SUPPLY CHAIN MAPPING OF APPAREL EXPORT FROM BANGLADESH TO THE USA MARKET – A CASE STUDY FROM BUYER'S PERSPECTIVE

by

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DEPARTMENT OF INDUSTRIAL AND PRODUCTION ENGINEERING (IPE)
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY (BUET)

August 2018

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A project submitted to the Department of Industrial & Production Engineering, Bangladesh University of Engineering and Technology, in the partial fulfillment requirements for the degree of Masters of Engineering in Advanced Engineering Management

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CERTIFICATE OF APPROVAL

The project titled "SUPPLY CHAIN MAPPING OF APPAREL EXPORT FROM BANGLADESH TO THE USA MARKET – A CASE STUDY FROM BUYER'S PERSPECTIVE" submitted by Md. Abu Hasan, Roll No. 040808107P, Session April, 2008 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Master of Engineering in Advanced Engineering Management** on 13 August 2018.

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It is hereby declared that this project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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DEDICATION

To my wife, Marufa Hasan and son, Adi Hasan.

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I would like to express my sincere gratitude to my project supervisor, Dr. Abdullahil Azeem, Professor, Department of Industrial and Production Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka, for his continuous guidance and support on conducting this project work. Due to my job relocation in overseas, I almost lost hope on completing this project work. However, with the encouragement and support from my project supervisor through emails and long distance telephone calls I could submit this project report.

I am also thankful to my wife, Marufa Hasan for her unfailing support and encouragement to me to complete this project work.

ABSTRACT

Bangladesh remains an attractive source for global apparel manufacturing for past several years mainly due to its cheaper labor cost. Most of the worlds renowned apparel brands and retailers are highly dependent on Bangladesh as their one of the major supply base. On the other hand, apparel industry plays an extremely important role in Bangladesh's economy for export earning as well providing employment. However, long lead time is a major threat to Bangladesh's long term competitiveness as labor cost keep increasing, which will make Bangladesh less competitive in future compared with the competitors who benefit from relatively shorter lead-time due to various reason. This project work took a macro look at overall supply chain of the garments made in Bangladesh from a foreign buyer's perspective and explore opportunities for overall lead time reduction. This study used a tool named Supply Chain Value Stream Mapping (SCVSM) or Mapping the Extended Value Stream (EVSM). The result showed 27% potential lead time reduction opportunity for overall supply chain of apparel products made in Bangladesh for USA market. If implemented, both Bangladesh apparel industry and foreign apparel buyers can be benefited from it.

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INTRODUCTION

1.1 Introduction

Apparel industry in Bangladesh has become one most important economic pillars. Since early 1990's this sector is contributing with major portion of Bangladesh's export. Bangladesh exported around $28 billion worth of apparel products in 2016-2017 fiscal year which accounts for around 80% of its total exports (Export Promotion Bureau of Bangladesh, 2017). This thriving sector has contributed enormously to the country's development, creating jobs and generating foreign income, attracting foreign direct investment, triggering infrastructure projects and providing a host of other related business opportunities.

Apparel industry in Bangladesh specialized in high-volume, low-cost production of technically simple garments and utilizes the world's largest low-cost labor pool. With the blessing of cheaper labor cost, pressure for globalization of production based on location economies as well as the favorable treatment from developed countries, Bangladesh and some other countries gradually has become global player in RMG business (Nuruzzaman & Haque, 2009). At present Bangladesh is facing many challenges especially from ever increasing delivery and pricing pressure from US retailers. In the beginning of 1990s, the lead time was 120-150 days, but in 2007 it reduced to 90- 100 days. China requires only 30 days' lead time due to their strong backward linkage and export friendly management and policy support. It is 45-60 days for India and Pakistan. Therefore, it appears that RMG sector in Bangladesh won't be able to compete successfully in future in the international market due to unusually longer lead time (Nuruzzaman & Haque, 2009).

USA is the single largest destination country for Bangladesh's apparel export and a very important market. Beginning in early 1990s, a new form of retailing diffused across that major sector of United States Economy. This method of retailing- which a group of researchers based at 'Harvard Center for Textile and Apparel Research' dubbed as 'Lean Retailing'- fundamentally transforms how risk is borne among the distributors and suppliers of apparel products. Modern retailers no longer have warehouses full of products ready for the selling floor. Rather they have become 'lean retailers' owning the just the products on the selling floor. Thus, suppliers' warehouses and distribution centers act in many ways as virtual warehouses and distribution centers for the retailers. The sourcing decision for apparel manufacturers and suppliers for US market are daunting and far more complicated than commonly acknowledged. With expanding global trade, there are more potential producers in a wider variety of countries. With consumers demanding more variety, more fashion, more product access and lower prices, pressure on suppliers to search for new sources will only increase. Modern retailers place greater risk arising from added variability of product demand further up the supply chain, forcing suppliers to balance the direct cost of sourcing against the consequence of indirect consequences of being left 'holding the bag' of inventory. For a manufacturer or sourcing agent seeking producers of apparel bounded to US, the sourcing decision may seem ambiguous when looking only at factor cost. The preferred producer for the product does not surface until the impact of the proximity is taken in account by determining work-in process inventory, finished goods inventory costs, as well as inventory at risk. (Weil, 2006) . 'Lead Time' is the main variable for above mentioned impact of proximity. Lead time has become far more important as a competitive factor for many of the products provided by apparel suppliers in a world of lean retail distribution (Abernathy, Dunlop, Hammond, & Weil, 2002).

The case company of this study, Sunrise Inc., (pseudonym) is one of the world's largest apparel company based in USA, is importing over $500 million worth of apparel products from Bangladesh. This company owns multiple brands, have their own retail store around the world, as well as having significant wholesale business with some of the retail giants in USA. This company is closely working with their manufacturers in Bangladesh and fabric mills on production capacity management and overall lead time reduction to speed up to the fiercely competitive US market.

This project study took a case study approach to map overall supply chain of apparel product export to USA market from an American buyer's perspective. To achieve this objective, this project study used a Supply Chain mapping tool named Extended Value Stream Mapping (EVSM) to assess total lead time for overall supply chain for Sunrise

Inc. apparel sourcing from Bangladesh and ship to their retail store. EVSM tool is based on lean manufacturing principles and look at all the activities within the supply chain as value added and non-value added level from end customer's point of view (Jones & Womack, 2002). This study also developed future and ideal states of supply chain map showing potential improvements by following the guidelines of EVSM.

1.2 Rationale of The Study

In a recent study by global consulting firm *McKinsey* surveyed Chief Purchasing Officer (CPO) of 63 global apparel brands. The survey result reveal that 54% of CPO thinks proximity sourcing is becoming more important than before which is driven by shorter lead time and agility in supply chain (McKinsey&Company, 2017). It implies that future success of apparel brands and manufactures will largely depend on their ability for 'speed to the market'. This is the area Bangladesh apparel industry is lacking mostly, due to its depended on foreign mills for fabric supply specially for woven sector. However, Bangladeshi apparel manufacturers has little to do with this fabric lead time since mills are nominated by the foreign buyers like Sunrise Inc. For this reason, it requires a study from brand's overall apparel supply chain perspective where Bangladeshi manufactures are just a part of it

The long lead time challenge Bangladeshi apparel manufacturers and foreign buyers facing today in Bangladesh can be addressed with systematic approaches. There are academic tools available like EVSM to address this kind of problem. Automobile industry has been quite successful with the use of EVSM and other lean manufacturing tools. With EVSM study, it can give the apparel brand an invaluable insight of their current state of overall supply chain in lead time perspective and shows future state considering potential improvement opportunities.

If total lead time for apparel brands is reduced for product sourcing from Bangladesh to end customers it will be a wining situation for both Bangladesh and foreign buyers including this case company.

1.3 Background of This Project

In the currently available literatures about lead time in apparel industry is seen from different tier of supplier's perspective, for example lead time for Bangladesh manufacturers is about 90 – 120 days (Nuruzzaman & Haque, 2009) or fabric manufacturing lead time is about 48.8 days (Hodge, Ross, Joines, & Thoney, 2011). These studies are missing a link in global apparel supply chain point of view which is the apparel brand who meddles between fabric manufacturer and apparel manufacturers and have some more activities in brand's distribution centers before reaching to retail. Most cases big apparel brands like Sunrise Inc. book fabric earlier with financial guarantee at the mills that helps apparel manufacturers to procure the fabric in shorter than true lead time. Looking at lead time in tier level miss an opportunity for collaboration among different tiers of supply chain and improve overall supply chain lead time in end customers point of view.

This project work tried to have a macro level look in overall supply chain activities to make an apparel product in Bangladesh and distribute to retail / end customers, and find total lead time in retail point of view and find potential opportunities to improve.

1.4 Problem Statement

The American apparel brand and retailer Sunrise Inc. is placing about 50% of their global order in Bangladeshi factories due their very competitive price and service. Based on this company internal data, about 95% of those products are made of woven fabric. Bangladesh is now pretty much self-dependent on their knit fabric supply with currently supplying about 90% of their domestic needs. However, situation in woven fabric sector is completely opposite. For the case of Sunrise Inc., only 7% of their total fabric needs for Bangladesh production is from Bangladeshi mills. About 70% of their fabric comes from China. All those fabric suppliers and nominated by Sunrise Inc. so, the Bangladeshi apparel manufacturer has little to do with it other than following the instruction from their customer. Thus, importing fabric from a 3rd country significantly add more time in total lead time for Bangladesh production.

On the other hand, Sunrise Inc. is facing tremendous pressure from market about reducing this long lead time. While Bangladesh apparel manufacturer has a little to do with long lead time associated to fabric procurement, there long manufacturing lead time (currently over 30 days) also worth to be investigated. Beside transportation time, there might be significant opportunities to improve in fabric mill's manufacturing lead time as well. Some internal work flow within buyer company such as sample approval also responsible for long lead time (Nuruzzaman & Haque, 2009). There is also a significant time spent on Sunrise Inc.'s Distribution Center (DC) for Value Added Service (VAS) such as adding hangers, packing assortments on finished goods and more pressure in their overall long total lead time.

This study dealt with the long lead time problems in different segment of the apparel supply chain and integrate them together to have a macro level view from Sunrise Inc.'s perspective.

1.5 Objective of The Study

The specific objectives of this project work are:

1. To map the existing global supply chain of an American apparel brand for importing products from Bangladesh to USA market.
2. To map a future state of their supply chain identifying ideas to eliminate non-value added times for potential opportunity to reduce the lead time.

The outcome of this project work showed some potential opportunities for an improved supply chain process which can yield shorter total lead time compared to existing lead time for the company's product sourcing from Bangladesh to USA market.

1.6 Methodology

To achieve above objectives, the author took a lean manufacturing approach named Extended Value Stream Mapping (Jones & Womack, 2002) which has been described as a tool of Supply Chain mapping by (Miyake, Torres Jr, & Favaro, 2010). The extended value stream mapping problem has been dealt in 3 sub categories. Sub-category one involved with tier 2 supplier which is fabric mills current state mapping; sub-category 2 involves with tier-1 supplier which is apparel manufacturers current state mapping; and sub-category 3 deals with Sunrise Inc.'s distribution center current state mapping. All those sub-categories current state mapping has been compressed into extended value stream mapping (current state) with transportation links. With possible improvement within the boundary of lean manufacturing principles a future state has been developed for extended value stream map. This study also aims to develop an ideal state of overall supply chain with the principles set up in Extended Value Stream mapping approach (Jones & Womack, 2002).

Below method has been followed for overall data collection and analysis:

I. Walked through various process of the supply chain and observe high level processing times, identify value and non-value activities and times

II. Collected standard lead times from apparel manufacturer and suppliers SOP for the lead time of backward linkage items, accessories etc.

III. Semi structured interview conducted with some key personnel in various department to get their inputs in case of standard lead time is not available in SOPs

IV. Collected current standard operating lead times for various activities for this company from their SOPs and tracking reports for secondary data

V. Analyzed the collected data

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter aims to have a review published works related to different aspect of this project work which includes: Supply Chain Mapping tools, Global Apparel Supply Chain, Bangladesh Apparel Industry context, Lean Manufacturing and Lean Supply Chain.

