IMPACT OF CONTINUOUS FLOW ON OPERATIONAL PERFORMANCE IN A WAREHOUSE OPERATION - APPAREL SECTOR CASE STUDY.

I. S. W. Jayasooriya

179212M

Degree of Master of Business Administration of Supply Chain Management

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ABSTRACT

The aim of this research is to investigate the possibility and requirement of devising the use of the one piece flow to increase operational performance.

The empirical research is used to understand the reasons for outsourcing 3PL providers to utilise the concepts continuous flow in an apparels finished goods hub operation. Moreover the paper discusses the aspects of continuous flow in terms of information and material flow and applying theories of Value Stream, Layout and the one piece flow. A quantitative study is conducted focused on professionals from apparels finished goods hub operations. Thereafter operational performance is defined and elaborated with specific and relevant indicators i.e. KPIs.

The results indicated that the knowledge and understanding of the 3PL professionals to be at a high level in terms of continuous flow and its contribution towards operational performance. However several key concerns were also highlighted which hindered the implementation of the concepts discussed.

The experience of the 3PL service provider in this study provides insights and promote the benefits of continuous flow that can enhance warehouse performance which will contribute to improve Sri Lankan national productivity.

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LIST OF ACRONYMS

Abbreviation	**Description**
SCM	Supply Chain Management
POLI	Purchase Order Line Item
3PL	Third party logistic
CLH	Central logistic hub
NLH	Nugape logistic hub
CCA	Client certified Audits
VSM	Value stream map
GPS	Global positioning system
RFID	Radio frequency identification
EFA	Exploratory Factor Analysis
CT	Cycle time
NPT	Net production time
A/P	Account payable
A/R	Account receivable
NVA	Non-value addition
VA	Value addition
JIT	Just in time
IFR	Item fill rate
OTD	On time dispatched
CBM	Cubic meter
VAS	Value added service
KPI	Key performance indicators
ETA	Estimated transfer arrival
ERD	Estimated received date
PTP	Plan to perform

CHAPTER 1: INTRODUCTION

1.1 Background

3PL companies are seeking for different types of methods to achieve business performances and to reduce costs. At the same time focusing to improve the service quality standards and flexibility. Due to the present global competition, most companies outsource internal logistic processes more and more to third party logistics providers (3PLs). As a consequence, the supply chain becomes more complex because the direct flow of goods and information between the "OEM" and end customers is diverted via the 3PLs (Overboom, Small, Naus, Haan, 2013).

In the Sri Lankan apparel sector, a trend of out sourcing the entire warehousing and transportation activities can be seen at present. To achieve the business goals of 3PL operations, clients stocks, distributions, services and operations of internal and external customers are needed to manage effectively by ensuring short lead time and optimum cost. To achieve long term sustainability, 3PL companies need to focus on handling large volumes with optimal costs.

Improving material flow and the information flow is critical to compliment a sustainable and profitable 3PL business. It will help improve operational performances and achieve competitive advantage. Continuous flow processing eliminates the stops and starts that are common in a traditional production system. To accomplish continuous flow processing, it is necessary to produce an item and immediately pass it on to the next small process. It also influences the entire value stream. According to Piatkowski (2004) Continuous flow is where all the knowledge of lean methodologies, tools, and process are put to an ultimate test to generate "cost reductions and improvements to quality, efficiency, and performance".

1.2 Research Objectives

Find the relationship between materials flow and operational performance.

Find the relationship between Information flow and operational performance.

Find the relationship is between one piece flow and operational performance.

Find the relationship is between continues flow and operational performance.

1.3 Significance of the study

This study contributes to the body of knowledge through the following;

Focused on continues flow related to operational (warehouse) performance, investigating the relationship between continuous flow and warehouse performance. It will help identify the relationship between two variables and its impact to the apparel sector warehouses in Sri Lanka.

Provides organizational KPIs that can contribute to achieve business performances contributing to reducing the probability of warehouse operation failure.

Encourage 3PL and apparel sector warehouse operators to identify the operational gaps and solve operation failures. This study will address the root causes for the operation failures and how to prevent the operation failures in apparel sector warehouse operations.

Educate and promote the benefits of continuous flow that can enhance warehouse performance which will contribute to improve Sri Lankan national productivity.

1.4 Basic Approach/Outcome

The questionnaire survey was posted to the Sri Lankan 3PL companies and apparel clients that use lean technics to improve their operational performances. In additional that finished good operation data will gather and analyses.

1.5 Validation and Conclusion

Conclusion will validate based solutions which was cater for two selected problems and How continues flow impacted to improve the operation performances.

Quantitative data and questionnaire findings will help to identify the impact of continues flow on warehouse operational performances.

1.6 Limitations to the study

- Availability of apparel sector warehouses who practicing in concepts like lean and lean six sigma in Sri Lanka are in a limited number.
- Continues flow concept is one of the lean principles. To implement and practice this concept, companies need to have a background on this concept.
- According to the company's policies and regulations, it is not easy to gather all data for external research specially KPIs and the financial performances.

1.7 Outline of the chapters

Chapter 1 – Introduction

The purpose of this chapter is to lay the background to provide a general overview and state an outline to the study undertaken in the paper. The aim is to suggest the importance of continuous flow.

Chapter 2 – Literature Review

Introduces the relevant theories discussed in the paper and provides a literature rationale with definitions to supply chain management, third party logistics, continuous flow, operational performance and an industry specific apparel supply chain scenario in Sri Lanka. This chapter states the theories and previous researches related to formulating questions for the questionnaire.

Chapter 3 – Research Methodology

This chapter explains the qualitative and quantitative methods that have been used for conducting the research.

Chapter 4 – Data Analysis

This chapter describes the study sites and participants (questionnaire results), the operational practices by the industry, the instruments for data collection and the method of questionnaire analysis for this study.

Chapter 5 – Discussion

This chapter synthesises the literature from chapter 2 with the findings from the questionnaire and the empirical study conducted. It highlights the importance of one piece flow and the repercussions of failing to implement continuous flow with reference to operational performance.

Chapter 6 – Conclusion

This chapter summarises research findings and analysis to draw conclusions based on the research objectives while implicating several aspects for future study. Limitations of the study and recommendations for further study for this area are also highlighted.

CHAPTER 2: LITERATURE REVIEW

2.1 Supply Chain Management

Supply chain management has been interpreted by different researchers in different ways. Based on the fairly recent development of supply chain literature, it is visible that there has been abundant debate to determine a specific definition for Supply chain management.

Ganeshan and Harrison (1995) defines a supply chain as “a network of facilities and distribution options that performs the functions of materials procurement, transformation of these materials into intermediate and finished products, and product distribution to customers”. According to Mason et al. (2003, p. 147), every industry can be described by the combination of one or more supply chains. Despite the importance in industry, supply chains have traditionally been fragmented, resulting in slow and sequential material flow downstream and equally, movement of data again upstream. The disorderly flow of inventory and information has led to a build-up of excess inventory and lack of real-time information to buffer uncertainties in supply and demand i.e. increased inventory carrying costs, longer order lead times, and difficulty in responding proactively to real-time changes.

Lee & Corey (1995, p. 44) detailed that supply chain management consists of integrated activities taking place among a network of facilities that procure raw material, transform them into final products, and deliver products to customers through a distribution system. Moreover Christopher (1998) defined supply chain as a network of organizations that are involved, through upstream and downstream linkages, in different processes and activities that generate value in the form of products and services in the hands of the ultimate consumer.

Supply chain management is the "strategic and systematic coordination of traditional business functions and the tactics across those business functions within a particular firm and across firms within a supply chain, for the purpose of improving long-term performance of individual companies and the supply chain as a whole". (Mentzer, 2001) While the separation of supply chain activities among different companies

enables specialization and economies of scale, there are many important issues and problems that need to be resolved for successful supply chain operations, this is the main purpose of SCM.

From the above definitions, it can be derived that a continuous flow on operational efficiency and productivity is an important criterion in a supply chain organizations. In other words, a continuous flow is a major node of the network of intra organizational processes which is defined as Supply chain management.

2.1.1 SCOR model

Supply Chain Operations Reference (SCOR) model is and early model of supply chain flow developed by the supply chain council by gathering more than worldwide 650 member organizations. SCOR is a standard model which includes management processes, standard tools to measure performance of operations, measures that should be practiced to get best performances, link between the standard processes and an alignment of software features and functionality.

SCOR model is used to link process elements, tools, features and standard practices involved in carrying out daily operations. It gives a different approach to an overall view compare to a traditional process model. This provides enough space for the organizations to interact and communicate on a same standard platform. SCOR model created the initiative for configuring the supply chain by using the business strategy. It compares and contrasts the values and strategies of similar companies and use them to build targets internally in order to come up with the best out puts. It identifies the best management practices and technology solutions to create best practices within the organization.

There are five major elements in SCOR model; Plan, Source, Make, Delivery and Return. One of the major popular business which benefited from the SCOR model is Intel as a solution to their complex business model.

2.1.2 Supply Chain Flows

In every supply chain, three major flows can be identified; Material, Information and Finance. The paper discusses Material and Information flow in detail with reference to the industry. Research on optimizing the continuous uninterrupted flow of processes in a Sri Lankan context and research which are undertaken specifically focusing on apparel logistics to optimize the continuous flow are lagging. Therefore, this research aims to fill the existing gap by analysing the issues related to continuous flow on operational performance in the apparel sector warehouse operations and investigating the impact of them.

2.1.2.1 Material flow

Movement of goods from the supplier until the customer is known as material flow Domingo and Alvarez (2007). The internal materials flow to and from each workstation depending on the production conditions and particular characteristics of each workplace. It is also included with the reverse flow where rejects are being collected in return. In an industrial scenario, main nodes of the supply chain are the supplier, manufacturer, distributor, wholesaler, retailer and consumer. If a fabrication shop is taken as an example, there raw steel is fabricated into many different building components by subjecting to cutting, general machining, welding and assembling them into a single product to be shipped to a customer. A link is being maintained in between the current stage and the previous stage along the entire supply chain.

Material Flow -

Receiving Process (Appendix B)	**Issuing Process (Appendix C)**
Issuing packing list & gate pass with receiving of notification	Checking the PPR & Splitting the cartons once issuing pre plan finalizes
Docking	Vehicle requesting with the Preparation of pick document
Unloading	Picking and loading the cartons
Update the tally sheet with acknowledgement of receipt	System logging & scanning the carton
	Goods loading to the lorry
	Goods dispatch

2.1.2.2 Information flow

According to the Wolfgang et al (2007, p. 33) information flow caused to improve the overall lead time in the company. Communication flow also one of the way to pass the information. To improve Information flow daily operation meetings, weekly shipping meeting, shift handover meetings highly contributed. Information flow is taken place in either way in a supply chain. Diversified information like material data, inventory days, product descriptions and pricing, inventory levels, ordering lead times, delivery scheduling, supplier and distributor information, delivery status, commercial documents, title of goods, current cash flow and financial information are included in the information flow. Quicker and accurate transfer of information highly contributes to an efficient and effective continuous flow of a supply chain. In apparel sector all the clients work with customized systems (ex: MK SAP Darwin, HDM-AX dynamics, MK brand –IFS). To ensure the uninterrupted information flow all the client systems are integrated with 3pl systems or client system extended to 3pl systems.

2.2 Third Party Logistics Operation

A third party logistics provider offers outsourcing services to companies which seek to only focus on their core businesses and outsource other processes in search of economies of scales. The concept and trend of globalization has lead most of the companies to outsource their sub businesses to Third party logistics companies.

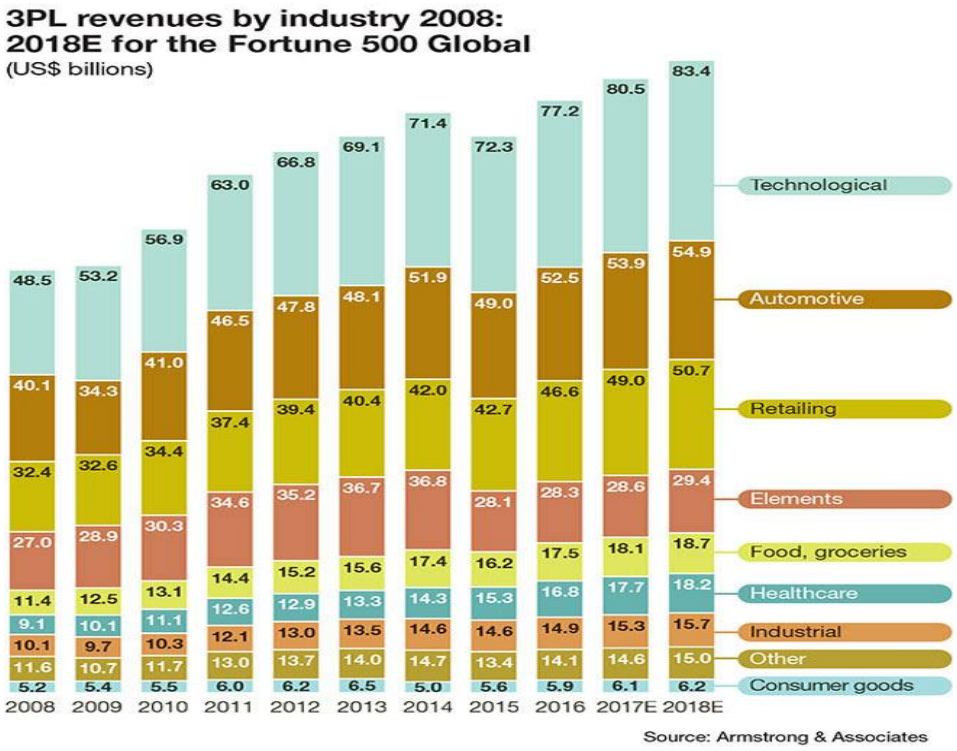


Figure 2-1 3PL Revenues (2008)

Murphy and Poist (1993, p. 153) argued that warehouse as the most costly activities in logistics because a major part of its operations is labour intensive thus to improve operational and organizational performance.

