Performance Analysis of a Two Stage Supply Chain Network Using Simulation - A Case Study

Ms. Ramaa.A, Dr. T.M. Rangaswamy, Dr K.N.Subramanya

***Abstract* — This paper is the result of a work carried out in analyzing the performance of a two stage supply chain network (SCN). The work has been undertaken at two electronic component manufacturing companies. Company A, a sister concern of an electronic company, manufactures primary components namely - deflection yokes, fly back transformers and tuners. The Company B, comprising of three subsidiary business units, is a second tier supplier to an electronic product company and a dedicated supplier to Company A. They manufacture plastic components like bobbins, resin cases and tube cases, all of which are used as components for the production of yokes and transformers. After studying the existing system, the objectives set were to reduce the supply chain lead-time at Company A, and reduction of inventory levels at Company B. A model was developed using ARENA, a simulation software package for company A. The results included a reduction of 32% in the lead-time for fulfilling an order at company A. The delivery performance to commitment date also increased to a high of 76% from the earlier 20%. Company B on the other hand, had 40 - 50% reduction in raw material inventories. The finished goods inventories came down to 1 - 1.5 days of supply from an earlier figure of 8 – 14 days of supply in company B.**

***Index Terms* - Performance analysis, Supply Chain Network (SCN), Simulation, Just In Time (JIT)**

I. Introduction

In today's just-in-time delivery of goods, supply chain has become very important for companies. Efficient supply chains not only lead to huge cost savings but are also a source of competitive advantage for companies. Short lead times are essential to provide customer satisfaction in a global market. Organizations that have focused on cycle time as a productivity measure can reduce delivery time and improve quality, thereby creating more satisfied customer. Before 1980, customers were accepting long lead times which enabled producers to minimize product cost by using economical batch sizes. Later, when customers began to demand shorter lead times, they were able to get them from competitors. This is when the problem arose and companies started to look for changes and be competitive. In an attempt to reduce lead time, businesses and organizations found that in reality around 90% of the existing activities are non-value added and could be eliminated. As soon as manufacturers focused on processes, they found wastes associated with changeovers, quality defects, process control, factory layout, and machine down time. So the companies tried to find ways to reduce or eliminate waste.

Manuscript received 27th February 2010.

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II. Literature review

SCN is a process oriented, integrated approach to procuring, producing and delivering products and services to customers, covering the management of material, information and financial flows. SCN has a broad scope that includes sub suppliers, suppliers, internal operations, trade customers, retail customers, and end users. SCN can form a loop that begins with the customer and ends with customer covering the entire product cycle [1].

Just in Time (JIT) is a philosophy aimed at to produce and deliver finished goods just in time to be sold, subassemblies just in time to be assembled in to finished goods, fabricated parts just in time to go into assemblies, and purchased materials just in time to be transformed in to fabricated parts [2]. The primary goal of JIT is to continuously reduce and ultimately eliminate all forms of waste. The focus is on minimizing raw material, work-in-process, and finished goods inventory with a view to cutting inventory costs and also helping to expose other more serious inefficiencies in the manufacturing cycle. JIT implementation elements are designed to eliminate these productivity problems. JIT implementation involves two broad principles: elimination of waste, and full utilization of people, equipment, materials and parts. These principles are embodied in a set of ten consistently discussed programs. These are focused factory; reduced set-up times; group technology; total preventive maintenance; multifunctional employees; uniform plant loading; kanban; quality control; quality circles; and JIT purchasing [1,3].

The importance of performance management in supply chains has long been recognized from a variety of functional disciplines. But much of the work has focused on designing performance measures with less concern for the other stages of the entire performance management process. The supply chain operations reference (SCOR) model, developed by the Supply-Chain Council (SCC), is widely accepted as the only cross-industry standard for supply chain management, which not only provides a standard description of supply chain processes, but standard metrics to measure supply chain performance. Based on the SCOR model, a comprehensive framework for supply chain performance management is presented by Changrui Ren(2006), which includes all aspects of performance management from performance measurement to performance improvement. The methods for performance model design and performance analysis are mainly discussed in his paper [4].

Simulation is a very useful tool for predicting supply chain performance. Herrman(2003) in his paper describes a novel supply chain simulation framework that follows the Supply Chain Operations Reference (SCOR) model. The simulation models are hierarchical and use sub models that capture activities specific to supply chains. The SCOR framework provides a basis for defining the level of detail in a way as to include as many features as possible, while not making them industry specific. This approach enables the reuse of sub models, which reduces development time. The paper describes the implementation of the simulation models and how the sub models interact during execution [5].