2.2 Supply Chain Mapping

Extensive academic works is available on single plant level material and information flow mapping such as Value Stream Mapping (VSM) (Rother & Shook, Learning to See, 1999) but a limited academic work is found on supply chain level mapping. However, discussions on supply chain mapping cases are found in academic works which brought to light the applicability and potential benefits of such a method (Hines & Rich, 1997) and (Naim, Childerhouse, Disney, & Towill, 2002).

(Hines & Rich, 1997) proposed a simplified value stream analysis tool (VALSAT) which allows users to choose most appropriate one among seven value stream mapping tools to identify and reduce or eliminate waste in the context of extended value stream. A quick scan methodology (QSM) is proposed by (Naim, Childerhouse, Disney, & Towill, 2002). Their model is based on the idea of assessing uncertainty in the product delivery process and reducing it. The authors of that article suggested that, QSM can be an initial step in a generic methodology to identify change management opportunities in the supply chain.

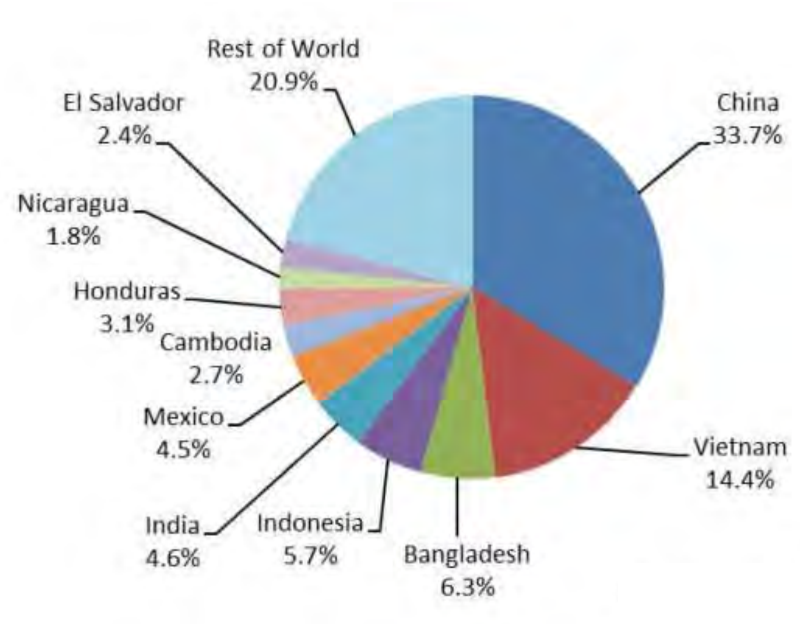
A book titled *Seeing the Whole* (Jones & Womack, 2002) published in 2002 seems took plant level Value Stream Mapping to the next level and covering entire supply chain mapping in a Lean Manufacturing perspective.

(Miyake, Torres Jr, & Favaro, 2010) defined Supply Chain map as below, ‘A supply chain map result from the collection of different kinds of data (e.g. demand, customer-supplier links, capacity, inventories, travel distances, lead times) and provides a holistic view that no one person has ever caught in its entirety. The mode of organizing and exhibiting the information gathered in a supply chain mapping exercise varies depending on the method adopted. In most plain forms, a supply chain map may resemble a tree diagram or a network graph in which a node represents a function, division, plant, firm or even an industry depending on the level of aggregation, and the links represent the supply relations among them. A similar mode is the exhibition in a form that resembles a high-level block diagram or process map in which the building blocks contain specific processes, macro-processes, facilities, or firms. Depending on the form of supply chain map, different types of flow are considered: (a) customer orders or sales forecasts transmitted upstream the SC, (b) materials flowing downstream from raw materials to customer, (c) return channels and feedback loops. For a more sophisticated form of visual display, supply chain maps can be based on richer graphic conventions that consider a set of pictorial icons instead of nodes or blocks, and a set of line styles to specify the nature of functional links or flows between the mapped entities. The maps obtained from VSM (Rother & Shook, Learning to See, 1999) and Extended Value Stream Mapping (EVSM) (Jones & Womack, 2002) methods are typical examples of this form'.

Even though there are few other supply chain mapping tools found, EVSM suits better for this study as it is based on Lean Manufacturing principles and drives toward lead time reduction. More elaboration of EVSM method is available on Chapter 4.

2.3 Global Apparel Supply Chain

Total retail value of global apparel products is 1.7 trillion US Dollar which employed 57.8 million people globally in manufacturing in 2014 (FashionUnited, 2018). In terms of import value in 2017 USA market imported 80.7 billion US Dollar worth of apparel products from global sources and among them 6.3% was from Bangladesh (Sourcing Journal Research, 2018).



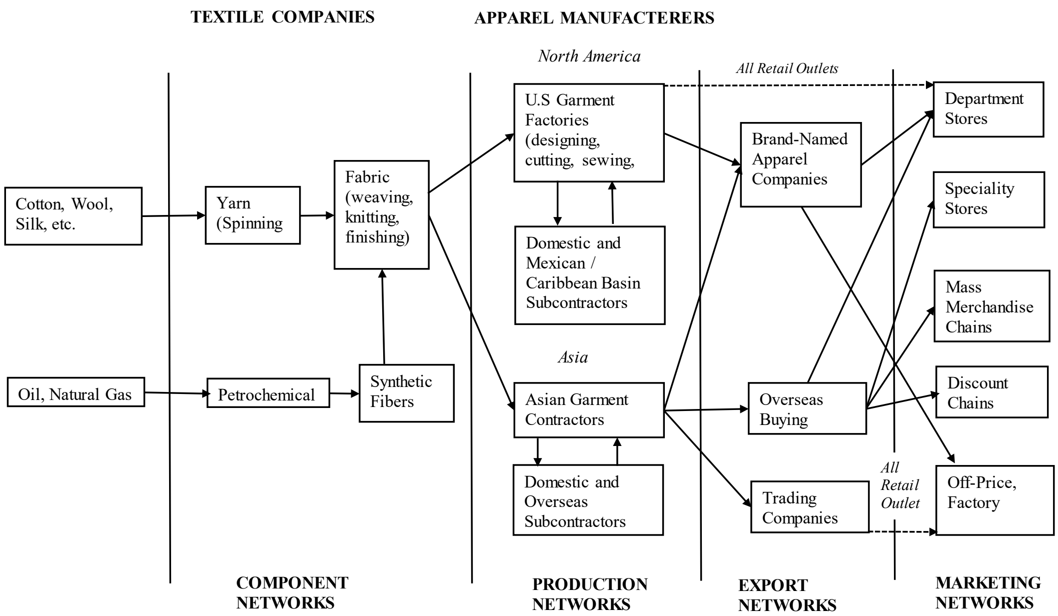
(Sourcing Journal Research, 2018) based on OTEXA data

Figure 2-1: USA apparel import by country of origin – FY 2017

Apparel industry is an ideal example of buyer-driven value chain (Gereffi & Memedovic, 2003). A notable feature of buyer-driven chains has been the creation since mid-1970s of prominent marketers with well-known brands which carry no production. They include companies like Liz Claiborne, Nike and Reebok (Gereffi & Memedovic, 2003). This is the reason why big apparel brands ever searching for new sourcing destination to compete in market.

Global brands and retailers determine what is to be produced, where, by whom, and at what price. In most cases, these lead firms outsource manufacturing to a global network of contract manufacturers in developing countries that offer the most competitive rates. Lead firms include retailers and brand owners and are typically headquartered in the leading markets—Europe, Japan, and the United States. These firms tend to perform the most valuable activities in the apparel value chain—design, branding, and marketing of products— and in most cases, they outsource the manufacturing process to a global network of suppliers.

The apparel value chain constitutes of five main segments: (1) raw material supply, including: natural and synthetic fibers; (2) provision of components, such as the yarns and fabrics manufactured by textile companies; (3) production networks made up of garment factories, including their domestic and overseas subcontractors; (4) export channels established by trade intermediaries; and (5) marketing networks at the retail level (See Figure below). Over time, there have been continual shifts in the location of both the most significant apparel exporting countries and regions, as well as their main end markets (Gereffi & Memedovic, 2003)



(Gereffi & Memedovic, 2003)

Figure 2-2: The apparel value chain

In a journal article (Sen, 2008) explains about apparel supply chain specific to USA market. A typical supply chain in the apparel industry includes 4 main sectors: fiber and yarn production, fabric production, apparel production and retail operations (Sen, 2008).

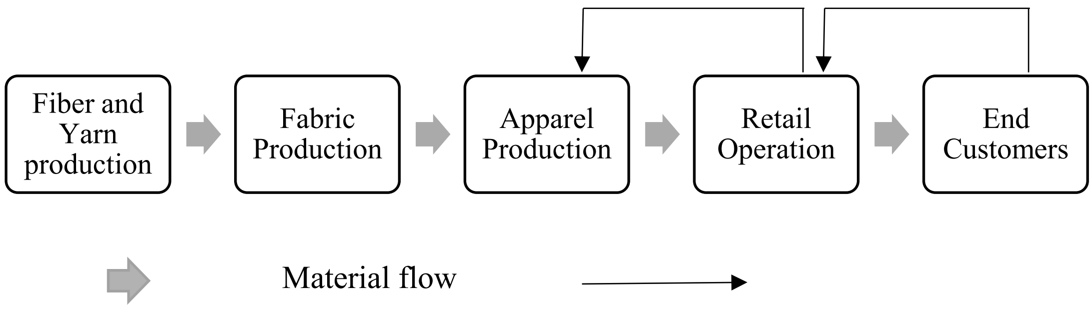


Figure 2-3:A typical supply chain in apparel industry

The apparel manufacturing requires lots of labors and therefore is often outsourced to manufacturers overseas, to developing countries with lower wages to achieve lower total costs (Şen, 2008). Yarn and Fabric is still coming from Cotton grower or other industrialized countries like USA, Taiwan, China, India and Pakistan due to its relatively low labor components. Most often the apparel manufacturer country has a lack of domestic supply of yarn and fabric. This requires the apparel manufacturers to import fabric from a 3rd country. All those geographical distances among the value chain, make the lead time very long and difficult to control. This makes the apparel industry supply chain a very complex one.

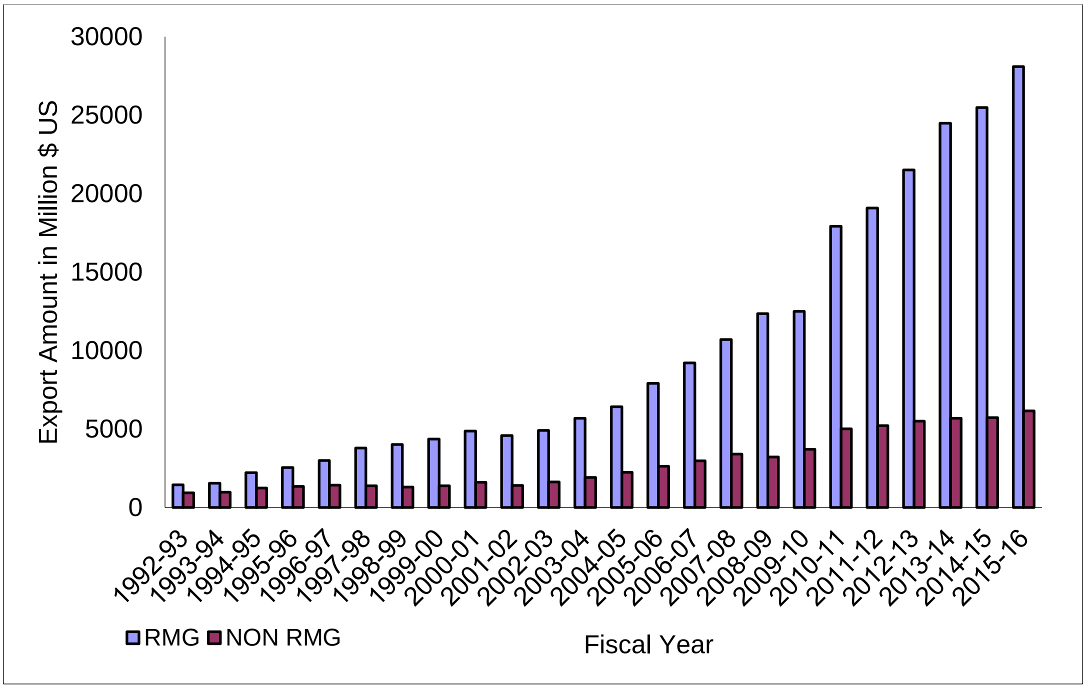
2.4 Apparel Supply Chain Bangladesh Context

Bangladesh is the 2nd largest apparel exporter in the world after China, both in terms of product units as well as product value (FOB) (Barrett, Baumann-Pauly, & Gu, 2018) and employs 5.1 million people and among them 56% are female (Labowitz & Baumann-Pauly, 2015). It seems quite difficult to find out total number of garment factories in Bangladesh. Some researchers from NYC University (Labowitz & Baumann-Pauly, 2015) estimated around 7,000 factories among them 3,800 direct exporters and rest are suppliers to those direct suppliers. This 7,000 number has been contested by some researchers from Pennsylvania State University saying their figures is 4,000 – 5,000 (Barrett, Baumann-Pauly, & Gu, 2018). Even though the lower estimates are true, still it is a massive number of apparel factories hosted in Bangladesh. These factories are mostly situated around big cities like Dhaka, Narayangonj and Chittagong.