2.2.1 Warehousing

A warehouse is one of the major nodes in a supply chain which connects goods with manufacturers, distributors and consumers. Amongst the types of warehouses an Apparel warehouse operation can be complicated due to quality inspection process and value addition process apart from the continuous inbound, outbound and storage of goods throughout the day based on the nature of the goods.

Warehouses are a substantial component of logistic operations and an important contributor to speed and cost in supply chains (Johnson & McGinnis, 2011, p. 224). A warehouse is where the inventory is stored, compromised with many specific operations which are carried out daily. As each inbound shipment arrives, responsibility for the goods transfers to warehouse personnel, products are identified, sorted and dispatched to their temporary storage location. Storage isn't a static thing but rather a process that includes security measures and maintaining an environment that preserves the integrity and usefulness of the items. Once it's time to move items, each order is retrieved, grouped, packaged and checked for completeness before being dispatched to their new destination.

Out of the functional areas in a warehouse unloading, VAS, inspection, and loading points incurred a considerable amount of time by a particular good which goes through checking and counting either to put away or to dispatch. Warehouses can have different configurations according to the product specification, customer requirements and service level offered (Staudt, Di Mascolo, Alpan, Rodriguez, 2014).

2.2.2 Types of warehouses

There are three types of warehouses; Private warehouses- a ware house owned and run by a single company to handle their own raw materials, working progress, Supplies and finished goods, Public warehouses- a warehouses that store goods of

others (Third parties) and Contract warehouses- a third party facility that contracts with customers to provide a set amount of storage (Work Research Book).

A third party logistic provider- a public or contract warehouse that contracts to provide storage and possibly other services.

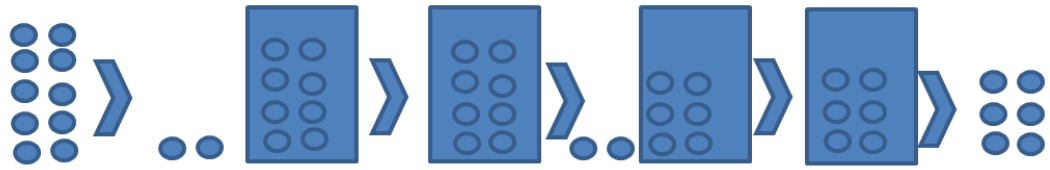
2.2.3 HUB Concept

Logistics hubs are large-scale structures within which different logistics service providers collaborate in order to offer value-added services by sharing assets. Such hubs impact on the efficiency of transportation systems, since they directly affect the flow of goods (Santos & Mendes, 2016, p. 383). Designing a logistics network that maximizes the utilization of the transport and warehouse capacity in the network with minimal inventory, supports the material flows in the supply chains of multiple clients, and delivers superior performance for each client, is a key imperative for the success of a third party logistics (3PL) firms (Cheong, Bhatnagar and Graves, 2007, p. 52).

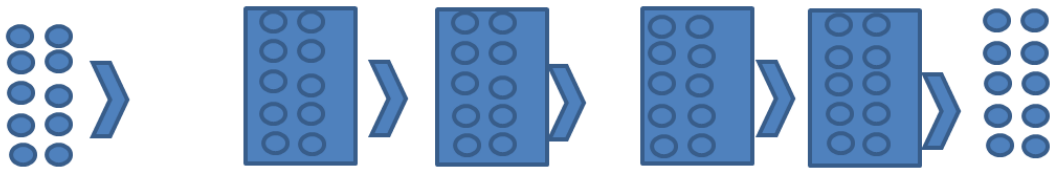
2.3.1 One Piece Flow

While the traditional mass production involves predetermined production of large lots of products referred to as 'batch and queue', the production processes in Lean Manufacturing are organized in such a way that processing steps are adjoining each other in a continuous, one-piece flow (Phogat, 2013, p. 99). According to Mulholland (2018) One piece flow is all about reducing Work-In-Progress to the point where everything is either waiting to be started, in progress, or complete. Hence it is also called "single piece flow" and "continuous flow" as everything is constantly progressing and only one item is in any given queue at a time. Due to the short product life cycle and increased customer demand for customization in traditional production lines it is difficult to produce one piece flow concept which would support more flexibility in process (Miltenburg, 2001, p. 312).

Ten customers walk in to a customer service outlet within an hour. Each customer has to go through four touch points (A, B, C, D) to get his task performed.



	A	B	C	D
Capacity	8	12	6	25
# Staff members	4	12	6	5



	A	B	C	D
Capacity	10	10	10	10
# Staff members	5	10	10	2

2.3.2 Value Stream Mapping (VSM)

Value Stream Mapping VMS was initiated by Toyota as "material and information flow mapping". It shows all steps in information and material flows in a diagram in a simple format which is easily understandable.

Two main types of mappings can be found in terms of VSM as follows.

Current state mapping	In order to understand current condition mapping the flow from placing the order until the delivery
Future state mapping	Identifying the opportunities to advance from the current state mapping to achieve a better output in the future.

Advantages of using VSM span from; visualize the whole process, See the sources of waste, Provides a common language for improvements, Makes decision about flow apparent, Ties together lean techniques, Forms the basis of an improvement plan, Show linkage between information and material flows.

According to Wolfgang, Li & Walton (2007) a typical VSM include cycle time, TAKT time, work in progress (WIP), set up time, down time, number of workers, and scrap rate.

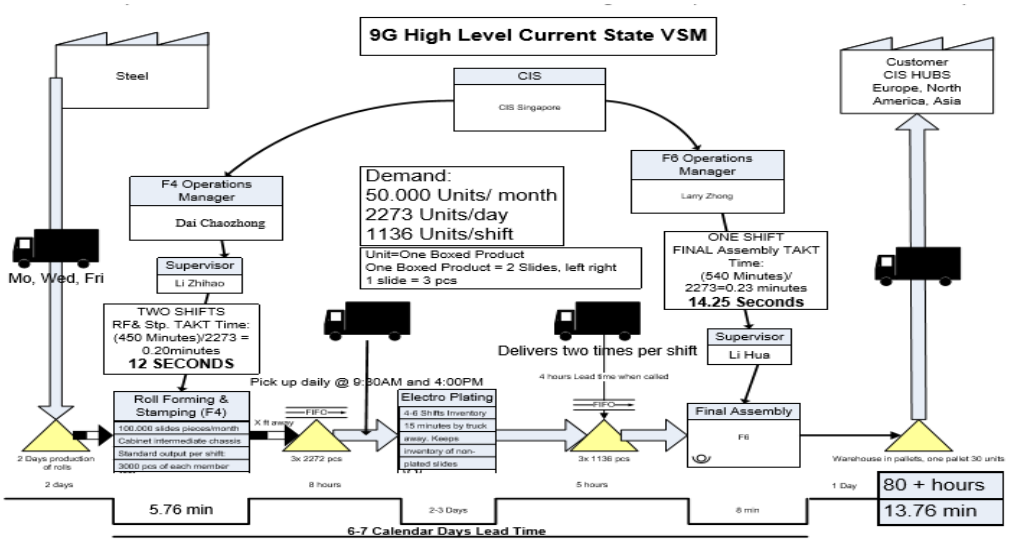


Figure 2-2 Value Stream Mapping by Wolfgang, Li & Walton (2007)

TAKT time is the total available time divided by the number of units in demand for that day.

2.3.3 Layout

Koster and Warffemius (2005, p. 767) argued that complexity of a warehouse operation has a large impact on the performance of the warehouse, and in turn the efficiency of the warehouse. According to Saifudin et al. (2012), the warehouses Layout and MIS are the main basic variables for process management improvement in making the warehouse to be efficient and achieve firm performance. Hence Warehousing Layout mediates positively the relationship of Warehouse Efficiency.

2.4 Operational Performance

Operational performance refers to the measurable aspects of the outcomes of an organization's processes, such as reliability, production cycle time, and inventory turns. Operational performance in turn affects business performance measures such as market share and customer satisfaction (Voss et al, 1997, p. 1047). A literature research is carried out in order to identify the indicators utilized by authors to measure warehouse performance.

2.4.1 Key Performance Indicators (KPI)

According to Velimirović, D., M. and Stanković (2011, p. 65), it is very important to define and standardized all processes within the organization in order to constitute an effective system of performance measurement. KPIs are financial and non- financial measurements that organizations use to reveal how successful they were in accomplishing long lasting goals. In order to include an effective system of performance measurement it is very important to have defined and standardized all processes within the organization. Warehouse activity improvement can be done based on the most important KPI in each activity in the warehouse. This would

facilitate warehouse managers in determining strategies and actions to improve warehouse performance (Kusrini et al, 2018).

Performance Measurement (Storage)	Performance Measurement (Inward)	Performance Measurement (Outward)
Cycle Count Accuracy	Dock to stock time	Order to Dispatch Time
CC Execution Achievement	Truck Turn Round Time	Picking Rate
House Keeping Audit	Cargo Unloading Rate	Loading Rate
House Keeping Audit	Cargo Putaway Rate	Loading Rate
CBM per Pallet position	Unloading Accuracy	Picking Accuracy
CBM Utilization	Putaway Accuracy	Loading Accuracy
Area Occupancy		Pick Lines per Picker (Per

Some of the KPIs used in the apparel industry are as follows; IFR (Item Fill Rate), Location Accuracy, Inventory Accuracy, OTD (On Time Dispatch) and Customer Specific KPI as Orders within cut-off, Orders after cut-off, number of Cancel Orders / SRN.

2.4.2 Operational and productivity measurement model.

Normally 3pl operational productivity measuring using warehouse KPIs, especially below KPIs are used to measure productivity.

Some examples for KPIs are OTD (On Time Dispatch), CBM per PP, CBM Utilization, Area Occupancy, Dock to stock time, Truck Turn Round Time, Cargo Unloading Rate, Cargo Put Away Rate, Unloading Accuracy, Put away Accuracy, Order to Dispatch Time, Picking Rate, Loading Rate, Loading Rate, Pick Lines per Picker (Per Hour), Contribution per manager, contribution per Executive, contribution per CBM and contribution per SQFT.

2.4.3 Multi-dimensional nature of measurements

All measurement systems have errors. If the amount of variation that is contributed to the measurement system is unknown or not captured, confident decisions cannot be made.

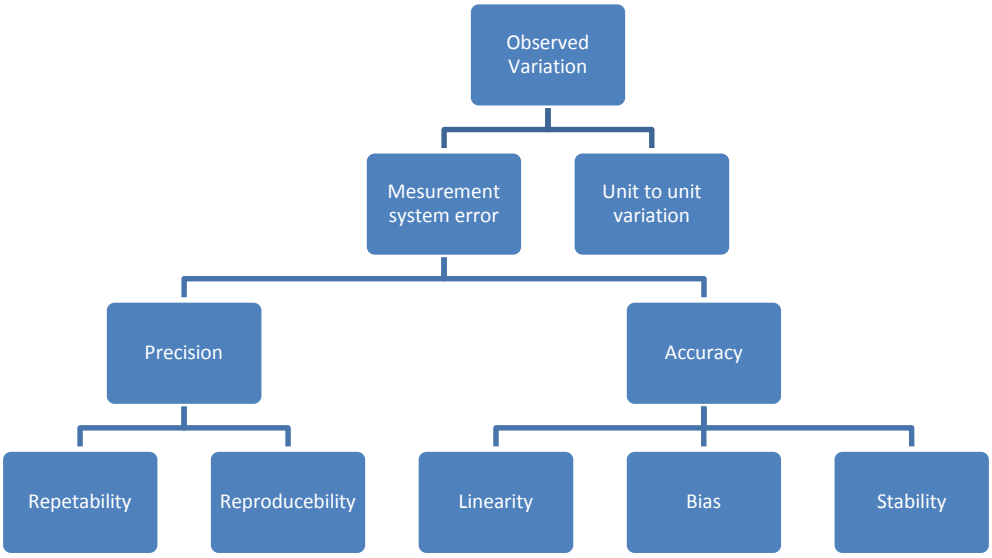


Figure 2-3 Nature of Measurement

Figure 2.3 Nature of Measurement

2.3.4 Real time problems solved in the industry

In Organisation A CLH apparel warehouse, an issue was raised in not meeting the 4.5 tons per day of commitment of order to dispatch. Also information visibility was very poor in the MX operation. According to the MX CO current PTP (plan to perform) achievement was 27%.