III. SCOPE OF THE WORK

The study has been carried out in two phases. Phase I is related to the study of company A, which is a sister concern of an electronic product company, manufactures primary components namely - deflection yokes, fly back transformers and tuners. All the processes of the company A are modeled using Arena, a simulation software package. Phase 2 is related to the study conducted in Company B, comprising of three subsidiary business units, is a second tier supplier to electronic product company and a dedicated supplier to Company A. They manufacture plastic components like bobbins, resin cases and tube cases, all of which are used as components for the production of yokes and transformers. The overall objective of the study was to reduce the lead-time for fulfilling an order for company A and to reduce inventories and improve the delivery performance for company B.

A. Phase I: Objectives

The study of the existing system revealed that longer lead times resulted in inflexibility to meet demand changes. This was analyzed as a consequence of sub optimal systems and unnecessary activities. Delayed transfer of information due to unnecessary procedures and documents caused inability to fulfill orders in time. Increased destinations for documents resulted in excessive movements of documents physically, resulting in an increase in lead time and delay in the decision making process. Unavailability of information to all players of the supply chain network caused a further delay as waiting for the information increased lead-time. Based on the above cited problems, the objective was to reduce the lead time of the supply chain network.

B. Methodology

The following methodology was adopted to achieve the desired results

1. The existing system was studied and process sequence was analyzed under the heads of Make, Source and Deliver. Also, information flows along with the documents being used were mapped. A partial flow chart of delivery planning and order fulfillment process sequence is shown in fig.1and fig.2
2. The data related to Sales and Operation Plan, Dispatch Schedule, Supplier Rolling-Plan, Elemental lead-time record, Raw Material requisition, Production reports such as Daily Production report, Operator reports, Overall equipment efficiency, and Finished goods transfer(FGT) note were analyzed.
3. The data was analyzed using process charts and process mapping. Lead time analysis was also carried out. Continuous brainstorming sessions were organized for better idea generation to improve the system

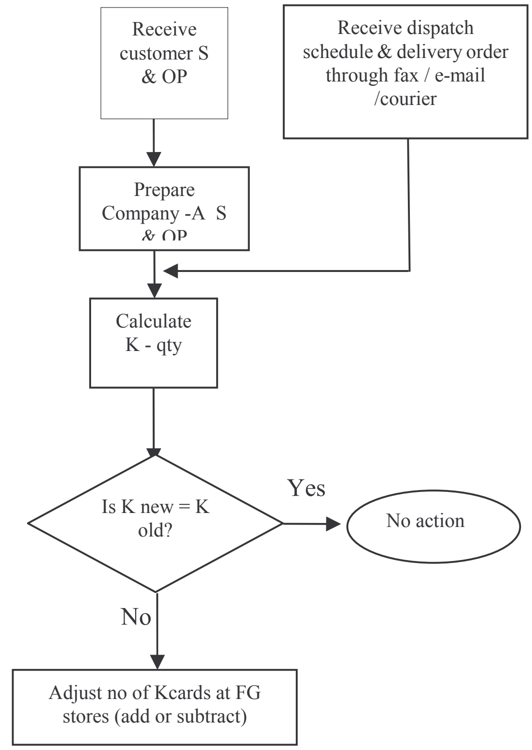


Figure 1: Delivery Plan

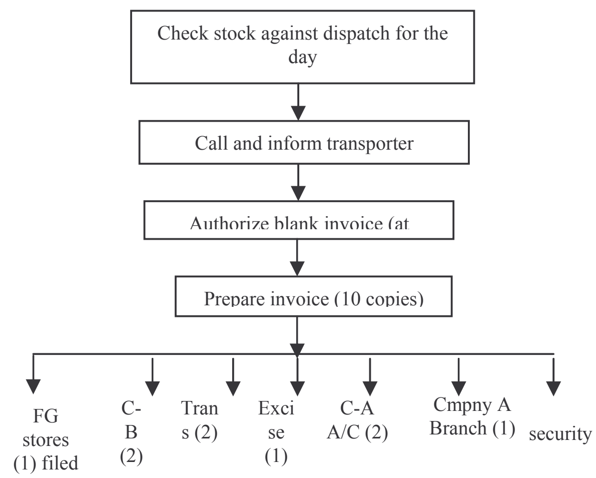


Figure 2: Order Fulfillment process

4. A simulation model was developed taking into consideration all the processes involved. The simulation was done using ARENA, simulation software and tested for the validity of the results using real time data. Both present and proposed method were simulated. Fig.3 depicts the simulation model for the present method
5. The findings were presented to the team heads in the presence of the line operators. The reasons for the current processes were questioned, listed and analyzed.
6. A new proposed model was developed after analysis of the system. Fig.4 depicts the new proposed model.
7. A time bound program for implementation was scheduled and implementation was done according to it.

