues across various business functions. These were refined by minimizing the non-value added activities. The refined business functions were then implemented as part of an MRP system to deliver a fully integrated system. Finally a number of performance indicators were set-up to monitor the implemented solution and help towards continuous improvement activities.

III. PROBLEM IDENTIFICATION

Process/Value stream map hybrids were constructed both at macro as well as micro level for the different business functions involved. This has not been a straightforward task due to the process and job variability. This is one of the reason for use of a hybrid map. Figure 1 shows the current state map. From this and use of micro stage evaluation the

following issues were identified

- Purchasing of materials are different from project to project which need engineers to advise
- Engineers often request parts at the last minute for next day delivery which is impossible.
- It's very difficult to find out if any project has made profit expected as there is hardly any record of the expenditure
- There are often request from Engineers to purchase special parts like hinges or fixings & fasteners which takes a lot of time to search and often have to specially make them with high price.
- Purchasing doesn't have exact record per project
- It takes 4 ~ 5 hours for purchasing to check record and report by project to senior management team due to low level of synergy between Engineering and Purchasing
- Suppliers are not happy about last minute ordering and very short lead time allowance.
- Purchasing is often de-motivated and feeling excluded.

Once the problems were identified a top level map along with a micro level one, where necessary, is put together towards evaluating suitable solutions. The top sevel strategy is shown in Figure 2.

The next section shows some of the solutions developed towards the above as well as other key areas within the business supporting functions of the organization.

IV. DEVELOPMENT OF SOLUTIONS

To solve the problems identified a number of cost effective solutions and procedures were developed and tested in Contechs

A. Purchasing initiated shopping list and budget tracker (common document between purchasing and engineering)

A shopping list is created by purchasing and engineers to record all parts required completing the project which captures:

- Parts required
- Quantity required
- Material & Specification
- Sourcing decisions
- Request for Quotation status
- Quote Status
- Costs
- Selected supplier information
- Ordering status
- Expected delivery date
- Delays of supplies
- Production Status
- Budget Status

This is the stage where purchasing and engineers work together to monitor the budget and reduce project cost as much as possible. This is shown in Figure 3.

The document uses traffic light system:

- Green means goods in stock

- Yellow with date means ordered and the delivery date is...

- Purchase Order (PO) number is in Comment box for future references

- Red means we have problem need to be solved.

- We also use different colour to highlight unique parts

All costs are monitored using a table that shows total, target and balance.

B. Understand current supplier base and control new entrance

Having the right supplier base is critical for SMEs in High Variety Low Volume environment. Contechs had a key foam supplier who supplied about 80% of total foam parts but unlike Contechs, this supplier mainly deals with high volume production. We had to batch quantities for every part which the supplier will make a batch. This sort of worked out well until Contechs had more one off jobs and development which Contechs had to pay for all liability stocks.

For example, when Contechs developed part A:

Part A Issue 00 - when Contechs order one kit, the supplier would make a batch of 5

When Part A changed issue to 01, Contechs has to take the remaining of the batch quantity.

To avoid the liabilities, Contechs found a supplier who is specialised producing low volume and high variety orders and as result, Contechs saved 20% of foam costs and reduced risks of having potential liabilities.

Hence, it is vital SMEs operating in high variety and low volume environment should consider having suppliers with similar manufacturing strategies, where supplier would expect short lead time and small quantity and high mix of parts and they are prepared to operate that way.

When Contechs had new suppliers who operate in low volume high variety environment, there was huge cost savings in relation to the parts Contechs purchase and reduced huge potential liability cost related to batch quantity.

The other solutions developed is that for SMEs like Contechs operating in low volume and high variety environment, it is more helpful to work with small local suppliers for these reasons:

- Cost saving in transport – as it's low volume it's not feasible for suppliers to spread the transport costs into parts prices. The suppliers normally would charge by each delivery, a transport charge by miles for each delivery. Contechs had spend huge amount of money paying for transport but with local suppliers this value has been minimised.

- Better supplier relationship – we could visit suppliers informally to discuss about the parts or suppliers would just visit us so often which made us more closely and have stronger relationship. With national suppliers, it's not feasible to visit them informally and often and they will not send someone over to spend a day with us without any extra profit or revenue.