To overcome these issues, a project was initiated to analyse the possible causes and to configure relevant root causes respectively. The main causes were identified as following; Poor warehouse arrangement, Non allocated system quantities, No clubbing method, Lack of information visibility, Lab receiving issues, Exceeding working hours (24hr operation) and Lack of knowledge.

By further analysing the main seven causes identified, using different analytical tools like five why analysis and causes prioritization, they have come up with the solutions to overcome the problems in order to smoothen the processes and avoid interruptions at the bottlenecks of the overall operation.

Verified root causes	Solutions
Poor warehouse arrangement	Based on 5S method, rearranging warehouse
Non allocated system quantities	Excess allocation methods implementation
No clubbing method	Introduce clubbing method to MLH transfers (70% of total requirement). This directly impacts to an uninterrupted flow.
Lack of information visibility	Implementing daily operation update sheet, daily SOLI dispatch visual board.
Lab receiving issues	Improve the lab receiving process and daily information sharing sheet.
Exceeding working hours (24hr operation)	Reducing to 12hr operation and this will directly impact to reduce duplications
Lack of knowledge	Training sessions planned for staff members and continue with TNA.

Table 2.1 Implemented solutions MTX

Finally, all the calculated solutions were prioritized by considering their amount of benefits and the cost incurred to the business.

Another project was carried out by Organisation A NLH apparel hub. Their transport cost increased to 3.5 million per month. This cost has been adversely impacted on FG hub operation as well as the Profit and loss of the overall business.

To overcome this issue, they have implemented a project analysing the possible causes and coming up with the relevant root causes respectively. Then they have identified the main causes as per the following; Weekly ERD, Lack of supervision, ETA at hub failures, Lack of information visibility, High number of deliveries in last moment, Less output in Value Adding Services (VAS), Less CCA output.

By further analysing the main seven causes identified, using different analytical tools like five why analysis and causes prioritization, solutions were designed to overcome

the problems in order to smoothen the processes and avoid interruptions at the bottlenecks of the overall operation.

Verified root causes	Solutions
Weekly ERD	Arranging method to ERD advance
Lack of supervision	Assigning a person for total transportation responsibilities
ETA at hub failures	Continuously following up with MK team
Lack of information visibility	Implementing daily operation update sheet, daily SOLI dispatched team
High number of deliveries in last moment	Scope changing and continuously following up with MK team
Less output in Value Adding Services (VAS)	VAS productivity improvement project
Less CCA output	CCA productivity improvement project

Table 2.2 Implemented solutions FG HUB

While brainstorming it was identified as a requirement to conduct three major projects to improve the situation. Several bottle necks impacted to increase FG HUB operation transport cost. Based on brain storming three projects were carried out simultaneously.

30% cost reduction in NLH transport within 6 month of period
50% productivity improvement in CCA process in NLH FG HUB operation during the period of September to December 2017
100% VAS output level increase in NLH FG HUB operation before 31st January 2018.

When comparing the related processes with the identified issues, they have identified that process third and second projects have highly impacted to the first project and they were interrelated. Second and third projects were identified as directly related

with continues flow concept. When they started this project weekly, CCA offering achievement was recorded as 480 POLIS (80 POLI per 12hr day), weekly offer to table achievement was 420 POLIs (70 POLIs per 12hr day), weekly Audit achievement was 420 POLIs (70 POLIs per 12hr day) and weekly Folding achievement was 420 POLIs (70 POLIs per 12hr or more per day).

Client requirement was 550 POLIs per day but only achieved 420 per week. To cater to the remaining quantity operation team had to work extended hours and continue working days. This had adversely impacted the customer's on time performances (OTP) and vender compliance performances (VCP). Once after the VAS process that also needed to follow remaining steps and if VAS process delayed entire process has faced delays. As a result of all the operations, they could observe a skew towards the week ends. High vehicle requirement for weekends has badly impacted to increase last movement burden and transport cost.

Another project has been carried out by the same department, NLH in Organisation A regarding smoothening the operational flow within the warehouse. Here the main issue identified by the team was the low output (70 POLLs per day) in the CCA process. By considering the major causes for the issue and analysing the further they have come up with the most possible causes as per below;

Workers demotivation, High searching time, High number of samples, High dock to stock time.

Then they have carried out a five why analysis and found out the root causes out of them. After that those major factors have been submitted to hypothesis test to come up with the following results. By precisely analysing the process flow through a VSM diagram, they have calculated the cycle times of overall operation as well as the individual processes. From the results of the hypothesis test as well as the calculated cycle times, major root causes have been prioritized according to their impact to the operation and the controllability.

As a solution, several processes have been marched and total lead time has been reduced. Another solution they came up with was implementing incentive based

KPIs for all the workers related and introducing a performance based incentive scheme. Class room sessions and on job trainings have been also introduced to all workers to increase their efficiency as well as quality. Client approval has been taken in order to reduce the number of samples dispatched. By increasing the information visibility, they have managed to increase the location accuracy as well.

Another project carried out by NLH apparel hub was reducing the low output levels of VAS operation. Due to this issue they have unable to cater to their potential volume. Like all the other projects carried out, they have first identified the possible causes to the issue and shorten them down to the major factors by analyzing the root causes respectively. Then they have come up with an implementation plan for each of the root causes.

Root cause	Improvement
No dedicated area for PM	Arrange dedicated storage area. (Approximately 1000 sqft) in W/H two premises for VAS PM and create mechanism for issuing PM.
Not adhering to one piece flow	Change VAS room layout and process where one PLOI is completed and handed over to next stage where both information and material flow is not interrupted.
No time study data related to different VAS categories	Conduct time study and identify output levels related to VAS categories (hanger, folding, sticker etc.)
Lack of information visibility	Implement hourly output measuring display board/ KPI review board/ current week VAS plan display)
Low output levels	Cost model to be converted from attendance based to per piece rate
Lack of awareness of 5s in WH	Arrange training session to VAS team

Table 2.3 Improvement plan FG HUB

Team has prioritized the issues along with the improvements by considering their impact on the operation and the respective controllability by each of them. When they went through two problems they could observe some similarities in both RM and FG operations which once interrupted the continuous flow. All of the projects were implemented to make sure the uninterrupted flow and then only they could clearly observe all the process improvements increased continuously.

Considering the Problem 01, implementation plan was prepared to improve the continuous flow. Newly planned warehouse structure highly impacted for easy and quick searching.

As implementations they have taken steps to improve information visibility to improve information flow and material flow. When they consider the Problem 02,

implementation plan was prepared to improve the continuous flow. One-piece flow concept was implemented and from that they were able to achieve the weekly commitment. Client's requirement was 600 POLIs per week day (Client requirement also increased) and the team could be able to achieve 660 POLIs per week. This has helped to improve continues flow concepts.

Finally, two problems were (Four projects) solved based on the above tools and techniques. In addition to that some changes took place in the management activities and staff changes have also done in align to the common objective.

These two cases can be seen in large scale RM and FG warehouses. There are some similarities in them. When continuous flow is interrupted issues are created and due to the solutions given for the symptoms and not for the root causes, it become worst. Logistics professionals tend to only address day today problems. Because of that, warehouse best practices can be missed. And also it may cause to occur inventory variances, to create location accuracy related issues. Finally, it may become the biggest and the complicated problem in the company. If the real reason behind the exact problem is identified, in this case it is, due to "interrupted continues flow", and if necessary actions are taken to improve continues flow problem, issue can be easily solved. Statistical analysis, lean principles are helpful to solve these types of problems. When implementing change, supporters, opposes, on the fence actors needs need to be identified. People development is the other part of these types of implementations. These were the main outcomes and results identified and understood by the team in achieving the expected solutions for the issues.

2.5 Apparel Supply Chain in Sri Lanka

According to the literature of Ali and Habib (2012) the textile industry is a long chain including processes of raw materials production, complement production, clothing production. Supply chain Management concept is made possible as a conventional management tool for all apparel manufactures to strive to improve their product quality, to reduce product and service cost and to shorten the product delivery and response times in a highly competitive market.

Apparel design, manufacturing and exportation can be considered as one of the biggest manufacturing industries in Sri Lanka and plays a major role in the advancement of the country's economy. Apparel industry represents more than 7% of Sri Lanka's GDP and employs about 15% of the country's workforce while accounting for more than 50% of total exports.

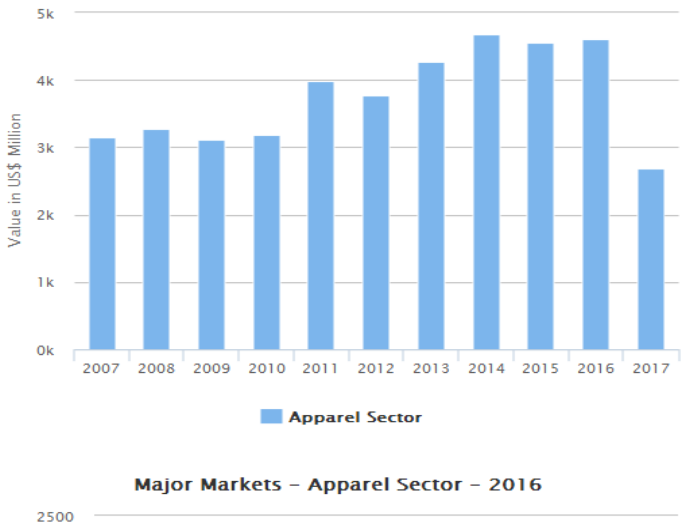


Figure 2-4 Apparel Sector Export Performance 2007-2017

Source: Sri Lanka Export Development Board

The statistics show the importance of apparel industry to Sri Lankan economy.

Propelling by the globalization, the apparel industry has to cope with high demanding customers. Consumers in today's market demand products to be produced at competitive price with the fastest turnaround time possible. The textile and apparel sourcing companies therefore have to be nimble enough to make prompt responses to the changing consumer preferences, along with value added activities (Yuen & Cheng, 2013, p. 1153).

2.5.1 3PL operations in the Apparel Sector

To mitigate the apparel industry related weaknesses and threats they needs to ensure short lead times and quality of the product by ensuring optimum cost. To ensure the above aspects most of apparel players focus on their core business and logistic part

outsourced to professionals in the logistic field. The inspection and quality controlling procedures are built into the warehouse operation due to the complexity of the apparel business. When operating clients like Nike, Levis, CK, Sainsbury and H and M, sudden changes take place. So the value addition is planned at the end of the process. Apart from these POLI splitting, destination changes also occur frequently. Volume fluctuation is also another major challenge. Because of these apparel warehousing activities become even more complicated.

If most or all operative functions of the clothing company's logistics are outsourced to a 3PL provider it means, there is less or no need for the company to own its own warehouse or transport facilities. This significantly helps lowering the amount of capital required for the business. This is particularly beneficial if a company has high variations (fluctuations) in warehouse capacity utilization. If your business is not using all the space in a warehouse because of a bad capacity utilization ratio it will most certainly reduce the company's profitability.

In an apparel supply chain, meeting lead time is a critical aspect. Goods should be available for the customers at the correct time at the correct place due to its fast moving feature. Therefore, it is always ensured that a smooth movement of goods is taken place throughout the supply chain. Being one intermediary of the supply chain, warehouse operations should be well planned and operated in a way it supports in minimizing the lead time of the overall supply chain. Above mentioned main points are some of the busiest places within the warehouse due to continuous inbound and outbound of goods throughout the day. Irrespective of Bulk or each quantity, every good should be well checked and packed/unpacked/ re-palletized before putting away or dispatched. Therefore, in those points bottlenecks can be created very easily. Therefore, they are very important nodes in the supply chain where the time should be managed well in order to meet up with the demanding lead time. Moreover, due to this specification, they are processes where a considerable amount of time can be saved by adhering to certain principles or practices by precisely analysing the ongoing processes. Hence, it is required to model the operations and find a strategy that will optimize the smooth and continuous flow of operation. To come up with an

appropriate model, first the issues which cause for bottlenecks and interrupted flows should be identified.

2.5.2 Supply chain design for 3PL operations in apparel sector

When considering Sri Lankan apparel warehouses most of the companies still doing in housed warehouse operation and most of companies still not much focus on warehouse efficiency and productivity. They all work to build up inventories to ensure material availability. Currently most of Sri Lankan apparel giants move to outsourcing to reduce their logistic cost while ensuring the on time material availability and 100% inventory accuracy. MK outsource their Raw materials and finished goods warehouse operations for 3rd party logistic companies. BX outsource their raw materials and finished goods warehouse operations for 3rd party logistic companies. Recently HDM also moving with 3PL operation. MK recently initiate the joint venture with 3PL Company. When we consider the all apparel giants more than 80% of them work with 3PL operators.