ISBN: 978-988-18210-8-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

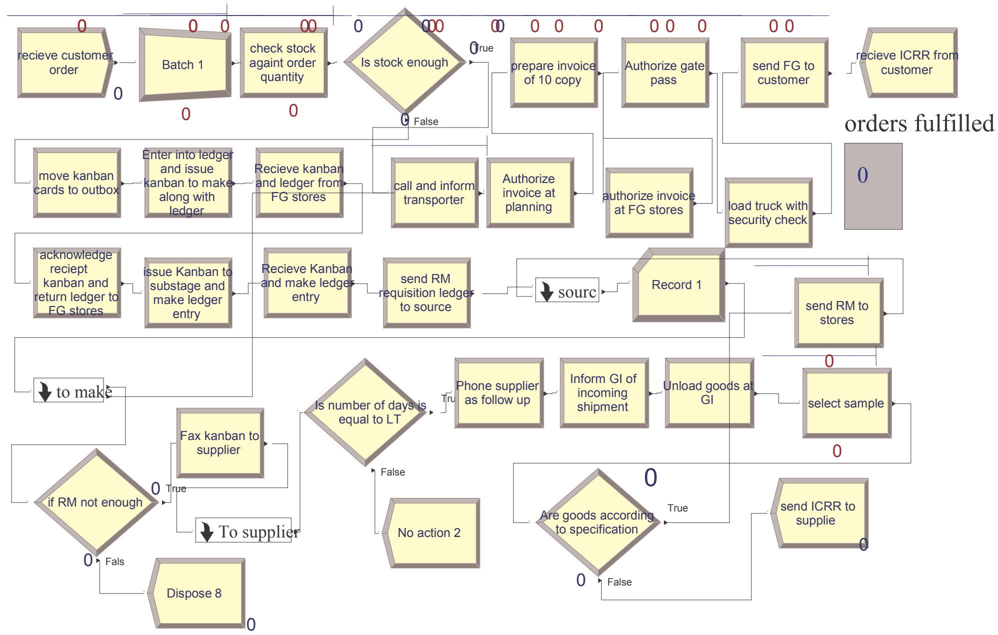


Figure 3. Simulation of the existing supply chain network

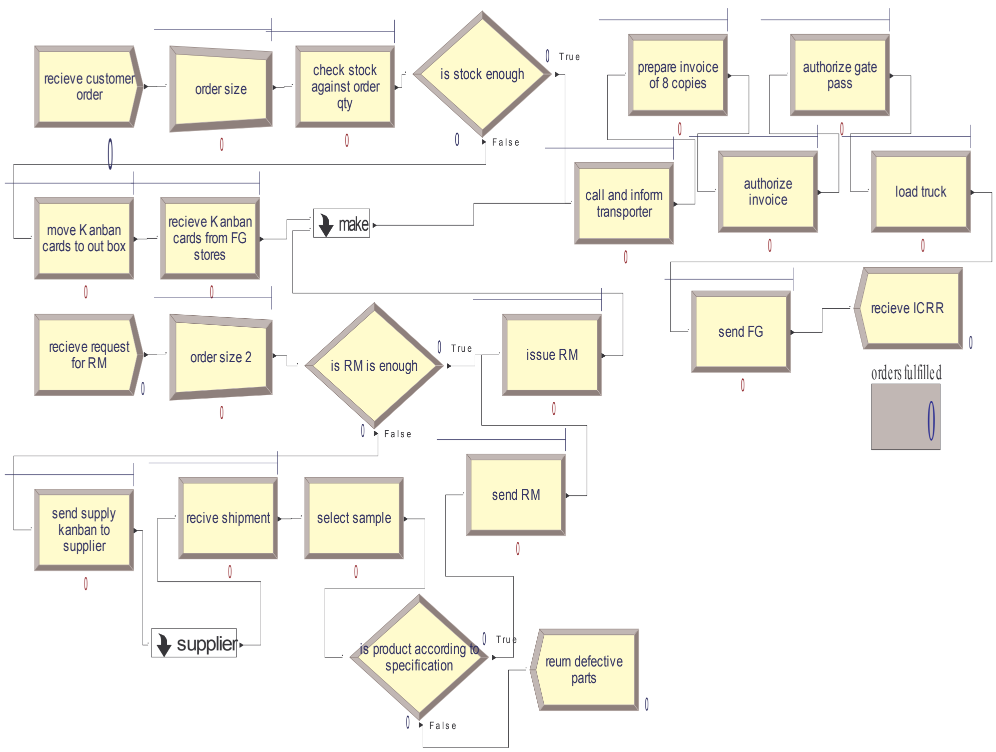


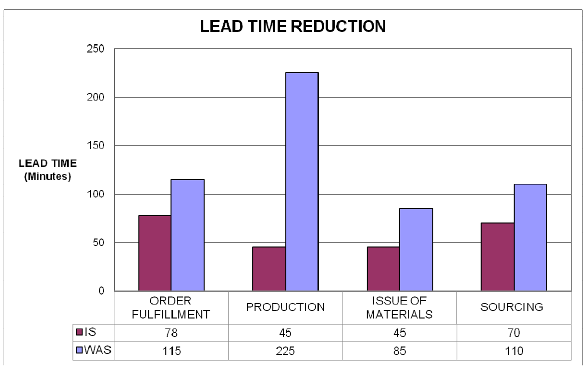
Figure 4. Simulation of the proposed supply chain network

C. Results

After implementation the following were the tangible benefits of the system. The lead times for the different elements of the supply chain are reduced after implementation as shown in the bar chart. There was a reduction of around 32% in the lead-time for fulfilling an order. The maximum reduction in lead-time was observed in the production department which showed around 80%. Simulation results showed that orders fulfilled per month is almost doubled after the study. Moderate reduction in lead time was found in issue of materials, sourcing and order delivery. All these were possible by reducing the non value added activities present in the processes. Delivery performance also improved drastically form 20% TO 70%. The comparison of lead time before and after implementation is as shown in the Table 1 and Graph 1.

Table 1: Comparison of lead time for Company A

PARAMETER	*WAS*	*IS*	*Reduction*
Lead-time for order delivery (excluding transit time)	115 mins.	78 mins.	32.17%
Lead-time for production (excluding conversion time)	225 mins.	45 mins.	80%
Lead-time for issue of materials to shop floor	85 mins.	45 mins	47.06%
Lead-time for sourcing material from supplier (excluding transit time)	110 mins.	70 minss	36.36 %
By Simulation			
Value added time (hrs)	10.27	6.65	35.248
Non-value added time (hrs)	1.39	1.02	26.61
Waiting time (hrs)	2.66	1.98	25.56
Total time (hrs)	14.32	9.65	32.61
Orders fulfilled per month	29	55	26 more orders fulfilled



Graph 1: Comparison of lead times at company A

D. Phase II : Objectives