During Fiscal Year 2016-2017 Bangladesh exported US $ 28 billion worth of apparel product among them Woven and Knitwear products ratio almost 50:50. (BKMEA, 2018). As a single destination country of Bangladesh's apparel export, USA is still the largest market for Bangladesh, mainly for woven products (BKMEA, 2018). Since the beginning of Bangladesh's export oriented apparel industry, this country is enjoying consistent growth despite many challenges. The following table and graph from Export Promotion Bureau of Bangladesh (EPB) showed this growth of Ready Made Garments (RMG) export compared to non-RMG.

Table 2-1: Bangladesh Export of RMG and Non-RMG

FISCAL YEAR	Export Amount in Million $ US		
	RMG	NON RMG	TOTAL
1992-93	1,445	938	2,383
1993-94	1,556	978	2,534
1994-95	2,228	1,244	3,473
1995-96	2,547	1,335	3,882
1996-97	3,001	1,417	4,418
1997-98	3,784	1,378	5,161
1998-99	4,020	1,293	5,313
1999-00	4,352	1,392	5,744
2000-01	4,861	1,607	6,467
2001-02	4,584	1,402	5,986
2002-03	4,912	1,636	6,548
2003-04	5,686	1,917	7,603
2004-05	6,418	2,237	8,655
2005-06	7,901	2,625	10,526
2006-07	9,211	2,967	12,178
2007-08	10,700	3,411	14,111
2008-09	12,348	3,217	15,565
2009-10	12,497	3,708	16,205
2010-11	17,914	5,014	22,928
2011-12	19,090	5,212	24,302
2012-13	21,516	5,512	27,027
2013-14	24,492	5,695	30,187
2014-15	25,491	5,718	31,209
2015-16	28,094	6,163	34,257



(Export Promotion Bureau of Bangladesh, 2017)

Figure 2-4: Bangladesh RMG and non RMG export growth over the years

The production processes of textile-clothing firms in Bangladesh mainly fall into three types: 1) vertically integrated, i.e., they buy fiber and then process the fiber into finished apparel; 2) semi-vertically integrated, i.e., they buy yarn and then convert the yarn into finished clothing; and 3) horizontally integrated, i.e., they buy fabric and then convert fabric into finished clothing (Masum, 2016).

Local firms mostly get contracts from Western brand retailers based on low-cost and high lead-time considerations. Sen (2008) stated that Western retailers and buyers choose Far East contractors for high lead-time (90 days or more) contracts. Bangladesh specializes in high-volume, low-cost production of technically simple garments and utilizes the world’s largest low-cost labor pool, which allows subcontracting from lead contractors to complete orders on time at a lower price per unit than lead contractors (Labowitz & Baumann-Pauly, 2015). “The activities of textile-clothing firms in Bangladesh do not begin with demand forecasting based on information from the point of sales or research office. Demand comes either from the brand retailers directly or the agents or franchisees. Foreign firms represent 75% of the agents or franchisees, known as intermediaries. These intermediaries earn a commission ranging from 1% to 4% from the export proceeds upon successful negotiation and finalization of contract performance. Therefore, firms in Bangladesh are not forecast-driven, because the retailers and distributors are the ones who perform the demand forecasting and play the key role" (Masum, 2016).

Biggest challenges the Bangladesh apparel manufacturers are facing today are to meet delivery expectation and price pressure from foreign buyers. Supply Chain planning in apparel manufacturing and sourcing is quite complex with numerous factors contributing towards it. One, garments are highly seasonal product, every season there plenty of new styles (items). This makes demand forecasting more challenging given that relevant demand is not available. Second, each style has sizes, dimensions, color, fabric attributes, finishing attributes that leads to numerous SKUs for single style. That demands to deal with huge amount of styles and SKUs in planning and operations. Third, supply chain of medium to large players in this industry are truly global wherein sourcing of fabrics and trims are done from many different countries (mostly China, Taiwan, India, Pakistan etc.) and manufactured in different countries (like Bangladesh, China, Cambodia, Vietnam etc.) and products are sold to big markets in America, Europe, Japan etc. Fourth, overall demand and supply lead time here is one of the longest compared to any other discrete commodity goods. Fifth, apparel makers are here actually in business of selling their factory capacities and not selling apparel. Production capacity management is thus a key in meeting buyer's expectation on delivery and price (Tanksale, 2010)

Bangladesh's apparel products are based on two types of fabric. 1) Woven fabric 2) Knit fabric. Knitwear sector is pretty much self-dependent with 90% of its fabric coming from domestic supply base (Asgari & Hoque, 2013). However, the scenario is completely opposite for woven sector. Only 14-15% of total demand of woven fabric at Bangladesh apparel manufactures are coming from domestic supply (Sohel, 2017). Woven fabrics in Bangladesh mostly coming from China, Pakistan and India. Long lead time to procure woven fabric for Bangladeshi apparel manufacturers is one of the major reason for very long lead time in total apparel supply chain. This factor is one of the major weakness in global competitiveness for Bangladesh apparel industry.

An analysis in a journal article (Asgari & Hoque, 2013) showed that lead time reduction increase competitiveness of Bangladesh apparel industry as well as increase sales. It seems there a big opportunity for Bangladesh in woven sector to speed up on lead time game and capture additional global market share.

2.5 Lean Manufacturing

Lean Manufacturing has been practiced by Toyota since the 1950s, the widespread study of lean started in the early 1990s with the publication of *The Machine that Changed the World* (Womack, Jones, & Roos, The Machine That Changed The World, 1990). That book surveyed the global automotive industry and compared global efficiencies and trends. It documented the fact that some Japanese manufacturers were applying fundamentally different concepts in their approach to vehicle development and manufacturing. Ultimately, *The Machine that Changed the World* came to represent something of an awakening for the North American auto industry. Womack and his research team at MIT in the early 1990's employed the term "lean" to describe this business model pioneered by Toyota. Since then, interest in lean manufacturing has resulted in a steady stream of books, articles, and seminars on the topic, all explaining the Toyota Production System (Womack J. , 2007).

Beginning in late 90's to 1st decade of this century a wide spread of industries like banking, airlines, hospitals, restaurants, asset management etc., applied lean manufacturing principles (Duncan & Ritter, 2014). Evidence also found for partial use of lean manufacturing principles in American textile industries ((Hodge, Ross, Joines, & Thoney, 2011).

Lean has gained acceptance in the North American manufacturing community, even though widespread implementation of lean is still a work in progress. Essentially, lean manufacturing seeks to produce a product that is exactly what the customer wants, when the customer wants it, while minimizing all non-value added activities in production (Womack & Jones, Lean Consumptions, 2005). In the literature, value is simply defined as what the customer is willing to pay for. Non-value added activities are generally understood to be either waste, or incidental activities that are necessary but add no value to the product. The best example of a non-value added activity is quality assurance.

Quality inspections do not add value to a product; they merely detect defects before they reach the consumer.

2.6 Ford's Contributions to Lean Manufacturing

The history of Lean manufacturing truly begins with Ford and his ground-breaking automobile manufacturing company in the early 20th century. Students of Lean history typically begin with the Ford manufacturing plant in Highland Park, Mich., in 1913. Lean manufacturing is modeled mainly after the Toyota Production System. However, even Toyota borrowed some concepts from Henry Ford ((Womack, Jones, & Roos, The Machine That Changed The World, 1990). Although Ford is known as the inventor of mass production, he also originated the concept of continuous flow (he called it *flow production)* which is an important building block for lean production. His flow production concept was best exemplified by his car assembly line at Highland Park. In this line, vehicles traveled along a moving conveyor setting a constant pace for assembly operations. In order to feed the main line he had to organize feeder processes in a way that approximated cellular manufacturing, where components were assembled in areas of continuous flow. Toyota would later take note of these practices and integrate them into their own production philosophy.

Some of Ford's practices have even been described as approximating lean production within an emerging mass production system ((Womack, Jones, & Roos, The Machine That Changed The World, 1990). Ford's accomplishments were revolutionary for the times. Ford's mass production system increased productivity by fine-tuning the division of labor, decreasing capital expenses through large size batching, and infrequent changeover times. Standardized work practices were another major component of the success of the Ford system. Standardized work at Ford subscribed to the "one best way" philosophy pioneered by W. Taylor. Taylor took the responsibility for work procedures out of the hands of the operators and mandated that the industrial engineers would henceforth design the work. Here again Ford helped to lay the groundwork for a lean approach. Toyota would later adopt standardized work, but not as a static approach. Instead, at Toyota, standardized work involves continuously improving work procedures mainly with the help of the people on the assembly line ((Liker, 2004).

While Ford created techniques that led to Lean methodologies, the one area he did not account for was variation. His processes, while revolutionary, did not allow for the types of variations that modern businesses require. In short, he was great at making a Model T. But when people wanted something other than a Model T, there were challenges (Lopresti, 2017).

However, the Toyota Production System (TPS) took Ford's process a step further. Ohno and other company executives built upon Ford's ideas and made changes to the manufacturing process that allowed for more variation in the workflow without creating untenable inefficiencies (Lopresti, 2017).

2.7 The Beginnings of Lean Production

Mass production remained unchallenged until about the 1960s when a new production system, pioneered by Toyota, started to increase its market share at the expense of the American big three ((Womack, Jones, & Roos, The Machine That Changed The World, 1990). The post-war 1950s was a time of economic hardship in Japan characterized by limited access to capital funds and limitation of goods. The Toyota motor company, who had been put to work assembling military trucks by the Japanese wartime government, was now returning to its core business of manufacturing civilian vehicles. In a bid to study America's successful automotive industry, Eji Toyoda visited Ford's Rouge Plant in Detroit in 1950. What he saw there was impressive. Nevertheless, Eji Toyota was clever enough to understand that mass production was wholly unsuited for Japan's post war reality. Not only was Japan's car market smaller than America's, it was also more diverse in its needs. Furthermore, borrowing capital in the quantities necessary to finance a mass production operation would not have been possible as post-war Japan was cash strapped. Right from the start, Toyota's operating principles were forged in an environment marked by extreme scarcity.

Toyota recognized that to produce cars for its domestic market it would have to do more with less. It needed to take a radically different approach from what Eji Toyoda observed at Ford (Liker, 2004). Furthermore, Japan's economic situation along with Toyota's own cash flow problems were of such a magnitude that Toyota saw itself forced to ask for one quarter of its workers to retire. This move resulted in a strike that would eventually result in a deal where Toyota signed-up to secure employment for its remaining staff. Toyota would now have to devise a survival strategy that hinged on getting the most from its remaining resources: namely modest capital assets and a permanent work force.