Increased lead times, inventory carrying cost and responding problems due to real time information unavailability lead to customer dissatisfaction. According to (Mason et al. 2003, p. 154) these problems can be resolved by integrating supply chain management systems for warehousing and transportation. They believed that by an integrating the system suppliers and warehouse, global visibility can be increased which will improve the accuracy, reliability and customer service as well as reduced cost. Furthermore, internet technology allows warehouse managers to receive orders more expeditiously and allows them to track the inventory connected with those orders. Therefore, WMS and TMS working together can reduce the overall cost within the supply chain by reducing lead time and optimizing the total cost. This leads to the reduction of the amount of safety stock that must be held to satisfy the projected supply and demand uncertainties since they contribute a significant cost to companies. With the integration of WMS with the TMS lead time variations will be minimized and therefore large inventory buffers will not be needed.

CHAPTER 3: RESEARCH METHODOLOGY

Research is a procedure of inquiry which is systematic, ethical and methodical that assist to solve practical problems and gain knowledge (Colin, 2007). Moreover, research methodology is an evaluation to find solutions for scientific and social problems through systematic and objective analysis, in search of knowledge to disclose hidden facts (Rajasekar, Philominathan and Chinnathambi, 2013). Similarly, research methodology is concerned with developing theoretical concepts about a natural or social phenomenon and relationship between those concepts (Bhattacherjee, 2012).

The above chapter depicts that most of the relevant literature are realistic studies and qualitative methodologies are used more frequently for this type of studies. This chapter clarifies the methods and means used by the researcher to come up with the intended outcomes. Also, the chapter portrays limitations of the methodology used in analysis. After reading the introduction and the Literature review chapter, the reader has a clear knowledge about the focus of the research and the literature around the area. In order to accomplish the research objectives, the quantitative and qualitative data had to be extracted from the industry. The collected data had to be analysed using solid statistical techniques to achieve the core objectives of the research.

3.1 Research Design

The research was focused on both quantitative and qualitative data.

To achieve the objective, it is planned to get the required information from existing operation data in Apparel warehouses and questionnaire to get the perception of executives and managers who are working in Apparel sector (3PL operations). Output from the questionnaire is used to rank the factors which “Impact operational performance through continuous flow in Apparel sector 3pl operations “

Illustrating the research approach is an important aspect of research, which is an effective approach to improve the validity of the research (Cresswell, 2007). In addition, there are mainly two types of approaches in research, such as inductive and

deductive (Soiferman, 2010, p. 3). Inductive approach is creating a generalized theory through observations (Kuder, 2009) and deductive approach is using existing theories to develop a hypothesis and designing a research strategy to examine the hypothesis (Kuder, 2009). Nevertheless, Mostaghel (2006) states that deductive approach is the most appropriate approach to examine the factors of service quality which affects the customer satisfaction in service industries. Saunders et al (2003) say deductive approach tests the validity of assumptions in hand which were found through the previous researchers. Therefore, in this research the author will adopt the deductive approach.

3.2 Population and Sample

Paula and Justo (2001) describe that population in a research is all the people or subjects a researcher needs to study. It is also defined that sampling as the process of selecting a limited number of individuals representing that group or subjects. A proper population had to be chosen where the outcomes of the research will be applicable to that population. Afterwards a sample had to be chosen to reflect the selected population. The results acquired from this sample will represent the whole population and so the results will be generalized to match the population. Hence the population of the study consist of employees that are Executives and above grade in the Apparel warehousing industry in Sri Lanka.

The Sample of the research was concentrated towards the clientele served by Organisation A; professionals from MK, BX, HDM and Organisation A. 31 responses were received out of a 47 sample size. 87.1% of the respondents were representing 3PL companies and 12.9% represented apparel companies. 84% of the respondents were below 40 years of old. 55.6% of the respondents had more than 10 years working experience. 39% of the respondents held managerial positions and 61% were in executive positions.

3.3 Data collection

3.3.1 Primary data collection

Primary data was collected through a questionnaire (Annex 3).
A questionnaire was prepared to be sent to Apparel sector warehouse operation executives and above positions. Targeting executives, Managers Number of expected responses are 30.

3.3.2 Secondary data collection

A literature survey had to be carried out to learn the background of the study and to investigate the standard methods used by the industry in these types of researches. It was impossible to find literature on Sri Lankan context because there hasn't been any research done on this area. As mentioned in literature review using past projects which was done by apparel sector 3pl operations collected the secondary data

Methods used to improve continue flow;
Identify the root causes for failures, Improve the information visibility, Improve the material flow, Measure the performance impact

3.3.3 Questionnaire Development

One questionnaire was used to collect primary data to achieve the objectives as previously mentioned. They were prepared by the information acknowledged through the Operational experience and the extensive literature survey carried out.
Questionnaire was compromised of six sections which was included with twenty six variables. It was prepared to examine the different factors of continues flow how to impact to the operational performances

Figure 3-1 Questionnaire Rationale

#	Diamentions	# of mesurements	Mesurements	# of item	Question items
1	Material flow	2	Material receving visibility level	2	1. Goods were received based on received information
					2. Packing list details and inbound goods accurate
			Material receving accuracy level	4	3. Put away accuracy
					4. Accuracy for offering for quality inspection
					5. percentage level of inspection pass at first time
					6. loading accuracy level
2	Information flow	3	Information receving method	1	1. Delivery related Information received from client
			Information visibility level	5	2. Do you experience sudden changes of the delivery details
					3. Do you have proper mechanism of information sharing
					4. All the required information readily available
					5. Are you sharing operational information with client/3pl partner
			Information reliability	3	6. All the information flow though the ERP system
					7. Delivery related received information frequently changing
					8. Reliability of the data source
					9. All information sharing happened based on cut-offs
3	Operational performance	2	Producytivity mesurement of operational performance	6	1. Do you measure the productivity index of Unloading line or CBM or Pcs per hour
					2. Do you measure productivity index of put away line or CBM or Pcs per hour
					3. Do you measure productivity index of pick line or CBM or Pcs per hour
					4. Do you measure productivity index of dispatched line or CBM or Pcs per hour
					5. Do you measure the index of per head contribution
					6. Do you measure the per SQFT contribution of your warehouse
			effeciency mesurements of operational performance	7	7. Do you measure the Unloading accuracy of your Inbound operation
					8. Do you measure the put away accuracy of your warehouse
					9. Do you measure the picking accuracy of your warehouse
					10. Do you measure the dispatched accuracy of your Outbound operation
					11. Do you believe W/H System leads to increase your operational performance
					12. If Location accuracy leads to increase your operational performance
					13. If Picking accuracy leads to improve the dispatched accuracy
4	Operational KPIs	2	KPI adhirance	2	1. Accurate information is usually available for decision making.
					2. On-time delivery has been improved
			operation without fire fighting	5	3. Customers' responsiveness has been improved
					4. Company's customers are satisfied with our products and services.
					5. Operational costs have been reduced within the Warehouse operation
					6. Service quality has been improved
					7. No firefighting situations
5	Relation ship between countinues flow & operational performances	2	Experionce by operating countinues flow		1. Do you believe the inter process connection impact to improve the operational performance
				2	2. Do you believe '**one at a time'** concept caused to Improve the performance
			Causes for interept the countinues flow	5	3. Does warehouse operating equipment impact to the Operational performance
					4. Do you believe warehouse layout leads to increase your operational performance
					5. Does Warehouse rack layout impact to performance
					6. Does bottle neck on inter processes leads to Operational failure
					7. Does majority of operations fails due to the Disconnection of inter processes?

3.4 Justification of the analytical framework

This research was based on the both Qualitative and quantitative data. Collected observations were converted into quantitative data and a quantitative analytical approach was taken in order to achieve the research objective and to answer the research questions. Theories of Statistical analytical methods were used in analysing data to achieve the objective of the research are discussed below

3.5 Analytical methods used

3.5.1 Descriptive Analysis

Descriptive analysis is the statistical method of representing the summary of collected data in a study. Descriptive analytical tools were used for identify the problem. Descriptive statistics are used for the purpose of extracting meaningful summaries from a pack of data. Tools like mean, median, standard deviation, variance, range, skewness and kurtosis can be used to represent the data set and those tools can be used in arriving at primary.

Descriptive analysis, Regression analysis and Scatter plots can be used in identifying a trend and a pattern in the collected data from the sample which represents the overall population.

3.5.2 Weighted average method use for analyse the questionnaire

Ex:

information flow	1	2	3	4	5		Weighted avg	
Delivery related information received from client			1	22	8	131	4.23	85%
you experience sudden changes of the delivery details		1	5	16	9	126	4.06	81%
You have proper mechanism of information sharing			3	24	4	125	4.03	81%
All the required information readily available		1	6	20	4	120	3.87	77%
You sharing operational information with client/3pl partner			5	22	4	123	3.97	79%
All the information flowthough the ERP system		8	16	3	4	96	3.10	62%
Delivery related received information frequently changing	1	4	14	12		99	3.19	64%
Reliability of the datasource is very high			8	18	5	121	3.90	78%
All information sharing happened based on cut-offs		3	8	14	6	116	3.74	75%

Table 3.2 Questionnaire analysis

3.6 Validity of the Test

Data was gathered in two methods; data collected from existing operation, questionnaire sent for data collection. All operational data was retrieved from daily operations. Questionnaire sent to professionals who work in the relevant sector.

3.7 Reliability of the results

Operational data were gathered from ERP system and cross checked data for 100% accurate. From the questionnaire, 31 respond received via google sheet and respondents working at 3pl companies and apparel companies.

CHAPTER 4: DATA ANALYSIS

This chapter elaborates the analyses carried out and the findings which were extracted from the analysis. Descriptive analysis and Factor analysis were used to assess the data and formulate the conclusions through Problem identification, Factors extraction, Calculation of the impact of the factors by mapping the overall process to identify performance at each stage, and its relationship.

The collected primary and secondary data were used to realise the main objectives of the research study. It was considered under several stages of the FG Hub operational process;

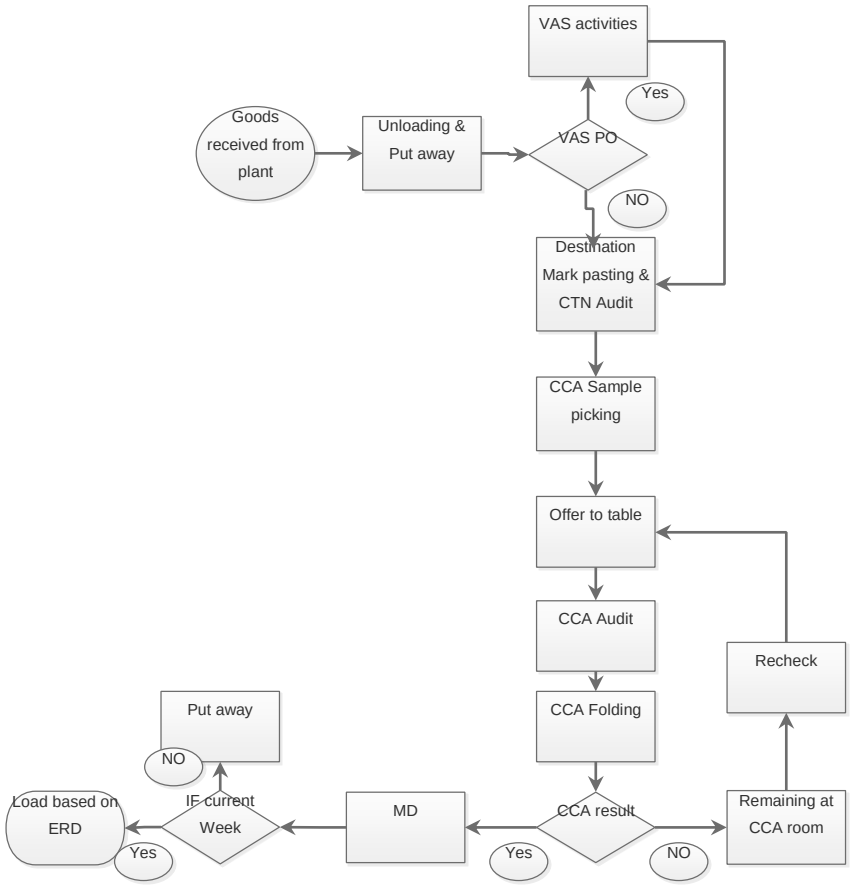


Figure 4-1 FG HUB Operational Process

Good receiving POLIS

CCA offering POLIs

CCA output POLIs

Loading POLIs

4.2 Background analysis (Daily receiving)

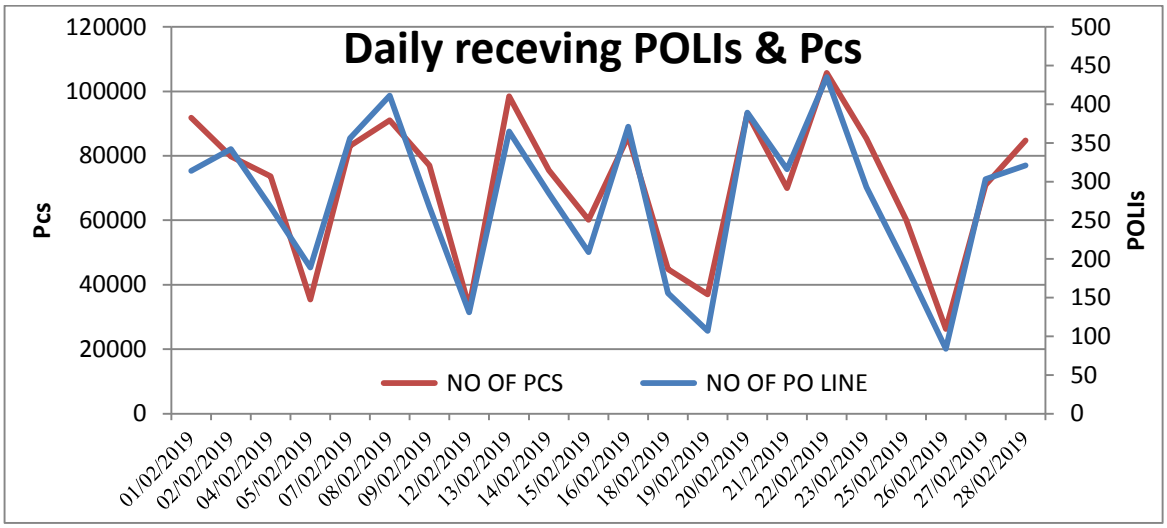


Figure 4-2 Daily receiving POLIs & Pcs

As per the figure 4.2 averagely 277 partial polis received, 71057 pcs per day, 2537 Ctn per day. Also we can see the cyclic pattern in every week.