A study of the existing system revealed high inventory levels of raw material, work in process and finished goods due to unpredictable orders from company A. Improper scheduling system for both Make To Order (MTO) and Made to stock (MTS) was leading to excess production. Therefore after analyzing the entire system the objectives set were to reduce the inventories and lead time at company B.

E. Methodology

The following methodology was adopted to achieve the desired results

1. The existing system was studied and process sequence of all the processes were documented under the heads of Make, Source and Deliver.
2. Data related to Supplier Rolling-Plan, Elemental lead-time, Production reports such as Daily Production report, Operator reports, Overall equipment efficiency, ISO 5S reports were collected and studied.
3. The data was analyzed using process charts and process mapping and position description chart. Lead time analysis was also carried out. Continuous brainstorming sessions were organized for better idea generation to improve the system.
4. The preliminary findings revealed that each of the 3 processes (make, source and deliver), had non value-added and redundant activities. The reasons for the current processes were questioned, listed and analyzed.
5. A time bound program for implementation was scheduled and implementation was done according to it.

F. Results

After implementation the following were the tangible benefits of the system

I. ***Lead time reduction*****:** After a conclusive method study and an intense brain storming session, the lead-times of the process were greatly reduced. The comparison of the system before and after implementation is as shown in table 2 and graph 2. It can be seen that there was huge reduction in lead time around 60% with respect to order delivery and production. Also marginal reduction was observed in lead time for issue of materials.