2.8 Principles of Lean

The Lean Enterprise Institute lists five principles of lean philosophy (The Lean Enterprise Institute, 2008). These are:

- Specify value from the standpoint of the end customer by product family.
- Identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value.
- Make the value-creating steps occur in tight sequence so the product will flow smoothly toward the customer.
- As flow is introduced, let customers pull value from the next upstream activity.
- As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced, begin the process again and continue it until a state of perfection is reached in which perfect value is created with no waste

(The Lean Enterprise Institute, 2008)

Figure 2-4: The lean principles

2.9 The Objective of a Lean Production System

After the WWII, in war torn Japan, Toyota Automobile company faced crisis on cash flow which compelled them to send over 1,000 employees to voluntary retirement despite many genuine efforts to save those jobs. During time, Toyota made their all-out efforts to eliminate all types of waste to save cost. This lead to identify seven types of waste in Toyota Production System by Toyota plant manager and chief architect of Toyota Production System (TPS), Taiichi Ohno (Liker, 2004) (Dolcemascolo, 2006)

Below seven types of waste identified by TPS (Dolcemascolo, 2006) :

1. Overproduction: Producing more products than what is required at current time. Overproduction can be counted at each work station level as well.
2. Transportation: Material and products moving from person to person or between departments and between plants.
3. Unnecessary inventory: More inventory than required at current time. It includes unprocessed material, work in process and undelivered finished goods.
4. Inappropriate processing: Unnecessary work beyond what is required to meet customer requirements.
5. Waiting: Periods of inactivity while waiting for next process step to begin. Delays and interruptions are typical examples of 'Waiting' types waste.
6. Excess Motion: Excessive movement by people and machine.
7. Defects: Errors or gaps in meeting specifications that result in scrap or rework. Inaccurate or incomplete information.

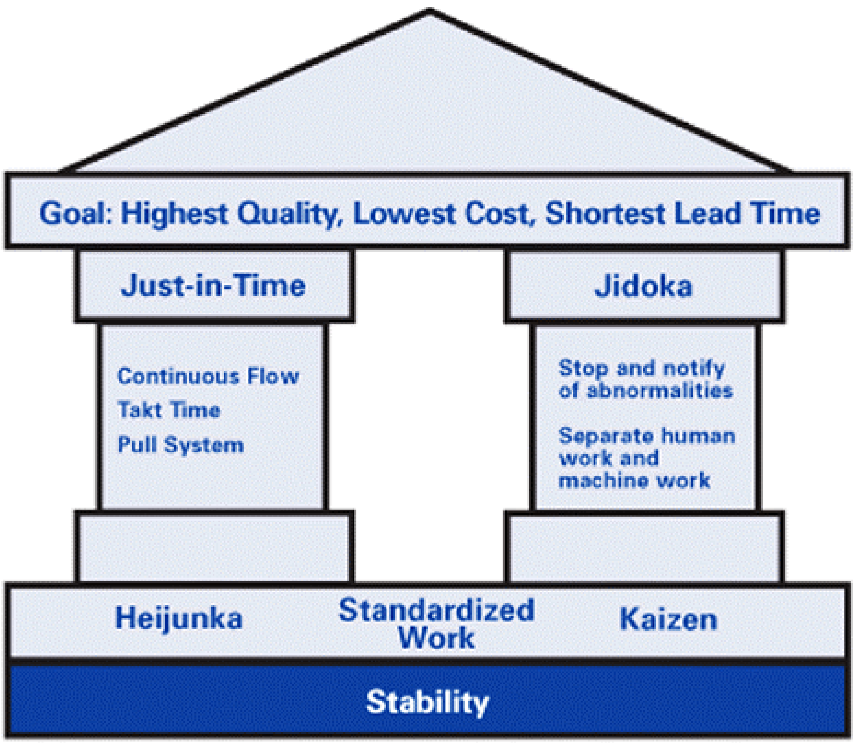
Some lean practitioners proposed to add the 8^{th} type of waste which is 'Underutilized People'. This is underutilized human capital.

2.10 The Elements of Lean Production System

The lean production system is also commonly known as Toyota Production System (TPS) as it originated at Toyota motor company. This can be illustrated with below figure in a model of house. The goal of TPS to provide best quality, lowest cost, and shortest lead time through the elimination of waste. The two pillars of TPS is 'Just in Time' and 'Jidoka'.

2.10.1 Just in time (JIT)

One of the main pillar of the Toyota Production System, Just-in-Time (JIT), came from Japanese observations of American supermarkets during the early visits of Taiichi Ohno in the year 1956 (Liker, 2004). The Japanese observed that supermarket shelves were easily replenished in the US. When the product was below a certain level, this would trigger restocking of the item. There was only enough stock on hand to supply to the immediate customers. The significance of JIT was that it was integrated into the Toyota Production System in the form of Kanban tools. These Kanban tools are the signaling apparatus that allows a pull system to exist (Jones & Womack, 2002). This is completely different from the mass production approach of having multiple orders sent simultaneously to multiple manufacturing locations in the production process. In a JIT operation, an upstream process only produces when a downstream is asking for a unit of production. This simpler and more efficient solution to satisfy demand is at the heart of pull production.



Toyota Production System "House."

The Lean Enterprise Institute

Figure 2-5: Toyota Production System "House"

JIT is basically based on the concept of total elimination of inventories or safety stocks during the production of the automobile. The same could not be possible without putting certain techniques and related philosophies into action. Here is the list of those elements that make this system run:

- Levelled Production
- Pull System
- Continuous Flow Processing
- Takt Time
- 5Ss (Sifting, Sorting, Sweeping, Spick-n-Span, and Sustenance)

2.10.2 Jidoka: the second pillar of the Toyota production system

Jidoka is a Japanese word which means, autonomation. This enables the process to stop automatically when a problem or defect is detected in the process. The fact is that Ohno was not starting from scratch in his quest to match Ford's productivity. In addition to being inspired by Ford's continuous flow invention, Ohno was drawing on the ideas of his Toyota predecessors. Most notably, Ohno would eventually integrate Jidoka as one of the pillars of the Toyota Production system. The concept of Jidoka, or automation with intelligence, was in fact pioneered by Sakichi Toyoda, Eji's uncle in the late 1800s when Toyoda was in the business of fabricating looms for the textile industry (Liker, 2004). This concept was a great technological leap as well as a philosophical tour - de-force. Essentially, when a thread broke in the weaving process, the loom was not allowed to go on producing defective material (waste). This became the original instance of Jidoka.

2.11 Lean Manufacturing to Lean Supply Chain

Lean started in manufacturing especially repetitive, assembly-line manufacturing, then gradually moved to other manufacturing processes, such as continuous flow (e.g., chemical, food and beverage) and, somewhat, to batch processing or job shop (smaller, often customer specific production). Most manufactures wanted to first ‘Lean Out’ within their ‘four walls’ before working heavily with customers and suppliers. So, in a way, it is natural evolution to move to the supply chain and logistics area (Myerson, 2012). One of the Lean tool that are mostly discussed in supply chain area is Extended Value Stream Mapping (EVSM). This tools has been discussed in next chapter.

2.12 Lean Supply Chain

The concept of ‘’lean’’ is originated and evolved in automobile manufacturing, especially at Toyota. Early researchers did focus their research on lean production rather than lean supply chain. In the beginning of 21th century, as the economic benefits of lean and pressure for other business competitors to spread lead throughout the supply chain show up, lean began to move to supply chain management (Myerson, 2012). Per (Liker, 2004) Just in Time (JIT) production is the most important pillar of ‘’lean house’’. How can enterprise achieve JIT production if the suppliers are not able to steady distribute the components in right quantity, right order at right time to the production function of the enterprise. Therefore, the suppliers should be encouraged to adopt JIT production and JIT delivery. JIT delivery from suppliers is critical when we want to keep the inventory level low in the entire supply chain to decrease inventory cost.

Lean supply chain also uses some other Lean Manufacturing tools like Kanban for inventory control, standardized work for to reach efficiently, Value Stream Mapping for lead time reduction. Value Stream Mapping expose the wastes which should be eliminated in the supply chain thus reduce lead time. Kaizen is applied in lean supply that as a lean enterprise we should be proactive to constantly analyze the efficiency of the internal and external functions, so that non-value adding activities could be detected and create base for improvements.

Lean supply chain management and lean sourcing strategies are relatively new to the apparel industry, generating more talk than broad implementation to date (McKee & Ross, 2005). An action guide was developed by (McKee & Ross, 2005) for lean supply chain implementation in apparel industry. Per these authors lean supply chain in apparel industry can bring below benefits:

- Improved time to market
- Reduced supply chain costs
- More pertinent and timely information about consumer demand
- Better and faster response to consumer requirements.

CHAPTER 3
EXTENDED VSM / SUPPLY CHAIN MAPPING

3.1 Introduction

A value stream is the set of all actions required (value added and non-valued added) to bring a product to the end customer starting from raw material. Value Stream Mapping is a systematic tool to map both material and information flow in a graphical representation. There are mainly two types of Value Stream Mapping tool available used based on their level of use.

1. Value Stream Mapping (VSM) – mainly used in a single plant level mapping
2. Extended Value Stream Mapping (EVSM) – this is done on multiple plants or across company level.

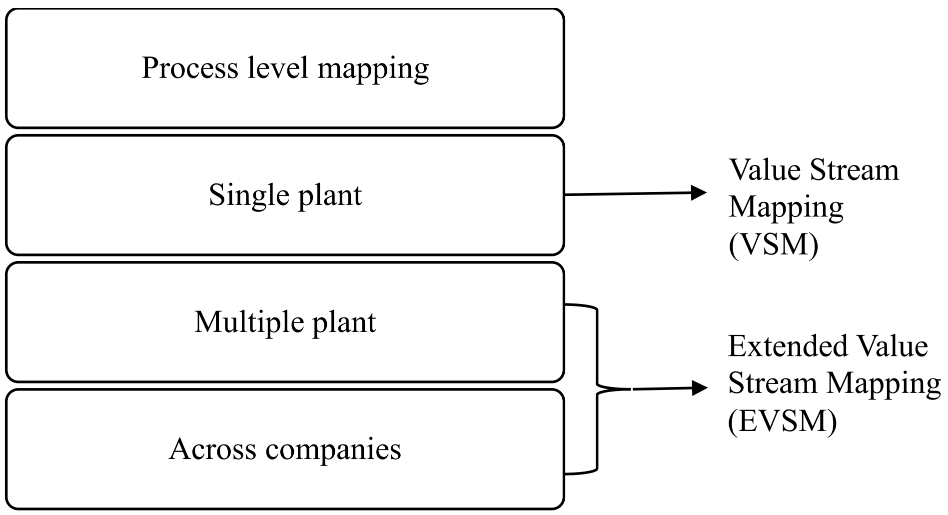


Figure 3-1: Types and Level of Value Stream Mapping

3.2 Single Plant Value Stream Mapping (VSM)

Value Stream Mapping involves mapping product and information flow in a given value stream. The mapping is done in a way that helps one to see the current state of the value stream and plan for a future state with improvements. The key goal for a value stream mapping is to reduce lead time (Dolcemascolo, 2006)

Value Stream Mapping (VSM) was introduced first by Mike Rother and John Shook in 1999 in a book titled *Learning to See.* Even though Mike Rother and John Shook coined the term VSM, but it was known in Toyota as Material and Information Flow diagram (Rother & Shook, Learning to See, 1999). In configuring value stream maps, Rother and Shook intended to capture process information, materials flow, and information flow for a given product family. Although value stream maps were developed within the context of the automotive industry, they have become popular in other fields such as health care and the service sector.

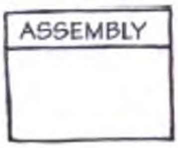
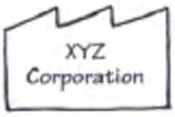
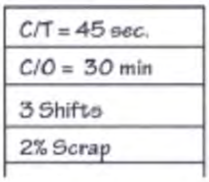
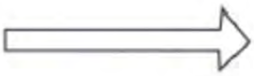
The value stream mapping process begins with a map of the current state. The current state should faithfully depict the operations as they are happening now (Rother & Shook, Learning to See, 1999). Both value and non-value added steps are shown in, a value stream map. Information flows also appear and are considered just as important as material flows. Icons are used to depict processes, material flows, and information flows. In addition, part accumulations in the form of WIP, inventories, and safety stocks also appear in the value stream. Special arrows are used to depict "pull" or "push" production. In addition to icons, value stream maps also record lean metrics inside data boxes located beneath process icons. Data boxes typically include cycle times, changeover times, and travel distances. The types of metrics used to populate the data boxes are chosen per the specifics of the value stream being mapped and the industry under consideration. In general, a timeline is also plotted along the bottom of the value stream to track metrics used for cumulative quantities such as total lead time, total travel distance, and total value added time. These cumulative quantities help to characterize the value stream and serve as a baseline for later comparison.