Description	*Sum of COMPLETE PO*	*Sum of WEEKLY COMPLETE PO*	*Sum of NO OF PO LINE*
Mean	100.3181818	47.63636364	277.3636364
Standard Error	8.95452348	6.098593073	21.3403207
Median	106.5	52.5	298
Mode	140	52	267
Standard Deviation	42.00043805	28.60493706	100.0949765
Sample Variance	1764.036797	818.2424242	10019.00433
Kurtosis	-0.430016296	-1.164700972	-0.736215326
Skewness	-0.659994782	-0.209753557	-0.449029893
Range	146	95	351
Minimum	13	0	84
Maximum	159	95	435
Sum	2207	1048	6102
Count	22	22	22
Confidence Level (95.0%)	18.621951	12.68271859	44.37962638

Table 4.2 receiving statistical summary

Table 4.2precented averagely 277 POLIs received per day with 100 polis standard deviation. 277 polis consist partial POLIs, same week completed POLIs, and completed POLIs which was belongs to next weeks also. Same week averagely 48 POLIs received per day with standard deviation of 29 POLIs, maximum of 95 same week POLIs received within one day and maximum of 159 completed POLIs recorded per day.

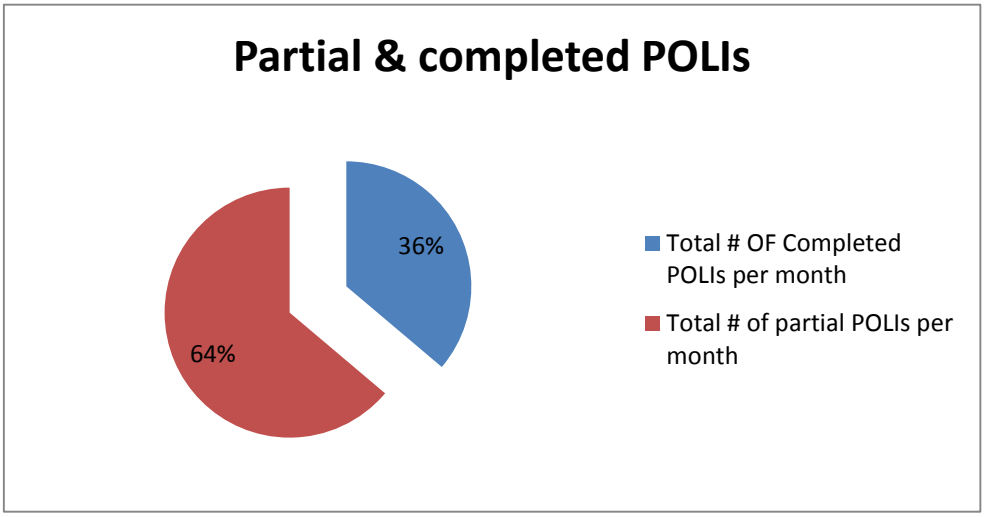


Figure 4-3 Partial & Completed POLIs

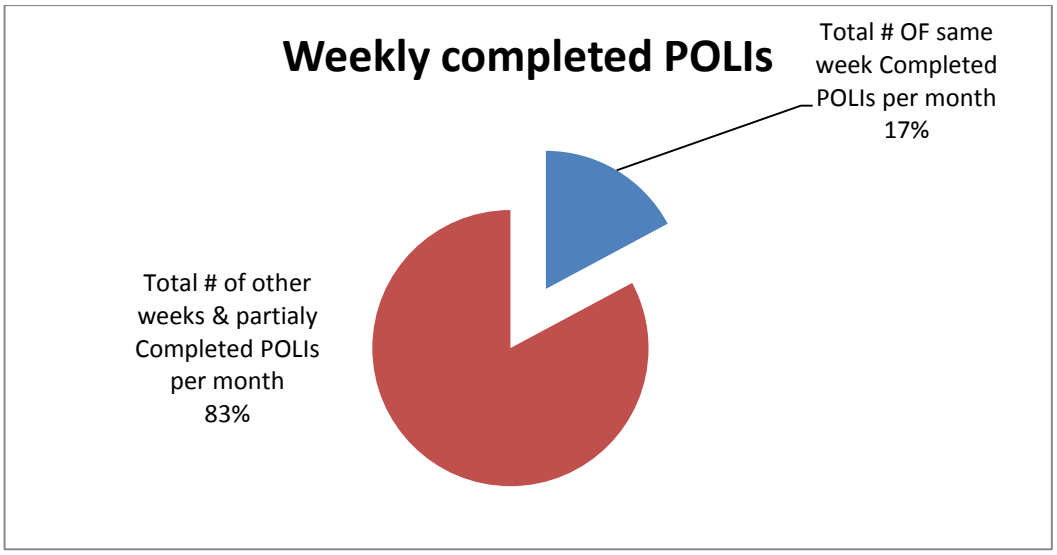


Figure 4-4 Monthly figure of weekly completed POLIs

As per the figure 4.3 and 4.4 monthly received POLIs, 36% of the Completed POLIs received and 17% of completed POLIs should be shipped within the week. Averagely per day 48 POLIs received which was needs to shipped same week. So unloading and put away performances highly impacted to next process

Raw Labels	Average of Minuets	Average of Time per POLIs	Average of Time per cartoon
BAY 01	239.8	5.835629071	0.832805055
BAY 02	277.7674419	7.043559173	0.672453183
BAY 03	226.6808511	12.26238187	1.089664622
Grand Total	**247.3259259**	**8.457839263**	**0.871155197**

Table 4.3 Unloading bays wise performances

As per the table 4.1, within working hrs unloading teams can unload averagely 190 POLIs based on Bay 3 figures there is opportunity to improve the unloading performance further.

4.3 CCA Operation

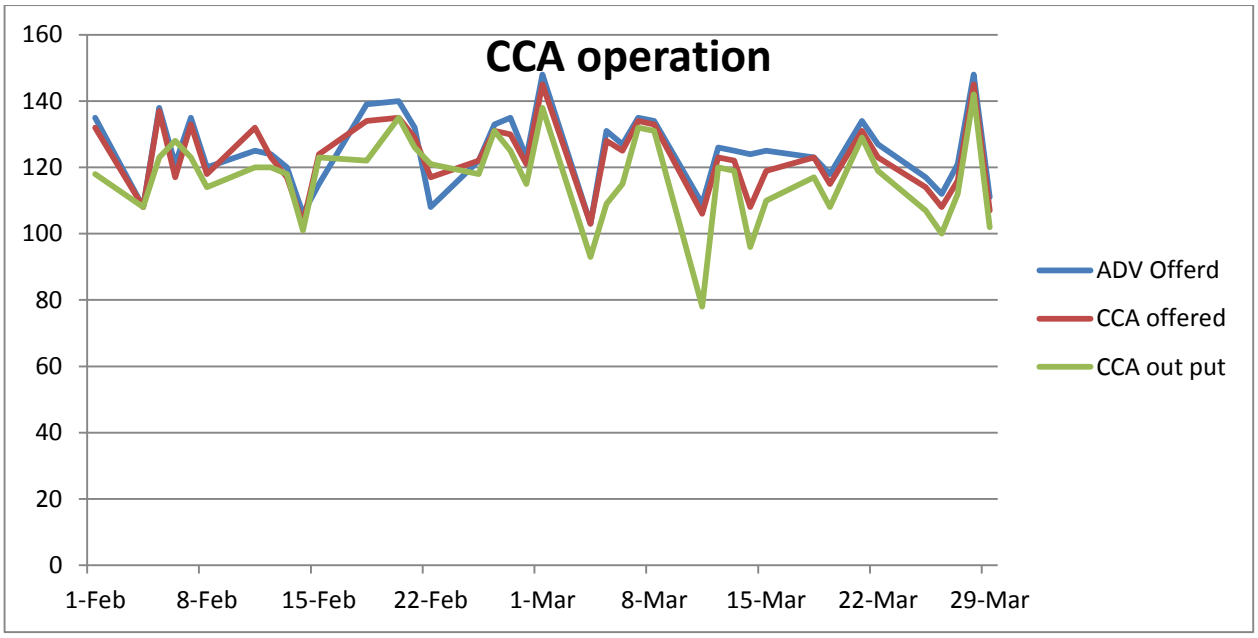


Figure 4-5 Daily CCA Operation

Description	ADV Offered	CCA offered	CCA out put
Mean	125.2105263	124.3684211	120.4736842
Standard Error	2.490424877	2.163236862	1.77435998
Median	124	124	121
Mode	135	117	118
Standard Deviation	10.85551036	9.429330872	7.734255843
Sample Variance	117.8421053	88.9122807	59.81871345
Kurtosis	-0.954658456	-0.102871464	1.46471704
Skewness	-0.349660405	-0.699345882	-0.648908928
Range	34	34	34
Minimum	106	103	101
Maximum	140	137	135
Sum	2379	2363	2289
Count	19	19	19
Confidence Level (95.0%)	5.232188513	4.544792002	3.72779199

Table 4.4 CCA statistical summery

As per the descriptive statistics averagely 125 POLIs CTN audit complete, 124 POLIs offered to audit and 120 POLIs completed the audit. Standard deviation for CTN audit completed were 10.85, offered to audit were 9.42 and Audit completed 7.73. That indicated CCA operation always stabilize operation. Because of deviation of CCA operation highly impacted to the next process.

SUMMARY OUTPUT CCA

Regression Statistics	
Multiple R	0.9636
R Square	0.928526
Adjusted R Square	0.924952
Standard Error	6.395845
Observations	22

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	10628.45	10628.45	259.821	6.34E-13
Residual	20	818.1368	40.90684		
Total	21	11446.59			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	25.51796	5.527608	4.616456	0.000167	13.98757	37.04835	13.98757	37.0483
CTN Audit	0.772511	0.047926	16.11896	6.34E-13	0.67254	0.872482	0.67254	0.87248

Table 4.3 CCA operation

As per the regression analysis R square value is 0.93 it interpreted strong relationship between CTN audit and CCA output. According to the above table we can identify the relationship between the Carton audit and CCA output. It can interpret as

IF CCA output = Y

CTN audit = X

Y = 0.77X+25.52

When # of CTN audit increased by 100, CCA output increased by 77

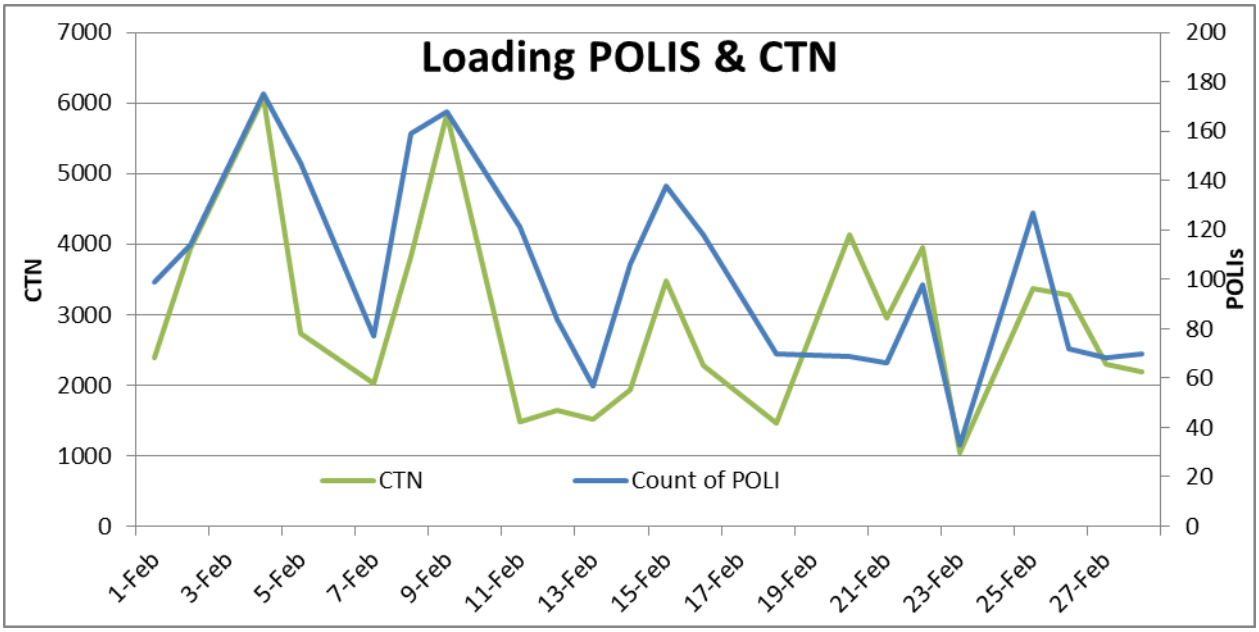


Figure 4-6 Daily loading POLIs & CTNs

	POLI	*Qty Pcs*	*CTN*
Mean	101.6363636	68333.45455	2900.090909
Standard Error	8.309892257	8249.323917	287.4792815
Median	98.5	60984	2556.5
Mode	70	#N/A	#N/A
Standard Deviation	38.97684961	38692.75891	1348.397352
Sample Variance	1519.194805	1497129592	1818175.42
Kurtosis	-0.754622739	2.304636451	0.545328844
Skewness	0.360080227	1.643146281	0.925986372
Range	142	144586	5027
Minimum	33	25685	1051
Maximum	175	170271	6078
Sum	2236	1503336	63802
Count	22	22	22
Confidence Level (95.0%)	17.28136699	17155.40823	597.8458938