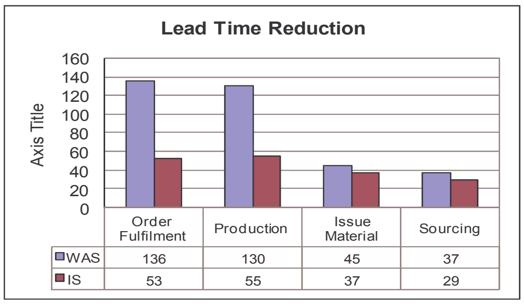
II. ***Inventory Reduction:*** During the initial study, high levels of inventory for raw materials, work-in-process and finished goods were identified. Also, at instances there were excess stocks of a particular component and stock out for others. After the implementation of the new system, there was drastic reduction in inventories. Around 40 - 50% reduction in raw material inventories was found as shown in graph 3. The finished goods inventories came down to 1 - 1.5 days of supply from an earlier figure of 8 – 14 days of supply as shown in graph 4.The number of stock outs per month also drastically reduced as shown in the graph 5.

All of these were achieved by adopting the following steps.

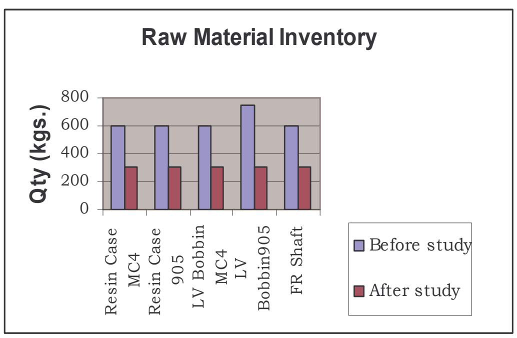
i. Optimizing the existent systems and procedures in each link of the chain by eliminating redundant and non-value adding activities, procedures and documents, thereby reducing the lead-time.
ii. Testing the feasibility of the new system.
iii. Altering elements and procedures not proving to be feasible.
iv. Re-testing the altered new system and repeating iterations till optimization.
v. Demarcating the company into three distinct links – Source, Make & Deliver.
vi. Arranging the premises and modifying the system to adapt to Kanban.
vii. Introducing Kanban to all products.
viii. Supervising the running of the new system and troubleshooting.

Table 2: Comparison of lead time for Company B

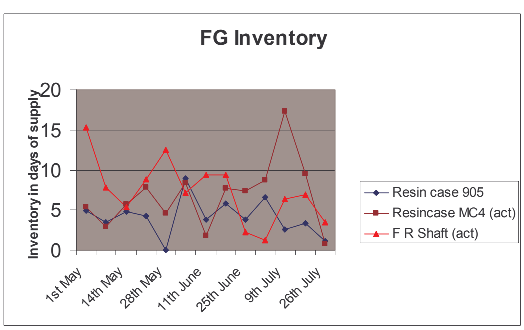
PARAMETER	WAS	IS	Reduction
Lead-time for order delivery (excluding transit time)	136 mins	53 mins	61.03 %
Lead-time for production (excluding conversion time)	130 mins	55 mins	57.69 %
Lead-time for issue of materials to shop-floor	45 mins	37 mins	17.77 %
Lead-time for sourcing material from supplier (excluding transit time)	37 mins	29 mins	21.62 %



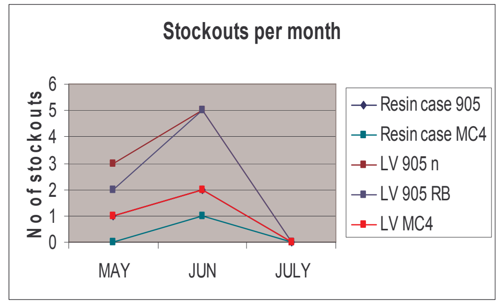
Graph 2: Comparison of lead times at Company B



Graph 3: Comparison of Raw material inventory at Company B



Graph 4: Comparison of Finished Goods inventory at Company B



Graph 5: Comparison of stockouts per month at Company B

IV. Conclusion

The objective of conducting the study was to optimize the existing systems and procedures in each stage of the supply chain by eliminating the non value adding and redundant activities, procedures and documents, thereby reducing the lead-time. This was accomplished by modeling the system. The feasibility of the new system was tested. By method study and conducting brain storming, existing systems and procedures were altered. Re-testing the altered new system was done and results proved substantially.

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ISBN: 978-988-18210-8-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)