The power of VSM is that, it can quickly enable the management to target right areas for the process Kaizen, track and implement the improvement (Dolcemascolo, 2006)

Once the current state value stream map has been drawn, improvement opportunities can now be identified in a visual manner in conjunction with an assessment of the metrics. With respect to improving the current state value stream, (Rother & Shook, Learning to See, 1999) take the view that the main objective in a lean enterprise is simply for any process to only make what the next downstream process requires, within the sho11est lead-time, at the highest quality, and at the lowest cost. To attain this, lean objective, they identified the following lean principles for achieving a lean future state value stream map (Rother & Shook, Learning to See, 1999)

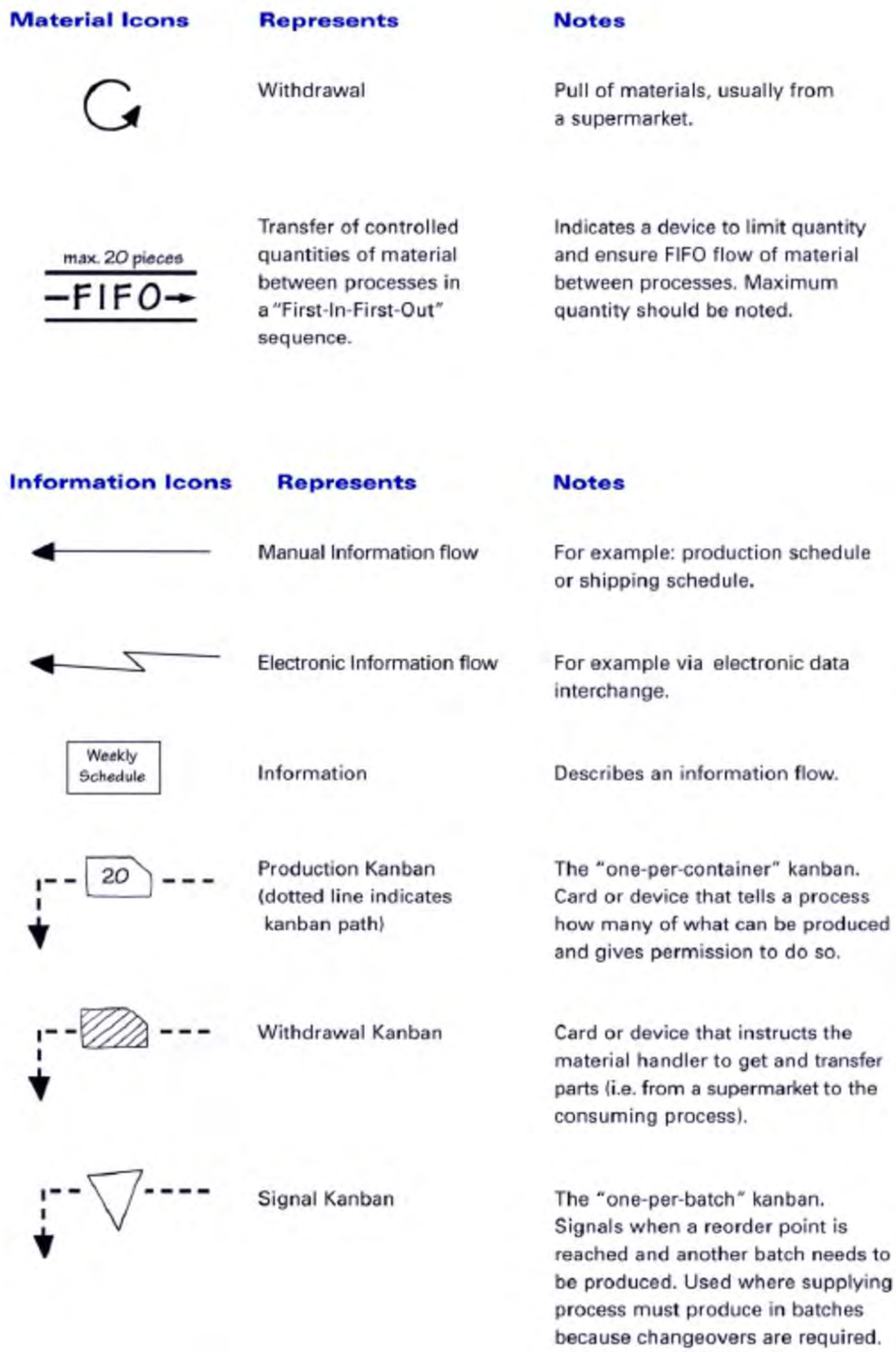
1. Produce to the takt time
2. Develop continuous flow wherever possible
3. Use supermarkets where continuous flow does not extend upstream
4. Send the customer schedule to only one production process: the pacemaker
5. Level the production mix
6. Create pull by releasing consistent increments of work at the pacemaker process
7. Develop the ability to make every part every day.

The VSM mapping icons and conventions introduced by (Rother & Shook, Learning to See, 1999) as below pages followed by an example of single facility Value Stream Map.

Material Icons	Represents	Notes
	Manufacturing Process	One process box equals an area of flow. All processes should be labeled. Also used for departments, such as Production Control.
	Outside Sources	Used to show customers, suppliers, and outside manufacturing processes.
	Data Box	Used to record information concerning a manufacturing process, department, customer, etc.
	Inventory	Count and time should be noted.
	Truck Shipment	Note frequency of shipments.
	Movement of production material by PUSH	Material that is produced and moved forward before the next process needs it; usually based on a schedule.
	Movement of finished goods to the customer	
	Supermarket	A controlled inventory of parts that is used to schedule production at an upstream process.

(Rother & Shook, Learning to See, 1999), Appendix A

Figure 3-2: VSM symbols – 1

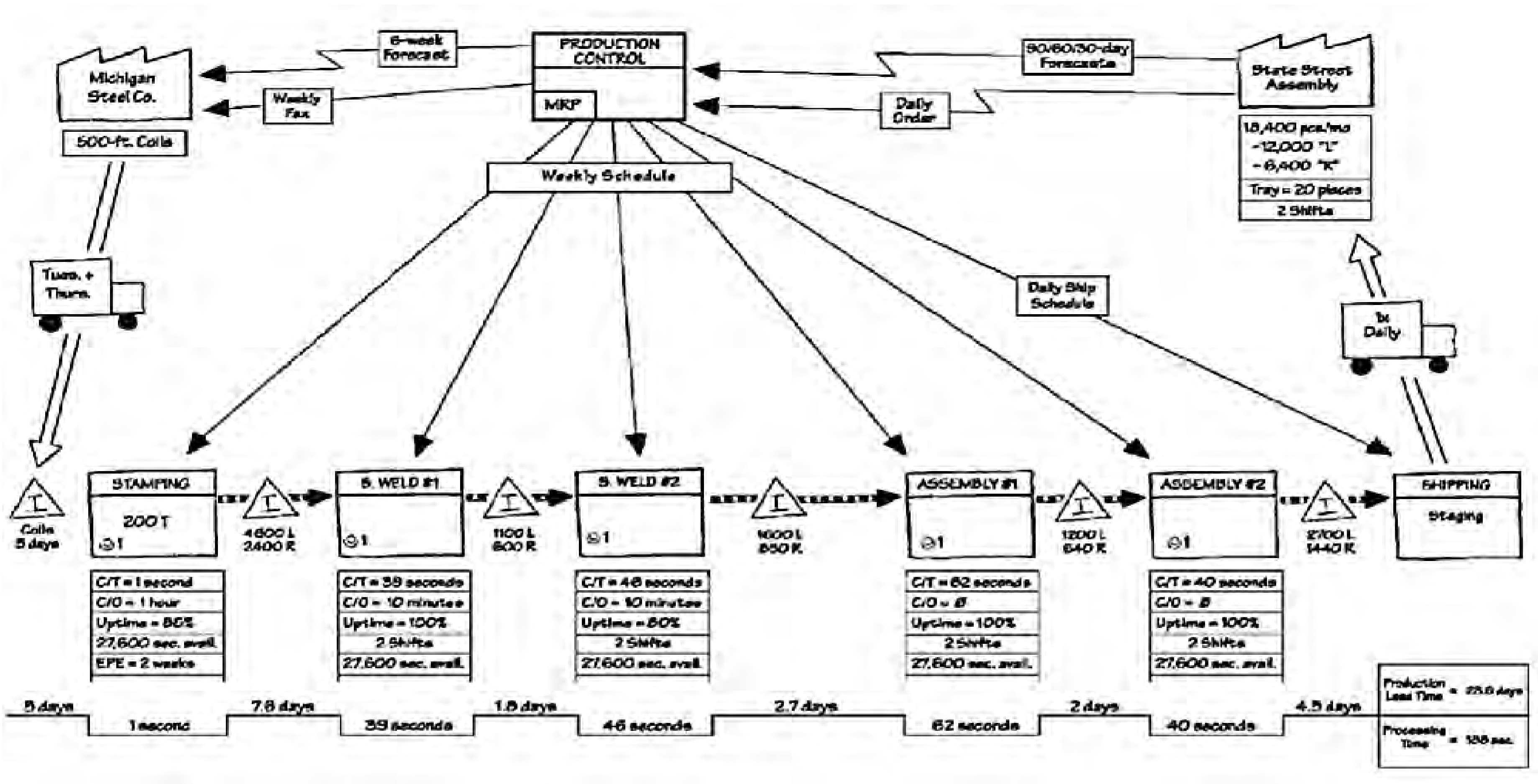


Material Icons	Represents	Notes
	Withdrawal	Pull of materials, usually from a supermarket.
max. 20 pieces FIFO	Transfer of controlled quantities of material between processes in a "First-In-First-Out" sequence.	Indicates a device to limit quantity and ensure FIFO flow of material between processes. Maximum quantity should be noted.

Information Icons	Represents	Notes
	Manual Information flow	For example: production schedule or shipping schedule.
	Electronic Information flow	For example via electronic data interchange.
Weekly Schedule	Information	Describes an information flow.
20	Production Kanban (dotted line indicates kanban path)	The "one-per-container" kanban. Card or device that tells a process how many of what can be produced and gives permission to do so.
	Withdrawal Kanban	Card or device that instructs the material handler to get and transfer parts (i.e. from a supermarket to the consuming process).
	Signal Kanban	The "one-per-batch" kanban. Signals when a reorder point is reached and another batch needs to be produced. Used where supplying process must produce in batches because changeovers are required.