- More frequent exchange of communication which smoothen the operation for both side

-

- Shorter lead time – when we are really struggling with lead time, it's always local suppliers to help and support us even outside of their working scope and hours.

It is very important for businesses to control and monitor assessment and selection procedure of new suppliers, hence new supplier assessment procedure has been developed to guide the business to follow step by step to check and record the processes of assessing and selecting new suppliers including having probation period for new suppliers to understand their capacity and compatibility.

Further the current supplier base is Mapped to understand the supplier qualities and to ensure the working time is used more effectively on strategic supplier and identify risks in supply chain and decrease these via suitable supplier development programme.

A number of these solutions were embedded within the MRP system towards delivering a seamless solution.

V. ENHANCEMENT OPERATION OF SOLUTIONS

To enhance operation of solutions, a simple material planning software has been implemented towards further reducing the process time. Some of the key uses include:

- Set up minimum and maximum stock level for consumables to manage these more effectively with minimum effort. Once the stock level hits minimum stock level it will alert purchasing.

- Purchasing maintenance area can store and record all purchase orders. This enables purchasing to report by project type and suppliers to support strategic decision making and further monitor spending against project budget.

- The software also works as a central data base to improve communication internally. This has cut down time spent on meetings, waiting for signatures and chasing suppliers by approximately X%.

- Recycling system set up to recycling 80% of production wastes, material and leather scraps are sold to companies make small leather goodies and foam scraps return to supplier to be reused.

VI. MONITORING AND CONTINUOUS IMPROVEMENT

Key Performance Indicators (KPIs) have been set up to monitor performances and seek for continuous improvement. The following KPIs were setup to monitor:

- Material cost savings achieved – Contechs has achieved approximately 15% of cost saving by bench marking supplier costs

- Material wastage in production and identify the reason of wastage. This allowed to form an action plan for production to minimise the wastage

- Production shortage occurred by purchasing to seek for improvement

- Monitor supplier performances in supplier rejects to encourage suppliers to improve on their quality standard

- Inventory level control to ensure Contechs has just

enough stock to ensure production but not too much stock which eventually would affect company cash flow

- Inventory level of high value commodity like leather and fabrics to support Finance department with cash flow management.

VII. DISCUSSION

To achieve an increased efficiency it is vital not just the shop floor areas are targeted but also the business support functions. This in itself can be challenging due to variability of work as well as roles but further complex due to the low volumes and high variations in variety encountered. Despite this, a number of the Lean principles were applicable by modifying and loosely using the core concepts. The business functions and in particular the High Variety Low Volume environment is similar to that of the service type organisations where Lean concepts, to some extent, have been applied successfully. Although effective, it was envisaged that application requires creativity of the user towards extracting the best possible benefits. It was also evident that the use of averaging, grouping and pareto classification helped towards carrying out the analysis within a shorter frame, while at the same time delivering reasonably effective results. This is not just restrictive to Lean concepts but also in the development of models for areas such as inventory and supply chain. This simplified method of application would be suitable for SMEs.

VIII. RECOMMENDATIONS

Some key recommendations for SMEs operating in such environment include:

- Challenges for buyers in this environment would need to be able to work toward very short lead time and have influence on designing and engineering stages of product and ensure minimum % of “special items” generated by Design and Engineering Department and persuade them to use mass customizable or off shelf items.
- Buyer need to have knowledge to control quality information release from engineering to suppliers and make sure they are easily understandable and sufficient.
- The buyer also has to work closely with Finance to ensure controlled expenditure on the project and ensure key suppliers are happy with the payment terms.
- An excellent relationship with suppliers would help with cost and lead time from supply side.
- Buyer also need to be able to work closely with production to advise ideal production schedule and stages to coordinate the available materials with production plan as some materials would be arriving earlier than others.
- Use local suppliers where possible
 - o Reduce transport costs
 - o More flexible
 - o Better customer service
- Group low costs products to have fewer suppliers
- Deal directly with manufacturers rather than distributors on critical parts & leverage parts from product matrix

- Form a network between SMEs to minimise waste by sharing equipment, transport and left over fabrics or consumables

- Share production schedule with suppliers to reduce lead time

- Standardise components as much as possible to reduce complexity in purchasing

IX. CONCLUSION

This paper has featured some key routes towards the achievement of optimized business function in low variety high volume environments. The work is shown through the use of a case study. This has also involved the use of some lean tools and concepts, showing their viability towards application in this area. It has also shown the unavailability of formal refinement approaches towards application in this area. This work has paved the way for the establishment of generic approaches towards application in these environments.