Table 4.4 Summary statistics

Table 4.4 presented averagely 102 POLIs loading per day with 39 POLIs standard deviation with a varying range of 142 POLIs. When considered the number of pieces, Averagely 68,333 pcs loading per day with standard deviation of 38,693 pcs it was vary range of 144,586 pcs. When we consider the number of CTN, Averagely 2900 ctns loading per day with 1348 CTN standard deviation and it were vary range of 5027 CTN .

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.78645
R Square	0.618503
Adjusted R Square	0.599429
Standard Error	6.888989
Observations	22

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1538.837	1538.837	32.42511	1.42E-05
Residual	20	949.1635	47.45817		
Total	21	2488			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	50.26877	11.98489	4.194344	0.000447	25.26872	75.26882	25.26872	75.26882
NCA	0.587342	0.103146	5.694305	1.42E-05	0.372184	0.8025	0.372184	0.8025

Table 4.5 Loading operation

As per the regression analysis R square value is 0.62 it interpreted positive relationship between Loading POLIs and CCA output POLIs. According to the above table we can identify the relationship between the Loading POLIs and CCA output. It can be interpret as;

IF Loading POLI= Y

CCA output = X

$$Y = 0.59X+50.27$$

When # of CCA output increased by 100, loading output increased by 59

4.4 Questionnaire Analysis

According to the responds, 77.8% were familiar with Lean concept and 11.1% of people were familiar with lean six sigma concept and 11.1% of people were familiar with 5S concept.

55.6% were practicing one peace flow concept

4.4.1 Information flow implemented

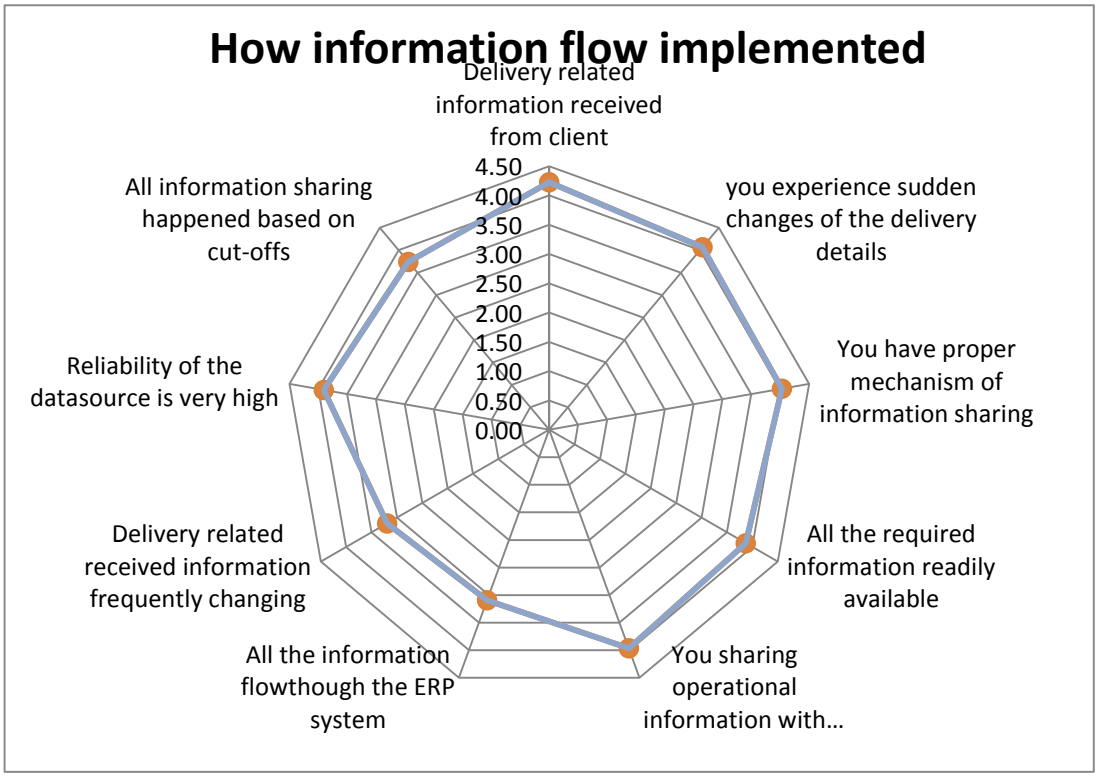


Figure 4-7 Information Flow

When considering the measurements of information flow, 3 lagging points can be seen relative to the others. Those are;

- All information are flowed through the ERP system
- Delivery related received information frequently change
- All information sharing happened based on cut-offs

When considering the 1 to 5 rating, other factors are aliened within the range of 75% to 85% in Sri Lankan apparel warehouse operation. According to the respondents, considerable amount of data doesn't flow though the ERP system even with the use of ERP systems.

4.4.2 Effectiveness of the material flow on the warehouse operation

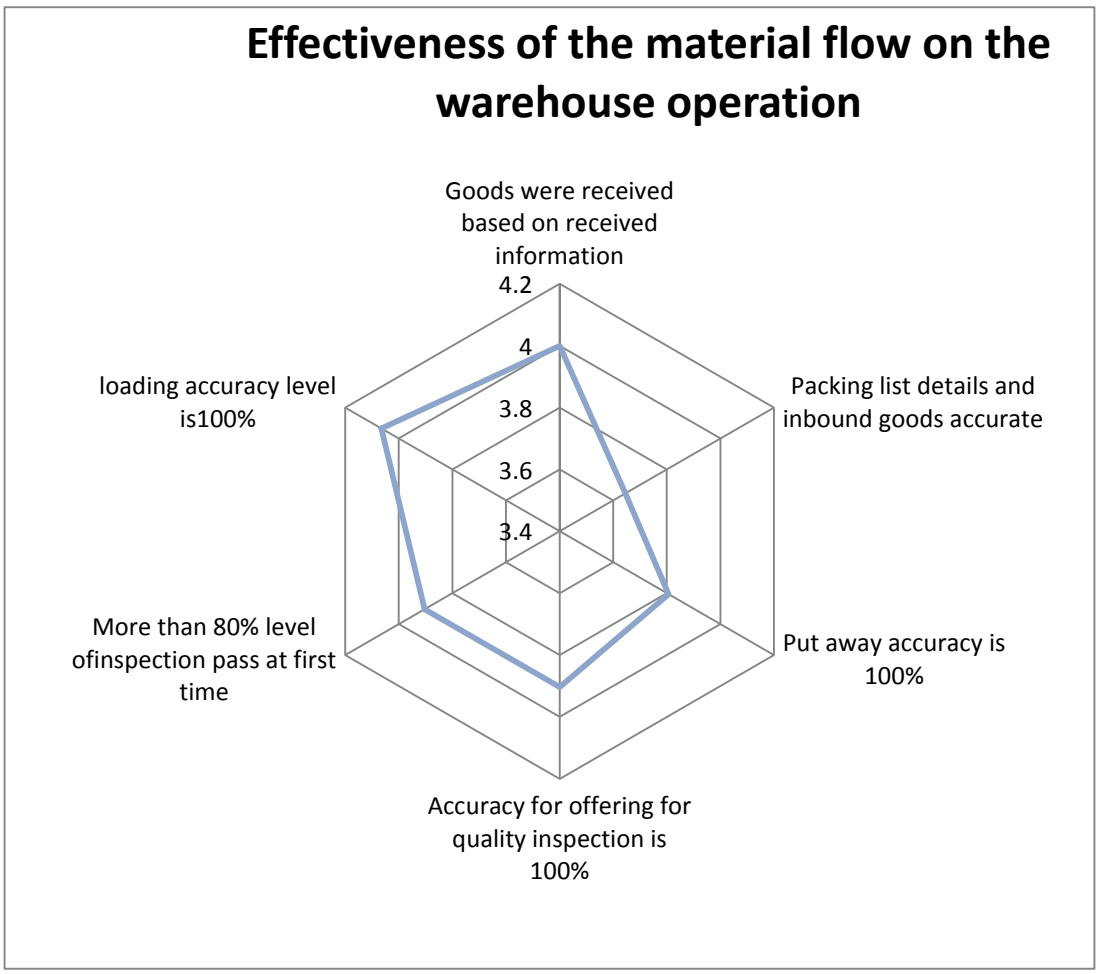


Figure 4-8 Effectiveness of the material flow

All the factors are aligned in 70% to 80% range. Relatively respondents have given low ratings for the 100% put away accuracy. Also respondents have mentioned that the packing list details and inbound goods are not matching frequently.

Most of the respondents have highly concerned about loading accuracy level and first

time inspection pass rate less than 80%. Based on all the components, still Sri Lankan warehouse operation's material flow also needs further improvements.

When considering the productivity related KPIs measurements, more than 65% of the respondents have measured productivity related KPIs

When considering the efficiency related KPI measurements, they have measured and keep high performances in inbound and out bound accuracy. But 22.2% of the respondents haven't measured picking accuracy, 5.6% of the respondents haven't measured the put away accuracy.

All the respondents have agreed to take as the factors of location accuracy, picking accuracy and the warehouse operating system to drive the warehouse performances.

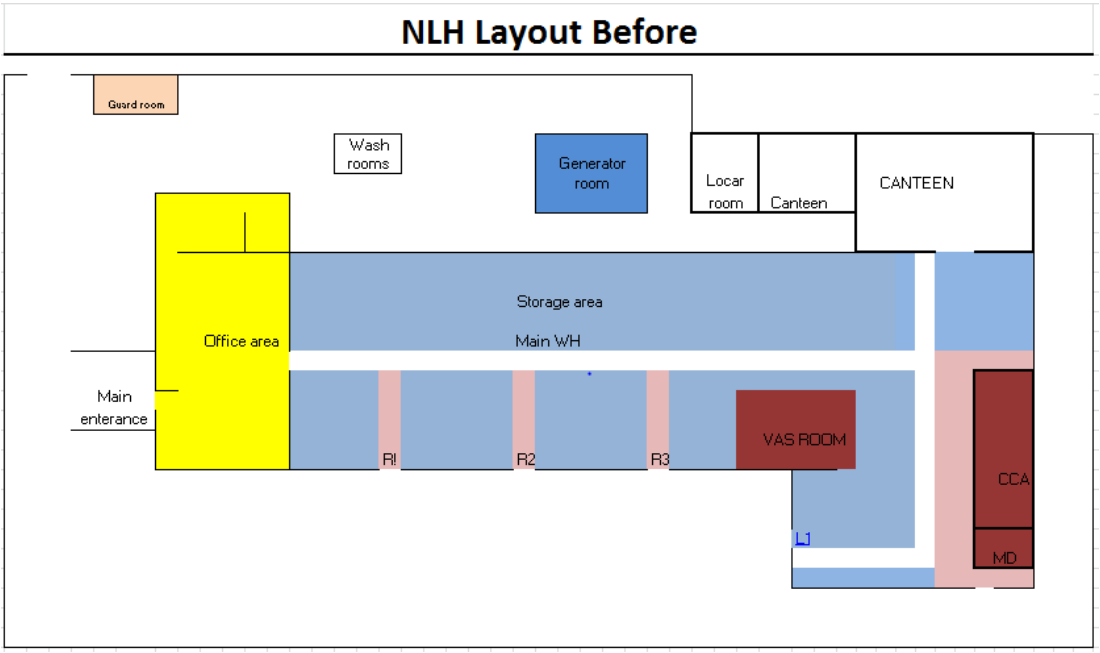


Figure 4-9 NLH Layout - Before

According to the initial lay out all the office located at front and all the operations going on warehouse area so lot of communication gaps experienced. Due to the high material movement, people movements, information sharing gaps directly impacted to the operational failures. Especially high number of people involve, Less CCA output, loading output as mentioned in literature review. Same time receiving team,

put away team, CCA team, CCA auditors, loading team, commercial team, transportation work on their silos. Only focus on their activity as a result of that create environment of firefighting.