(Rother & Shook, Learning to See, 1999), Appendix A

Figure 3-3: VSM symbols - 2



(Jones & Womack, 2002)

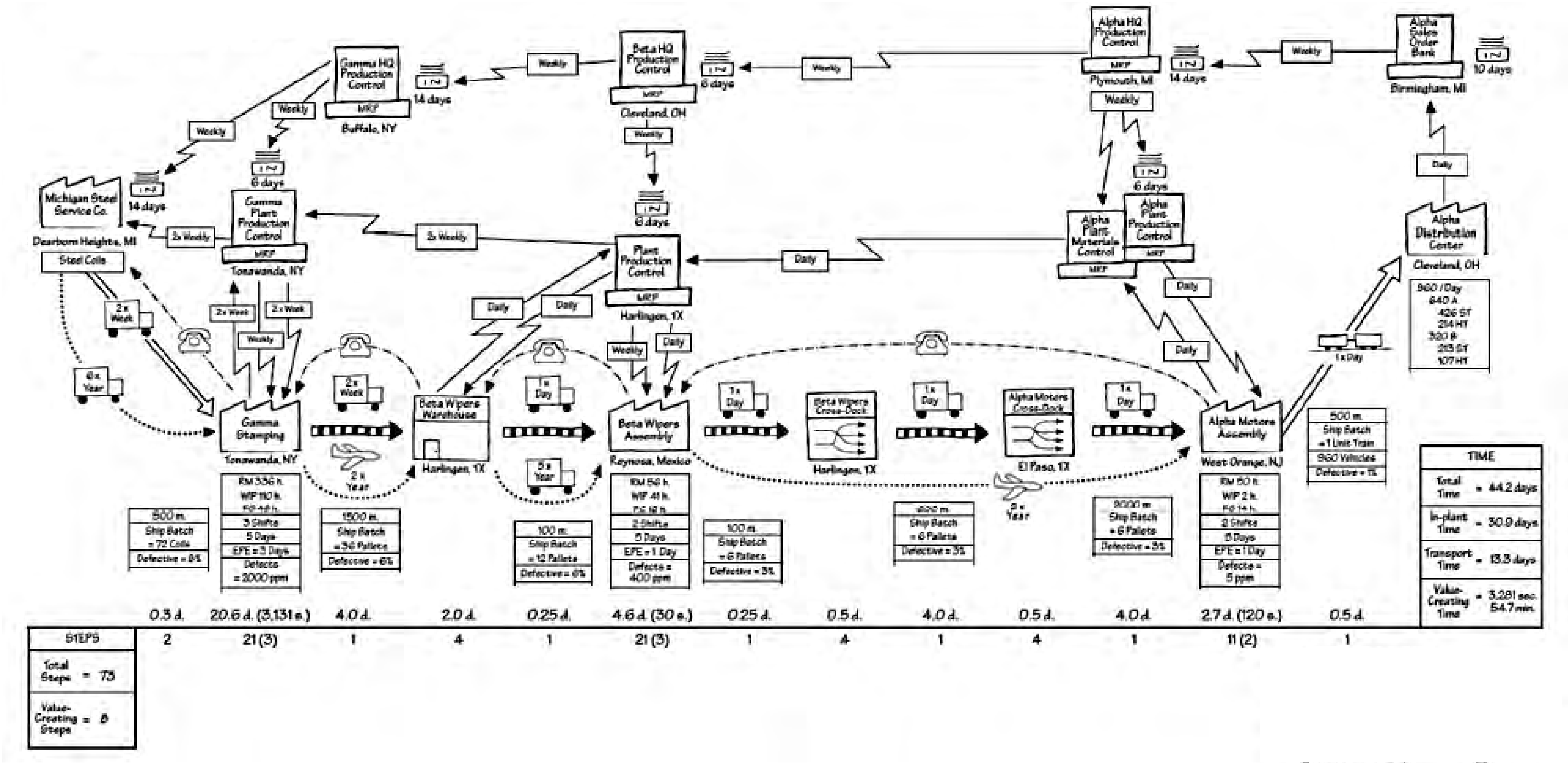
Figure 3-4: Single Facility VSM example

3.3 Extended Value Stream Mapping (EVSM)

VSM covers mainly process level or plant level mapping. The Extended Value Stream Mapping (EVSM) to a further step by mapping multiple plants and across companies (Jones & Womack, 2002). This EVSM tool was introduced by (Jones & Womack, 2002) in the book titled *Seeing the Whole.* In EVSM transportation between supplying facilities and transportation to the customer's facility is considered. A closed loop supply network is formed with product moving down stream and demand moving upstream. The concept of extended value stream mapping does not require the practitioner to map the supply chain back to the extraction of raw materials from the ground.

Just as in facility value stream mapping, extended value stream mapping starts with a representation of the current state. Since the flow of materials and information between facilities is the main consideration in extended value stream mapping, the focus of lean improvements shifts to addressing issues at interfaces between facilities. These include minimizing transposition between facilities and minimizing inventories of finished goods (Jones & Womack, 2002). To achieve the goal of a lean extended value stream, (Jones & Womack, 2002) proposed the following 6 principles:

- First, everyone in the entire value stream should be aware of the rate of customer consumption of the product at the end of the stream.
- A second feature of a truly lean extended value stream will be very little inventory.
- A third feature of an extended lean value stream is as few transport links as possible between steps in the production process.
- A fourth feature of a lean value stream is as little information processing as possible, with pure signal and no noise in the information flows that remain.
- A fifth feature of lean value stream will be the shortest possible lead time.
- A final principle of a lean value stream at the macro level is that changes introduced to smooth flow, eliminate inventories, and eliminate excess transport and lead time, should involve the least possible or even zero cast.



(Jones & Womack, 2002)

Figure 3-5: Multiple Facility VSM or Extended Value Stream Map example

3.3.1 Extended value stream: future states

When making improvements to an extended value stream, the very first step is to address the implementation of lean production in the individual facilities (Jones & Womack, 2002) Building a lean supply chain starts from the bottom up. Any company in the supply chain that is not prepared to implement lean within its own facility will be of little help in sustaining an extended value stream. The term **future state I**, therefore, describes the state of the supply chain when all suppliers have convinced to lean production within their own facilities. Future state I, involves with relatively easier improvements

Future state II, on the other hand, deals with transportation and communications links between facilities. In their book *Seeing the Whole,* (Jones & Womack, 2002) recommend direct transportation links between upstream suppliers and downstream customers, instead of intermediate warehousing or cross-dock facilities. Moreover, just as with value stream mapping within a single facility, it is recommended that suppliers and customers be linked by a Kanban type of information flow meant to establish a pull system between upstream suppliers and downstream customers. These are analogous to Kanban loops within a facility. For instance, large once-a-week batch loads should be replaced by milk runs whose transportation loops connect several facilities.

Before achieving a Future state II, suppliers and customers must work cooperatively toward a lean extended value stream. Suppliers and customers need to disclose opportunities for improvements. Ultimately, this means cost information may also have to be shared to select lean improvement projects that make sense for all. For example, if a supplier is buying raw material at a high price, but the customer can negotiate a lower price, then there is obviously an opportunity for improvement. Without disclosure of costs, this simple extended value stream improvement could not happen. This open book policy then leads to the possibility of re-drawing the extended value stream map on a collaborative footing. Only then can extended value stream maps be truly optimized.

3.3.2 Extended value stream mapping – ideal state

Beyond **future state II,** there is one last type of future state called the *ideal state* (Jones & Womack, 2002). After making improvements in **future state I & II** there should not much left to compress except the transportation links. In the ideal state, the overriding principle is to compress the value stream as much as possible while bringing the value stream closer to the end customer. This literally means bringing production operations geographically closer together as well as closer to the customer. This is like including all operations within a single work cell. Compressing the extended value stream and moving it closer to the customer, however, must be balanced against the possibility that the customer may be in a high cost region. (Jones & Womack, 2002), P.68 suggested below algorithm for relocation logic to compress the value chain in ideal state.

1. If the customer is in a high labor cost country (e.g., the U.S., Japan, Germany) and needs immediate response to orders, and if the product has relatively little labor content, conduct all the manufacturing steps near and close to the customer in the high wage country.
2. If the customer is in a high labor-cost country, is willing to wait for some shipping interval, and the product is price sensitive, manufacture the entire product, from raw materials to finished goods, near in a low-cost locale, shipping only the final goods. In our experience the correct location is almost always at a low wage country within the region of sale. For example, Mexico for the U.S., China for Japan, Poland for Germany. Shipment of the finished product by truck, or a short ferry ride, and across only one border can still permit response to the customer within a few days, while shipment by sea from another continent requires weeks.
3. If the customer in a high labor-cost country needs immediate response bot the product has high labor content, do a careful costing exercise to determine the correct location of manufacture. The best location might vary from a very low wage sire in another region of the world, with the product even delivered by air, to a new technology removing high-cost manufacturing labor in the

1. high cost country of sale and permitting the conduct of all manufacturing steps close to the customer.

4. If the customer is in a low labor cost country and scale requirements permit, manufacture the entire product -from raw material to finished goods -in geographic proximity in that country.

The ideal state won't never be achieved (Jones & Womack, 2002). But this can give a vision to a company for future direction and they keep improving toward this journey and pass additional value to the customer.

3.4 Cooperation in Extended Value Stream

For developing future state and ideal state of a supply chain value stream, it is extremely important to have a close cooperation among the plants, suppliers and main company. As future stare and ideal state maps are drawn up, it will quickly become apparent that positive change is most likely if the team can find a way for winners to compensate losers. This is because it will commonly be the case that a downstream participant can get better value at lower cost if an upstream participant leaves out wasted steps, implements leveled pull systems with its suppliers, introduces more capable process technologies, and relocates activities. However, even when everyone can see that the incremental savings exceed the incremental costs of these initiatives, little is likely to happen unless upstream participants are compensated by downstream beneficiaries for taking costly actions that optimize the whole. If it were easily possible to compare total product cost before and after the future state improvements, compensation might be an easier issue. However, traditional purchasing and accounting systems are often incompatible between value stream participants and in any case, are poorly suited for calculating product costs for each product family. These systems typically require enormous amounts of data to allocate overheads by product and they usually fail to calculate costs in a war that all participants will accept as valid. (Jones & Womack, 2002), p73. However, these authors also proposed to keep it simple by ignoring traditional systems and instead determining the incremental cost (in same common currency unit) and the incremental benefit (in the same currency unit) of each proposed change in the value stream in future and ideal states. This is surprisingly easy in many cases and can change the focus of the value stream team tram redressing (or defending) the mistakes and inequities of the past to discovering win-win-win alternatives for the future (Jones & Womack, 2002), p73.

CHAPTER 4
CURRENT STATE - SUPPLY CHAIN MAPPING

4.1 Introduction

Current state of supply chain map aims to have a macro view of material and information flow of a certain product type throughout the entire supply. As stated earlier, this project work used Extended Value Stream Mapping (EVSM) tool to map supply chain of case company, Sunrise Inc. Before going for Extended Value Stream Mapping or Supply Chain Mapping, each plant should have an individual Value Stream Mapping (Jones & Womack, 2002). For this purpose, individual VSM has been drawn as per method described below.

4.2 Selecting Product Types and Plants for Mapping

First step for VSM is to select suitable product (Rother & Shook, Learning to See, 1999). For finding suitable products, (Rother & Shook, Learning to See, 1999) described method has been followed:

4.2.1 Selecting Product

4.2.1.1 Product category selection

A Pareto analysis has been done based on 2017 full year order placement in Bangladesh for that brand to identify highest the product category with highest order volume. 2017 full year order volume data is shown in below table. Based on the analysis, cargo pant category has most volume. Thus, Cargo pants product was selected for mapping the process. Pareto analysis is shown in the figure in next page.

Table 4-1: Product mix analysis with annual volume

PRODUCT CATEGORY	% MIX OF TOTAL
CARGO PANTS	33%
BASIC SHIRTS	16%
DENIM 5 POCKET JEANS	14%
CASUAL PANTS	12%
INFANT & TODDLER PANTS	11%
WESTERN SHIRTS	9%
NON-DENIM 5 POCKET JEANS	4%
KNIT BOTTOMS	1%
JACKET	0%
SKIRTS	0%
DRESS	0%
TOTAL	100%