ACKNOWLEDGMENT

We would like to thank the Technology Strategy Board for approving the Knowledge Transfer Partnership Programme under consideration. This has part funded the project towards making some appreciable performance gains benefit while at the same time opening up potential area towards carrying out research activity in the future.

REFERENCES

- [1] Jina J., Bhattacharya A. K. and Walton A. D., (1997), Applying lean principles for high product variety and low volumes: some issues and propositions, *Logistics Information Management*, 10(1):5-13
- [2] MacCarthy, B. L. and Brabazon, P. G. (2008), Order Fulfillment in High Variety Production Environments, University of Nottingham ePrints digital archive. <http://eprints.nottingham.ac.uk>
- [3] Stevenson, M., (2009), Practical implementation of production planning and control concepts in SMEs and MTOs: an introduction to the special issue, *Production Planning & Control*, 20(7):541 - 547
- [4] Harland C. M., Caldwell N. D., Powell P. and Zheng J., (2007), Barriers to supply chain information integration: SMEs adrift of eLands, *Supply Chain Management in a Sustainable Environment; Special Issue on Frontiers of Empirical Supply Chain Research*, 25(6):1234-1254
- [5] Lewis, M. A. (2000), *Lean Production and Sustainable Competitive Advantage*, *International Journal of Operations & Production Management* 20, (8) 959-978.

Shilan Li Born in China on 25th Aug 1980 attended LiaoNing Province Primary Teaching College between 1996 to 2000, started living in England from 2001 learning the language and in 2005, graduated with BA Business Administration degree in Coventry University and continued study in Coventry University and achieved Msc Supply Chain management in 2007.

Shilan taught Korean language and Math during Internship in China and currently working in Contechs with support from Coventry University as a Knowledge Transfer Partnership (KTP) Associate.

Miss Li is joined Chartered Institute of Purchasing and Supply in 2006 and currently on Level 5 Advanced Diploma level and recently completed Chartered Management Institute Level 5 Management and Leadership diploma.