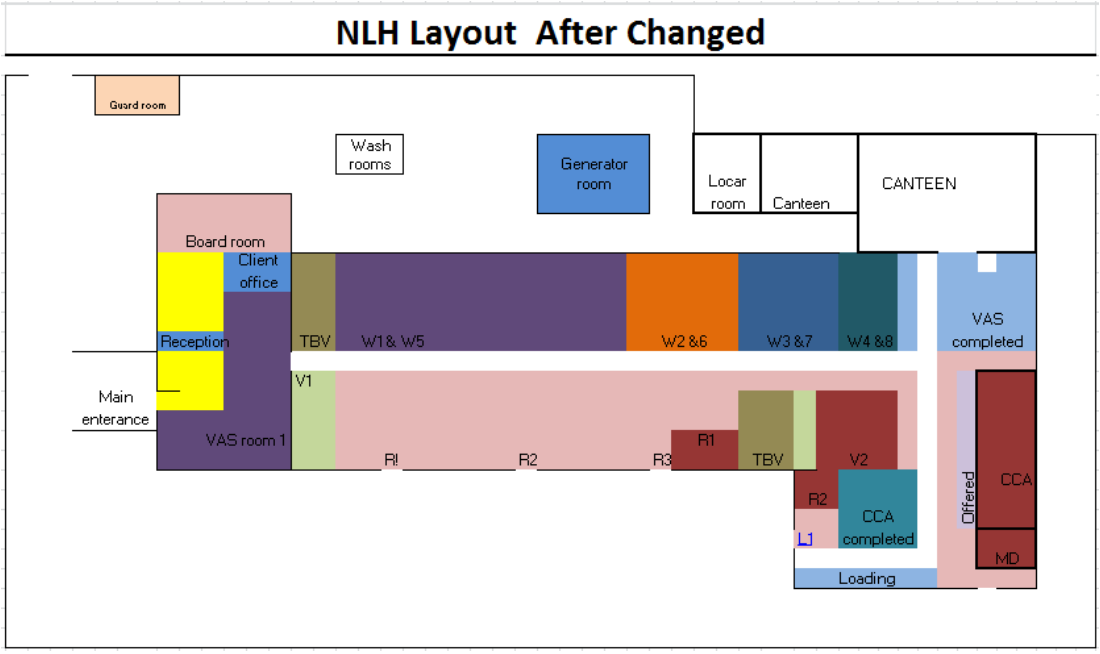


Figure 4-10 NLH Layout - After

Lay out changed to improve material flow and the informational flow and reduce the communicational gaps. Office relocated near to the operational areas to , Improve the Vas capacity (VAS room1 and VAS room 2), light green colour (V1) area used for storage VAS packing materials , TBV area storage to be vas goods and objective of material arrangement is reduce the VAS people movement and material movement, complete VAS POLIs located vas completed area which was light blue area. Other major thing is week wise inventory.

Due Good dispatched according to the weekly shipment plan and 50% of the current week POLIs complete same week introduced the week wise inventory model and layout also changed to facilitate that.it caused to reduced motions of CCA offering peoples and improve productivity.R1 is the receiving counter it located near the receiving bay it also caused to increase receiving accuracy and receiving and put away speed. Commercial and transport counter located near the loading bay it also caused to improve GDN accuracy and reduced loading errors. Operational lay out

finally support to the maintained uninterrupted flow (continues flow), one piece flow concept apply to VAS operation. Once completed the one POLI and it directed to the CCA process and MD process, finally loading operation.

According to the findings from the questionnaire, all the despondence 100% agreed to the layout changes impacted to the increased performances.

4.4.3 Operation performance based on KPIs

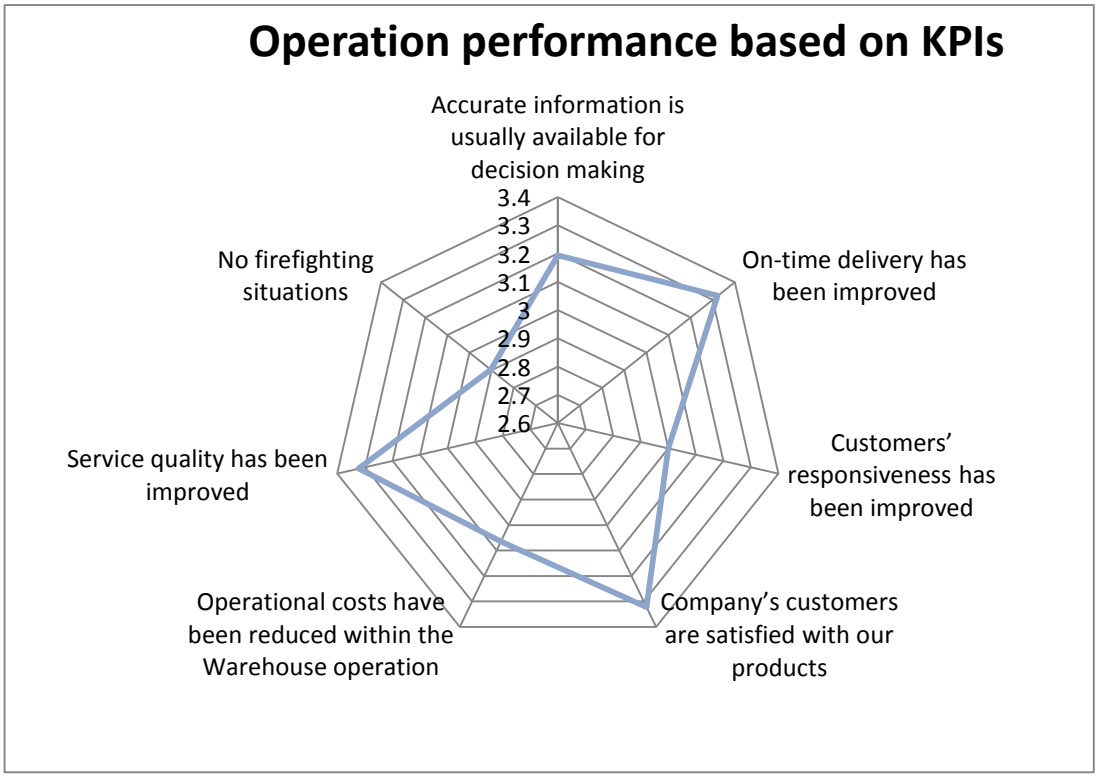


Figure 4-11 Operation Performance

All the factors are aligned in 55% to 65% range. Relatively respondents have given low ratings for no firefighting situation, because 60% of the respondents have given uncertainty about the related questions.

4.4.4 Relationship between the continues flow and the performances

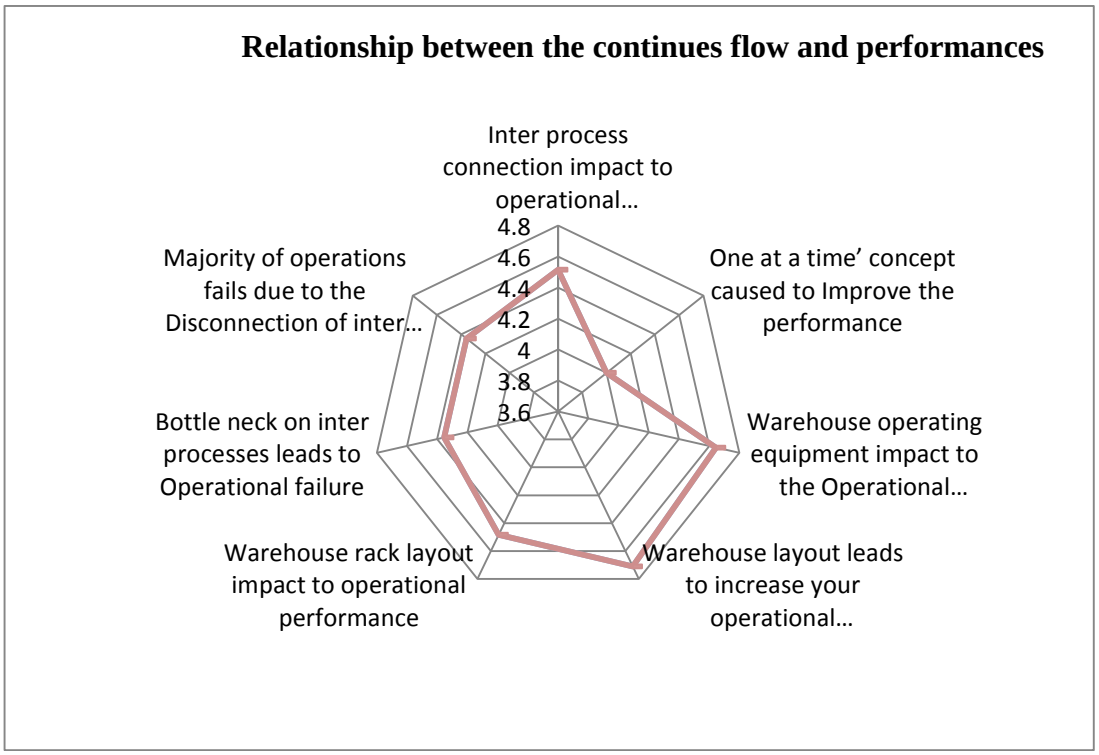


Figure 4-12 Relationship between the continuous flow and the performances

All the factors are aligned in 85% to 95% range. It is a considerable high value. But the respondents have given low rating for "one at a time concept caused to improve the performance". Based on the responses, respondents have given 85% to 95% rating to prove that there is a very strong relationship between the continues flow and the performances

According to the respondents, they have measured that the following KPIs for warehouse operations. Those KPIs are categorised into easy reference.

Main KPIs	
Inventory accuracy	On time delivery in full
Internal KPIs	**Performance measuring KPIs**
Location accuracy	Cost per pcs
GRN accuracy	Zero debit notes
GDN accuracy	Zero Customer complain
Return acceptance accuracy	Case per man hr
VAS/MRP accuracy	Contribution per CBM
Cycle count accuracy	Hourly output
Cycle count execution	Customer specific KPIs
Truck turnaround time	OTP
Warehouse utilization	VCP
Truck load utilization	ETA hit rate
Damage %	
MR services%	
Dock to stock time	

According to the respondents, they have measured a lot of performance measuring KPIs and internal KPIs. Most of internal KPIs such as location accuracy, return acceptance accuracy, Truck turnaround time, dock to stock time have impact to improve continues flow in the warehouse.

According to the respondents, they believed that the following points are caused to reduce the operation performances;

Lack of experience, lack of commitment, lack of good leadership, warehouse layout, not follow the best practices, not allocating suitable employees, lack of skill, negligence, planning issues, lack of preparation, lack of follow up, poor work load balancing, lack of mutual understanding on the operation requirements of client and operating parties. lack of interest and the knowledge in required people, Not knowing the Impact of a once activity for the next operation, Need to implement control points as much as we can (BPR),MHE breakdown, manpower shortages, system failures including network, email etc.. Resource shortages at peak times (pallet, lorries), Poorly designed processes, Discontinuation / miscommunication in the inter processes, Lack of smooth operation flow in the warehouse.

Other than the above causes As per the respondents they believe below points caused operational failures;

Poor information visibility, Non-compliance on the agreed SOP, If the Identified Main pillars do not rotate to an agreed tact time, Communication failures and lack of competency, Inefficient use of resources, Unavailability to capture Real Time data, Lack of planning and communication, Inter process discontinuation,

When going through the causes, to reduce ware house performances and reason for operation failures can be summarised all the responds as “not maintain continues flow though out the operation”.

CHAPTER 5 – DISCUSSION

In this chapter, the findings of the analysis described in previous chapter are elaborated and discuss. This provides a rational and logical overview for all the analyses conducted and conclusions are provided in an appropriate manner.

5.1 Literature Survey

The concept of continuous flow is one of the key principles of Lean Management. Nevertheless, Lean and Lean six sigma concepts are used in apparel sector, continuous flow concept is not vastly applied in Sri Lankan apparel sector. Hence this kind of research can benefit to the Sri Lankan apparel sector.

The current trend of the world is towards quality, cost optimisation and on time delivery along with advanced technologies. It is important to focus on this kind of concept to minimise the inter process discontinuation. Through this concept, a huge amount of time can be saved. And also the quality of the service, on time dispatch and customer satisfaction can be improved.

5.2 Background Analysis

In this research, two different types of methods were used to collect data; operational data were gathered from apparel sector warehouse which is practice continuous flow concept and a questionnaire was distributed among 47 professionals and it was shared in LinkedIn and via email. Therefore the output can be regarded as unbiased and diversified. Operational data were gathered from a Sri Lankan leading third party logistic service providing company. The data were collected from operational records to ensure the validity and the reliability of the data. One month data were considered for all analysis. Discrete count data were used to analyse. Regression analysis method was used for the analytical part.