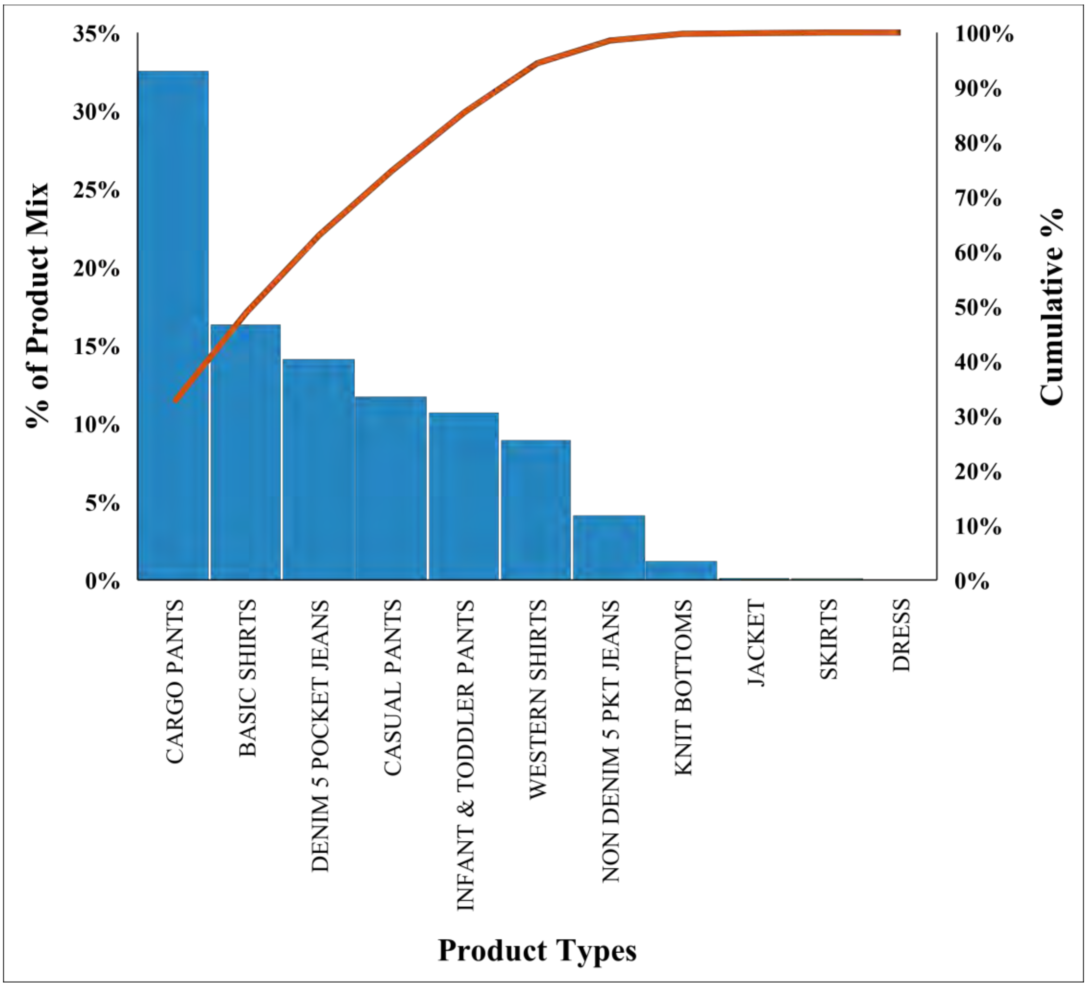


Figure 4-1: Pareto analysis of annual order volume

4.2.1.2 The product

Cargo pant is a type of pant having at least 2 cargo pockets with flap at the knee. Cargo pocket requires a complicated process and take significantly longer time to make compared with normal pockets. This is what separate this product from causal or 5 pocket basic pants. In terms of manufacturing process, there is a very little difference between Cargo Long pants and Cargo Short pants. For the simplicity of product categorization this Cargo pants include from Cargo Long Pants and Cargo Short Pants in same type throughout this study.

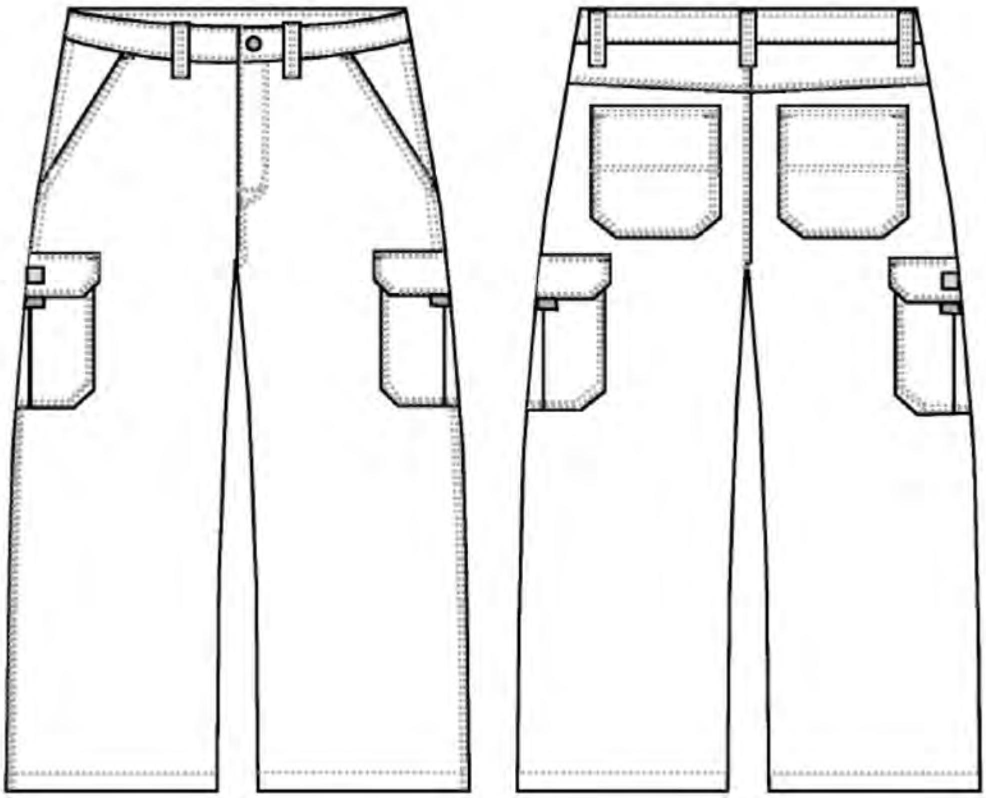


Figure 4-2: A sketch of boys' cargo pant that has been used in this study

There are 14 different types of materials are needed at garment factory to make a Cargo pant and ship as per brand requirement.

Table 4-2: Bill of Material (BOM) of a garment

Item	Quantity per Garment
Body fabric	1 yard (approx.)
Pocketing fabric	0.10 yard (approx.)
Thread	500 meter (approx.)
Zipper	1
Snap button	3 sets
Red button	2
Velcro	2 sets
Elastic	1
Care label	1
Brand logo	1
Hang tag	2
Hanger & clip	1 set
UPC label	1
Carton box	1 per 20 units

Per factory provided fabric usage data, one average Cargo Pants (considering both adult and youth) consume approximately 1 yard of body fabric. This study will use 1 yard body fabric requested for each unit of garment and calculate fabric demand accordingly

4.2.2 Selecting apparel manufacturing factory

Once the product has been selected, next step is to find suitable factories to map the process. Below rationales were used to find the apparel manufacturing plant in Bangladesh.

Selected product type is mostly produced in a factory located in Ashulia, Dhaka region. This factory produce around 54,000 units of Cargo Pants on weekly basis. Due to higher volume of selected products, this factory is chosen for value stream mapping of this case study. The factory owns cutting, sewing and finishing facilities and housed inside same building but different floors. However, they outsource Laundry service from a Washing plant in Manikgonj from their partner factory.

High level process flow of making a garment is like below.

Figure 4-3: Simplified process flow diagram of apparel manufacturing

Detailed operation level breakdown is in below diagram

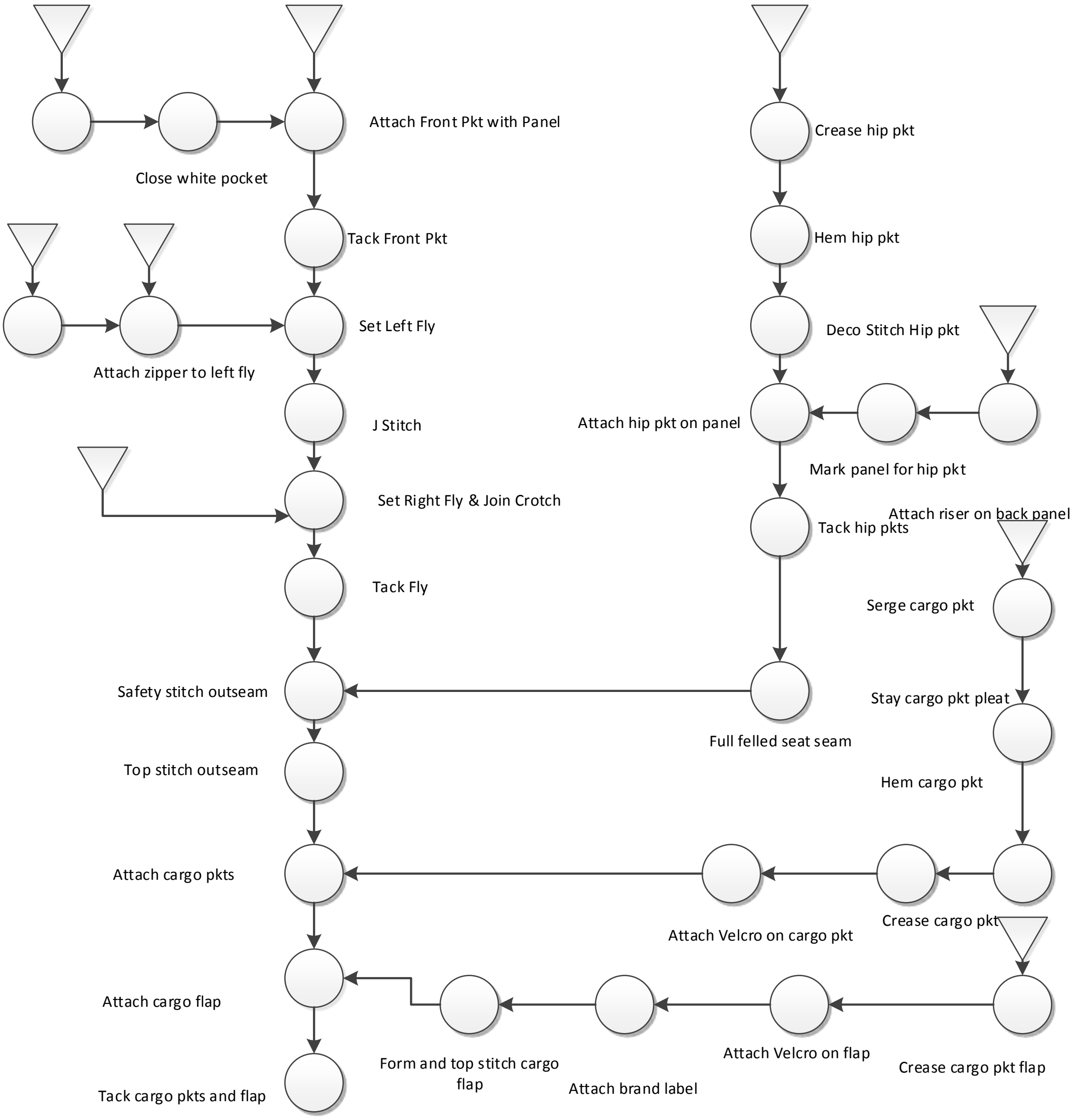


Figure 4-4: First half of full diagram of production process flow at garment factory