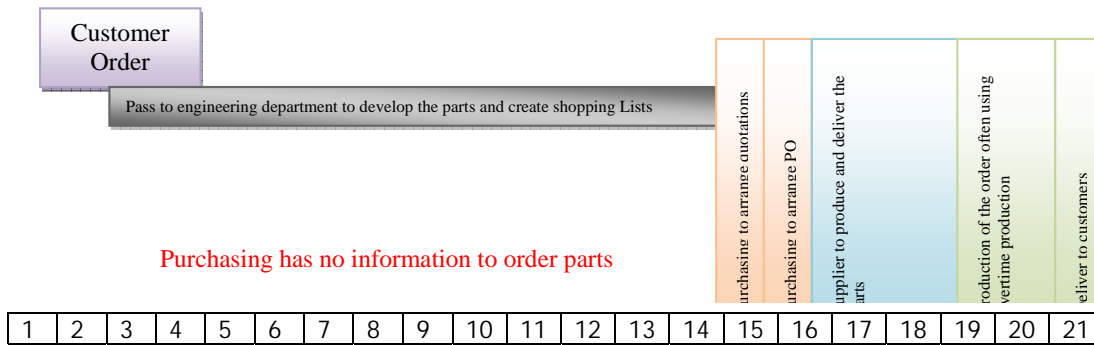


Fig. 1 : Macro Level Current State Map of the purchasing function

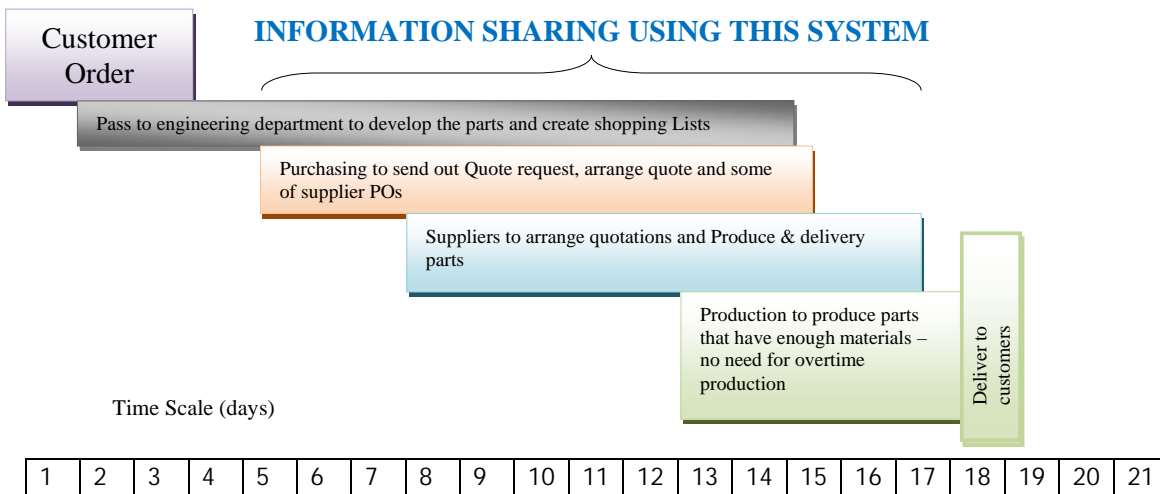


Fig. 2 : Macro Level Future Map of the purchasing function

Item No.s	Part Description	Category	UP#	RFQ 1	RFQ 2	RFQ 3	Unit Price	Total Price	Supplier	Delivery Date	Costs	Comments		
690	691	Bow Bather Suntrrella	Foam	1			£204.48	£204.48			£204.48	Way to order		
3	3	C1600 Cockpit - Backrest Moulding 1												
4		Cockpit Backrest 1 Substrate	Sub	1			£17.10	£17.10			£17.10	Way to order		
5		Cockpit Backrest 2 Substrate	Sub	1			£21.30	£21.30			£21.30	Way to order		
6		Cockpit Backrest 3 Substrate	Sub	1			£17.10	£17.10			£17.10	Way to order		
4	5	6	Cockpit Backrest 1,2,3 Foam Kit	Foam	1		£113.15	£113.15			£113.15	Reciculated foams to be ordered		
7	8	9	Cockpit Cushion 1,2,3 Foam Kit	Foam	1		£159.58	£159.58			£159.58	Reciculated foams to be ordered		
10			FD Backrest 1	Sub	1		£121.23	£121.23			£121.23	Squared ended parts to be ordered		
11			FD Backrest 2	Sub	1		£163.00	£163.00			£163.00	Squared ended parts to be ordered		
12			FD Backrest 3	Sub	1		£163.60	£163.60			£163.60	Squared ended parts to be ordered		
10	11	12	FD Backrest 1,2,3 foam Kit	Foam	1		£78.40	£78.40			£78.40	Reciculated foams to be ordered		
13	14	15	16	17	18	FD Cushion 1 - 5 & Nav Cushion	Foam	1			£271.24	£271.24	£271.24	Reciculated foams to be ordered
19	20					FD Helm Seat 1,2 Sub	Sub	2			£283.31	£566.62		
21	63	64				FD Bather No Bimini PVC	Foam	1			£192.00	£192.00	Way to order	
22	63	64				FD Bather No Bimini Subtrrella	Foam	1			£0.00	£0.00		
23	24	25				U/Saloon STBD Settee BR Foam Kit	Foam	1			£0.00	£0.00	Unique kit to be ordered	
23	24	25				U/Saloon STBD Backrest Sub	Sub	1			£41.60	£41.60	11-May	
26						U/Saloon - Rear Fascia Panel Sub	Sub	1			£7.00	£7.00	11-May	
27	28	29				U/Saloon STBD Settee Cushion Foam	Foam	1			£97.29	£97.29	Way to order	
31						U/Saloon Amrest Unique Foam Kit	Foam	1			£3.21	£0.00		
31	32	41	42			U/Saloon Amrest 2 Sub Common	Sub	4			£32.40	£129.60	11-May	

Fig. 3 : Project monitoring visual control