When gathering data from the questionnaire, professionals were focused in the apparel sector and the 3PL sector. When looking at the background of the respondents and the organizations, it is evident that almost all the respondents are having the knowledge and the experience in lean, lean six sigma concepts to accurately answer the questionnaire. Therefore, the accuracy and the reliability of the responses are assured, and the analysis is based on reliable information. So, the findings of the analysis can also be treated as a reliable output backed by proper information.

5.3 Findings and Discussion

Operational data were used to analyse about inter process relationships. Regression analysis was used to identify the inter process relationships and compared with operational KPIs. When analysing the Questionnaire, respondents were practising lean, lean six sigma, 5s concepts for warehouse activities. They were fluent about the internal, Customer specific and performance related KPIs. Their operation performances were held at good performance level and it indicates that they use continues flow concept to improve their warehouse performances. But when studying through the information flow and material flow separately, several gaps were identified in the implementation. To receive more benefits and to eliminate the operation failures and poor performances, they have to improve their material flow and information flow. Thus, inter process discontinuation could be eliminated and result in better performances.

According to the operational data output, within every 8 minutes one POLI is received to the warehouse. When studying the unloading performance for each bay, further opportunities in the 3 bays can be seen. According to the data analysis 180 POLIs can be unloaded within the working hours.

When considering the CCA operation, if Carton audit is increased by 100, the CCA output is increased by 77;

It follows the following equation

Y = 0.77X+25.52

IF CCA output = Y

CTN audit = X

According to the CCA offering process, 124 POLIs were offered for audit and 120 POLIs were completed per day. This operation was carried out in two audit rooms. CCA audit must be completed for one POLI within every four minutes. That means in every 8 minutes one room needs to complete one POLI.

Loading operation was based on client ERD. According to the descriptive statistics 102 POLIs were required to load per day (68,333 Pcs, 2900 Cartons). According to the regression formula, loading is followed under the below equation.

IF Loading POLI = Y

CCA output = X

Y = 0.59X+50.27

When # of CCA output increased by 100, loading output increased by 59

To achieve 102 POLIs for every 4.7 min, loading team needs to complete one POLI (660 pcs, 23 boxes)

When summarising all data;

Description	receiving	CCA Offering	CCA out put	Loading
Time per POLI per bay	8	7.741935484	8	4.705882
# of bay/ Rooms allocation	3	2	2	1
# of POLI per day	180	124	120	102

Table 5.1

POLIs received partially was completed in the warehouse and thereafter the remaining process is started. To perform the operation by optimizing resource, they need to create an uninterrupted operation flow known as “Continues flow”.

According to the questionnaire responses, information flow and material flow are implemented in all the companies. But there are more opportunities to further improvements. Also companies’ measure performance related KPIs and they believe that uninterrupted operational flow affected to higher performance in warehouse operations. Most respondents have mentioned inter process discontinuation and poor leadership as the main causes for operation failures and poor operational performance.

Figure 5.1 Value stream mapping use to identify the end to end material and the information flow. Below VSM clearly indicate how information flow and material flow impacted to continues flow.

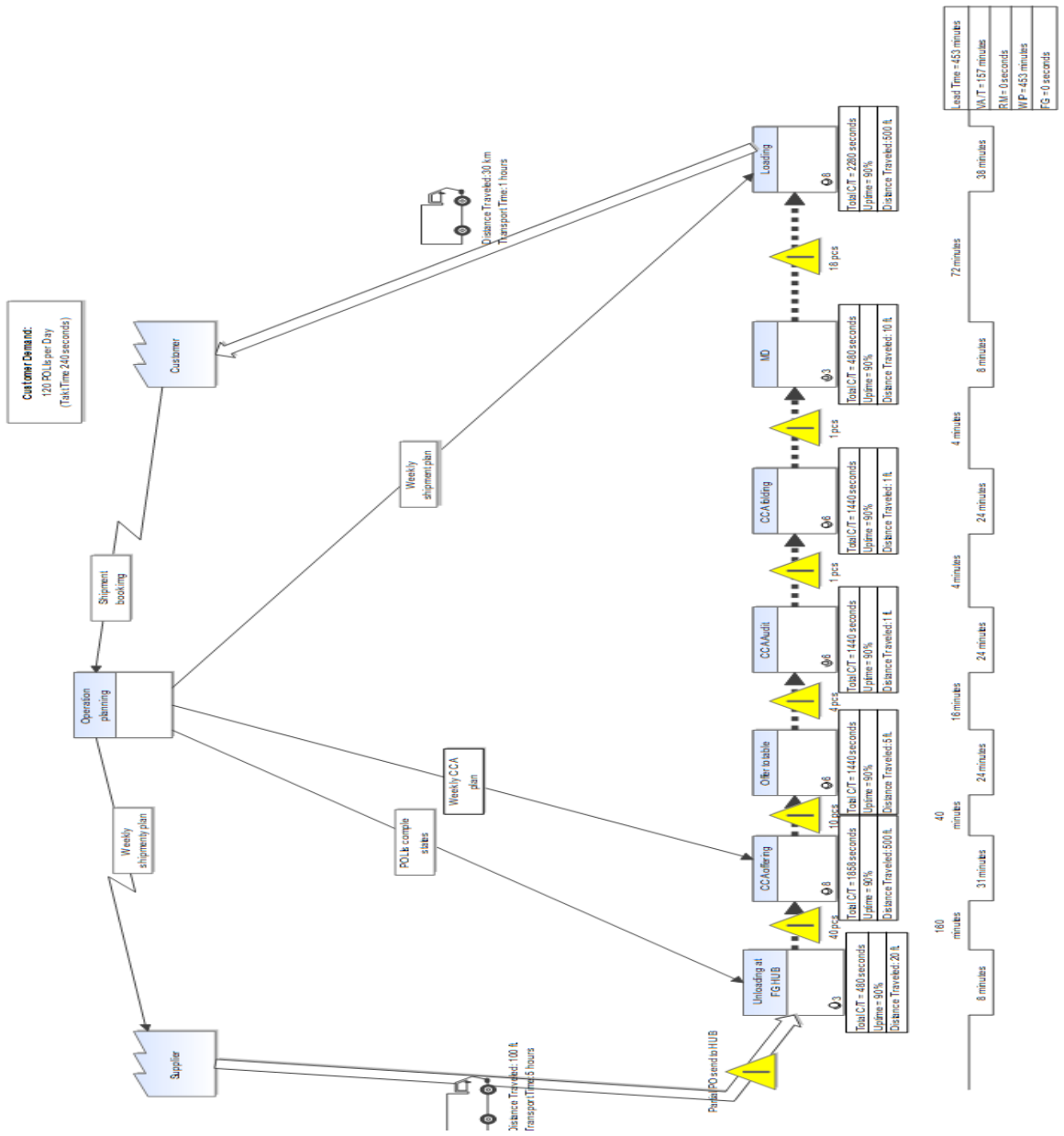


Figure 5-1 Value stream mapping for FG hub operation

According to the figure 5.1 (Unloading to Loading), 1037ft worth of steps are required to complete one POLI. This highlights the opportunity for improvement in the considered operation. Contradicting to Mulholland, examining the operation follow t there were several POLIs remaining at few points. It caused to increase the

process lead time. It shows there is further improvement opportunities in ‘future state’ mapping.

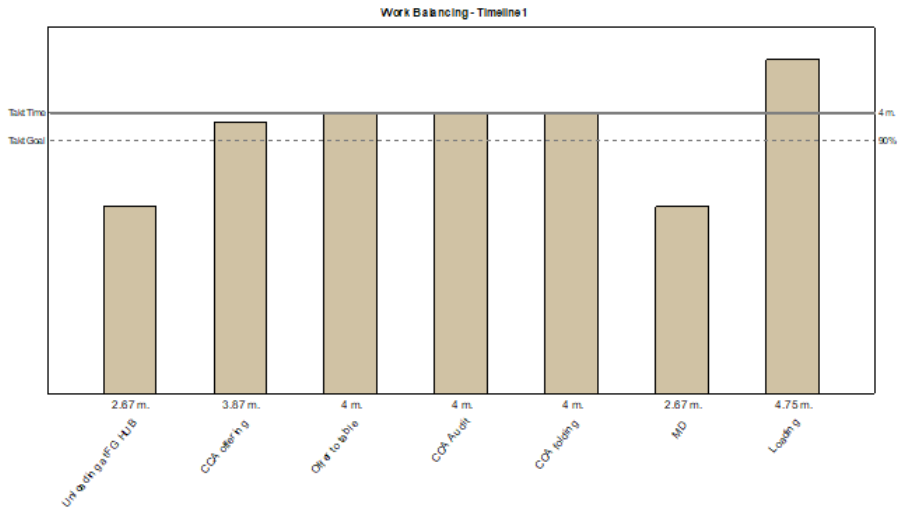


Figure 5-2 Yamasumi Chart (Workload balance graph)

According to Figure 5.2 workload balance chart clearly indicated operation process being aligned with the one piece flow concept. One POLI go through each process within 4 minutes. Final activity taken 4.75 minutes. Based on the chart by increasing two pickers, loading time could reduce to lower than the takt time. Work load balancing chart can use as a formula to improve output.

When we consider the operational data analysis of the FG hub operation .we can see the process of partial POLIs receiving to the hub then POLIs completed at the hub and then the completed goods offer to the CCA process and finally once after complete final audits (CCA) and the MD process, dispatching is done based on weekly shipment plan.

In this case 277 partial POLIs received per day and 100 POLIs completed per day. Same time 50% of the completed POLIs dispatched same week so inter process connectivity highly impact to maintain uninterrupted operational process.

In CCA operation 125 POLIs offer to audit and sample unwrapped for 124 POLIs and final audit complete 120 POLIs per day. Based on those data we can conclude mentioned CCA operation flows according to the one piece flow concept to achieve continues flow in total operation.

When we consider the relationship between the Cartoon audit and the CCA output, we could interpret it as;

Y= 0.77X+25.52, Y- CCA output, X- # of CTN audits

It clearly show when CTN audit increase by 100, CCA output increase by 77 POLIs per day. When we consider the relationship between loading and the CCA output, we can interpret as Y= 0.59X+50.27, Y-Loading POLIs p/d, X- CCA output p/d.

It shows that when CCA output increases by 100 POLIs loading output increased by 59 POLIs. It clearly interprets the relationship between the two variables. Similarly it shows loading activity depends on other causes i.e. previous week CCA passed POLIs, Shipment dates and ERD advancements.

When considered the Yamisumi chart and the value steam map (VSM), we can clearly see how work load balanced throughout the entire operation. It is a key evidence to the FG hub operation performing with optimum resources and delivering results. Based on the graph only 4 min taken to dispatch one POLI and all the process in line with 4min or less than 4 min. That interprets the impact of continues flow to deliver operational performances. Every 4 min each POLIs go through each process. Finally one POLIs always enter to process and out from the process. This proves the assistance provided by the one piece flow leading to an uninterrupted work flow. Finally this research conclude one piece flow's impact to improve continues flow and finally continues flow results in improving operational performances.

CHAPTER 6 – CONCLUSION

The research was carried out focusing on the objective of "how continuous flow impact on operational performance in apparel sector warehouse operation in Sri Lanka" which was addressed through four research questions. At the end of the study, the research objectives was accomplished and successful results were obtained. According to the questionnaire, information visibility was played a wide role to ensure apparel sector operational performances. Uninterrupted informational flow has given a high impact on operational performances.

To ensure uninterrupted material flow, the most of respondents focuses on loading accuracy. But good receiving accuracy, put way accuracy, picking accuracy, unloading time, put away time, picking time are highly impact on performances.

Based on the responses, the lowest rate can be seen for impact of one peace flow on performance. Respondents believe that the warehouse design, racking layout, operating equipment are directly impact on operational performances. Whether they have given a high rate for inter process connection impact on the operational performances, they do not identify how to build inter process connection. It was interpreted by giving low rate to "one at a time concept impact on improving performance" statement. When analysing responses about relationship between continues flow and the performances, all respondent's ratting are in 85% to 95% range. It indicates that the continuous flow is caused to improve the operational performances in apparel sector 3PL operations.

Summary of the material flow, information flow, operational performances based on KPIs are as follows;

Description	rating
How information flow implemented	3.79
Effectiveness of the material flow on the warehouse operation	3.89
Operation performance based on KPIs	3.16
Relationship between the continues flow and the performances	4.44

Table 6.1

In additional to that, reasons for operation failures, lack of performances were identified through the questionnaire. It clearly interprets that poor leadership, discontinuation of internal process, information visibility issues impact on operational failures and poor performances. Which is a result of interrupted continuous flow.

Most of the Sri Lankan companies are trying to move into technological approaches, lean management systems, and six sigma management concepts. But most of the companies are fail in 3PL due to not following principals of the concepts, lack of support from top management, lack of commitment from employees and organisation culture issues.

6.1 Recommendations for future research

This research is limited to apparel sector warehouse operations. It can be continued throughout the all industries. This can be extended to develop a model at all the industries.

The research was based on both qualitative and the quantitative data due to limitations of the information. If this could be done using exact quantitative data it will be really benefited to the industry.

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