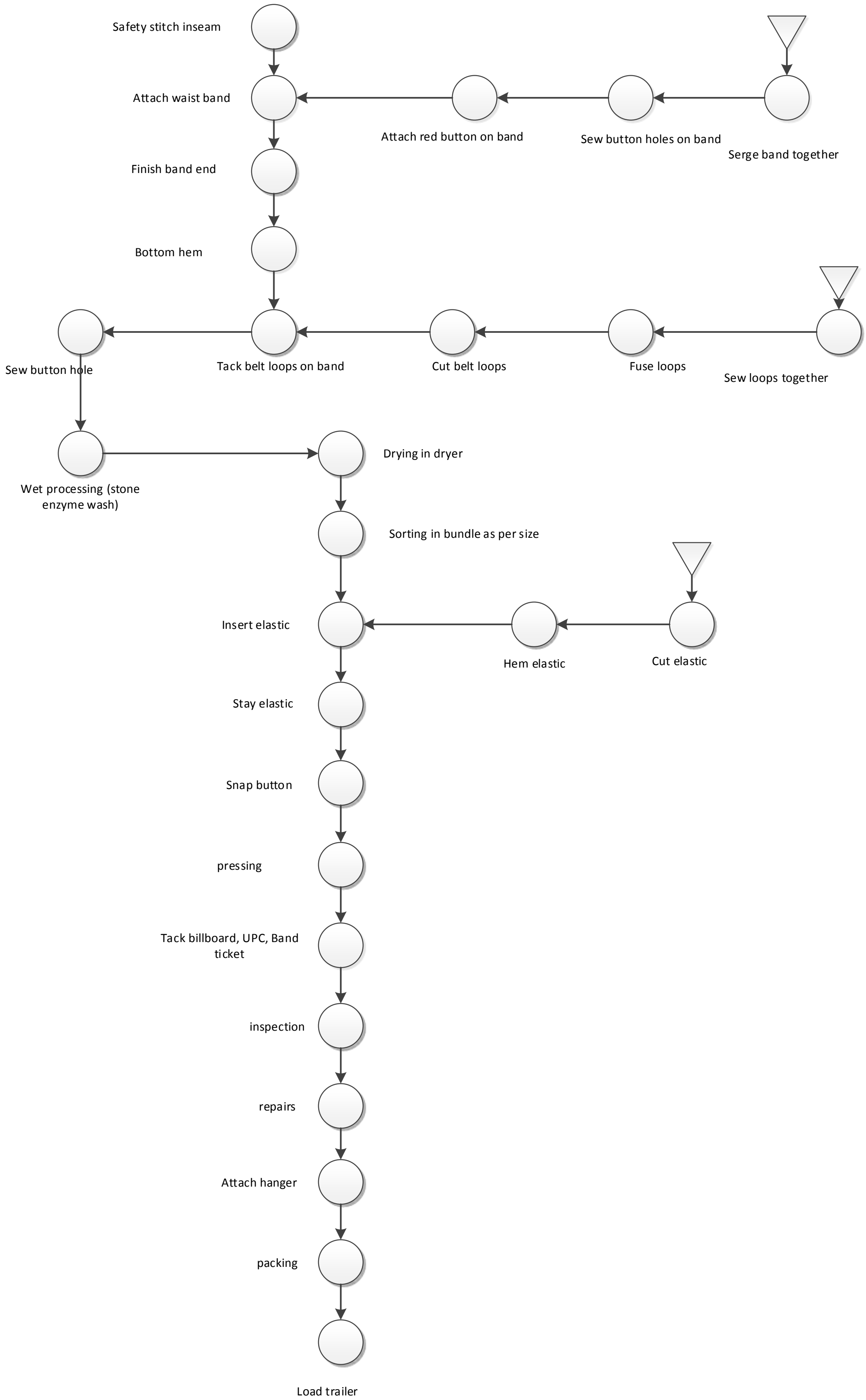


Figure 4-5: Second half of full diagram of process flow in garment production

4.2.3 Selecting fabric mill

Despite having several woven fabric mills in Bangladesh, this brand uses around 80% of their total fabric for Bangladesh production from mills outside of Bangladesh, mostly from China mills. The fabric used in selected product category mostly come from China. For this case study, one of fabric mill north China is identified who supply only woven fabric for this brand.

Based on visit to several fabric mills below simplified process flow chart is drawn. This flow is for woven fabric without any special treatment like coating or printing.

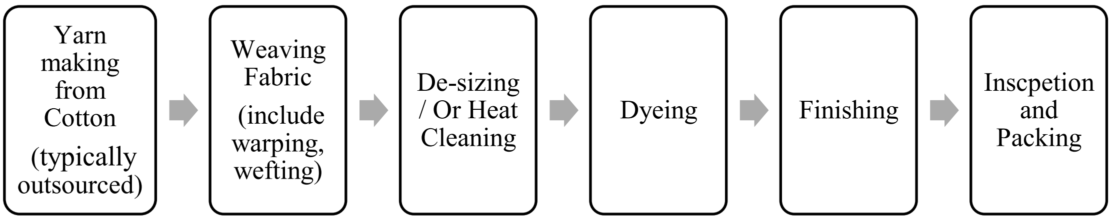


Figure 4-6: Simplified diagram of fabric mill process flow

4.2.4 Selection of brand's distribution center (DC)

This apparel buyer / brand has several DCs in USA in different states. One of them is in California. The author got an opportunity to visit this DC and observe their process flow. For this study, the DC based in California has been used.

4.3 Mapping Current State

For mapping, current state, first one garment manufacturer is identified this apparel brand who is making highest volume of Cargo pants. After analyzing their full year order history for 2017, it was found that, they ship 54,000 units of Cargo Pant for this customer on weekly basis with total 61 different styles. And their average Purchase Order (PO) size is around 8,000 units. Factories are required to ship products per PO. Factory also place order for fabric and other trim materials per the garment PO from customer.

From garment factories lead-time calendar for raw material procurements, it was identified that fabric is the single longest lead time material they need to make a garment. If the fabric procurement is shorter, it can shorten the whole supply chain lead time. Thus, for value stream mapping, only fabric item will be mapped among raw materials.

Table 4-3:Raw material standard lead time chart

BOM Items	Lead Time Days
Fabric	60
Pocketing	14
Care Label	3
Thread	10
Zipper	18
Snap Button	50
Velcro	45
Red Button	14
Button Hole Elastic	10
UPC ticket	10
Hang Tag	10
Hanger & Clip	14
Carton	7

Note: This fabric lead time is only from greige fabric to finishing. Apparel buyers already booked yarn and mill capacity in this case that gave shorter lead time to garment factory.

Physical steps and corresponding time required to make a garment and ship to the end consumer. Processing times are based on analyzing primary data related to process and asking questions to concerned people. Inventory times are calculated based on raw material and work in process inventory and daily demand of those plants. Transportation and Logistics times are from buyer company standard lead time files. Cycle times for mills operations are taken from a published journal article (Hodge, Ross, Joines, & Thoney, 2011). The details of the physical steps with corresponding required times are shown in a table under Appendix A.

From activities and steps with corresponding time as shown in Appendix A, below summary table can be drawn from it. Value creating steps are defined from end customers' point view as if they are willing to pay for those activities or if they will less satisfied if those activities are not done at all. Corresponding cycle times for those 'value creating' activities per unit flow is considered as 'value creating time'.

Table 4-4: Physical activity summary

	Total	Value Creating
Steps	49	10
Time	162.75 Days	630.29 Min

4.4 Overall Supply Chain Value Stream Map – Current State

All activity processing times are based on lot basis or how product is moved to the next process. Value creation time is per unit garment basis and how the end customer see value of it. For this reason, there were many activities that may add value to the process or to facility but may not be a value to the end customer.

All inputs in this map came from detailed individual facility based Value Stream Map which are available in Appendix B & C. Steps and times inside parenthesis are value creating steps and time on the timeline bar at the bottom of the map.

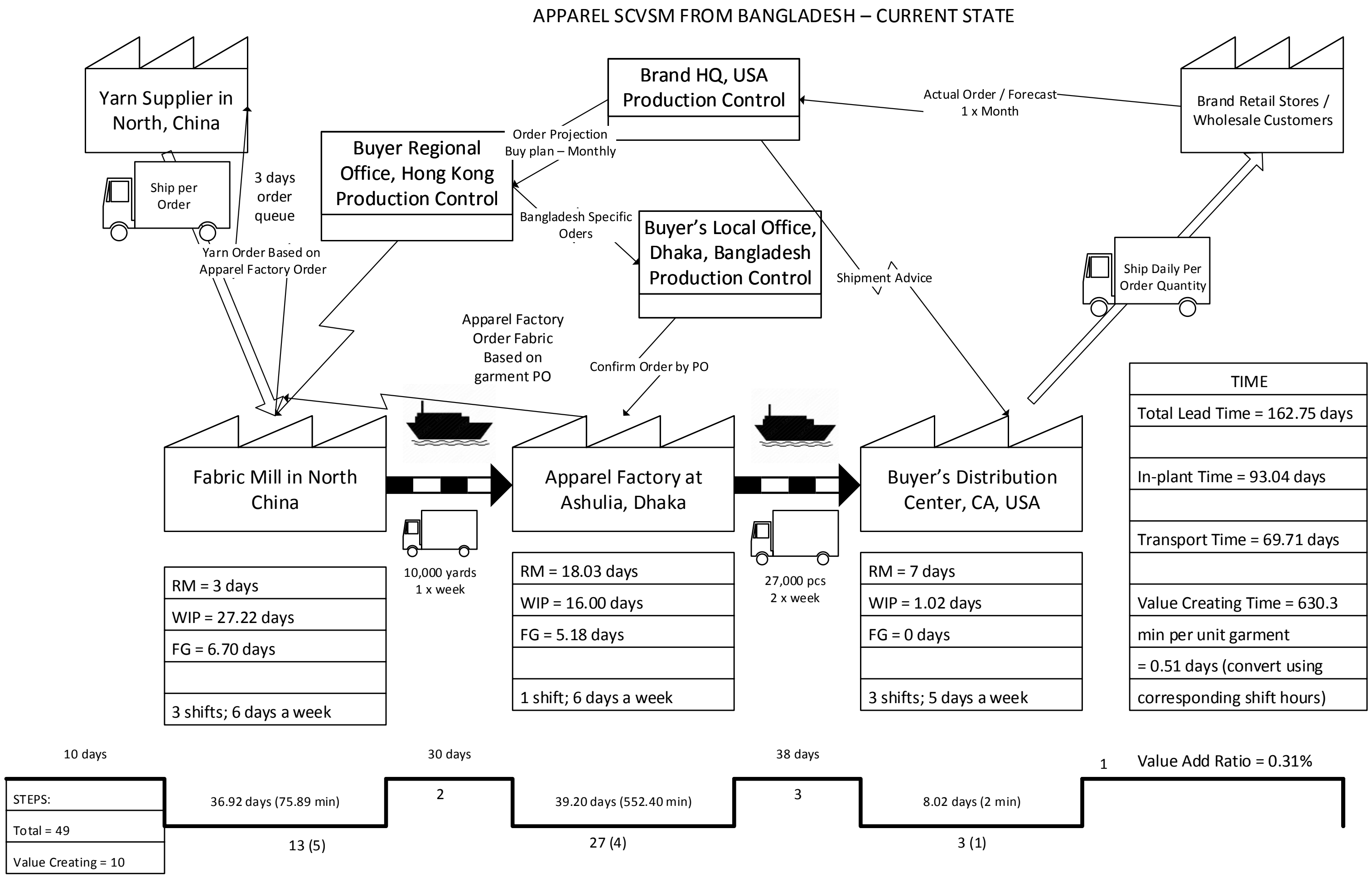


Figure 4-7: Overall Supply Chain VSM – Current State

Key information from above Supply Chain VSM can be summarized in below table. It takes 162.75 days to bring an apparel product to the retail store from the Purchase Order issue date. Out of those days only 0.31% time spent for value creating activities. All other time are some form of waste like transportation, waiting, duplicating approval processes or simply non-value added from end customer's point of view. A future state has been developed in next chapter by addressing those wasteful processes.

Table 4-5: Current State Summary

	Current State
Total Lead Time	162.75 days
Value % of Time	0.31%
Value % of Steps	20%

CHAPTER 5
SUPPLY CHAIN MAPPING – FUTURE STATE

5.1 Introduction

Whereas the Current State Map provides the insight into the problems that exist in the value stream, it is the future state that determines the goal for the Value Stream Mapping team (Nash & Poling, 2008). Once the current state is drawn, the logical next step is draw a future state by identifying improvement opportunities in current supply chain value stream. For identifying improvement opportunities, lean manufacturing principles have been flowed to eliminate wasteful process and activities.

In this project work two stages of future states have been developed here inspired by (Jones & Womack, 2002). Those are 1) Future States & 2) Ideal State. Future state here implies here that can be achieved quickly with moderate effort by the organization. While Ideal State takes an idealistic view from lean thinking point of view and may take very long time to achieve or may not be achieved at all, but can act as vision of the company for their long-term goals.

Below paragraphs explain how the future state has been developed in this project work.

5.2 Developing Future State

For developing Future States, guidelines mentioned by (Jones & Womack, 2002) has been followed. This is basically an effort to eliminate seven types of wastes from the current state value stream wherever possible. Major opportunities were identified in below areas:

5.2.1 Fabric mill

1. Apparel buyer book or guarantee fabric at mill based on forecast. That will help mills to place yarn order placements or book earlier to avoid order queue time. Even though forecasting may be seen a wasteful process from end customers view point. However, (Kahn & Mello, 2004) argued that, lean forecasting is not a wasteful process rather it improves company’s internal process and save resources.

2. Kanban pull system at mill to pull yarn from preparation area throughout Weaving looms to Finishing

3. Implement continuous flow from Weaving loops to Dyeing process. This will eliminate Inventory between processes.

4. Quick changeover Kaizen event to reduce changeover time for dyeing batches which includes dye formula adjustment and other preparations.

5. Real time inspection data transfer to garment factories and apparel buyers to have increased transparency on the fabric quality. This can avoid delays on fabric shipment over quality issues.

6. Ship fabric 2 times per week, instead of waiting for full PO to be ready. Since garment factory won't need all fabric in same day, this option is viable. This can reduce finished goods inventory at the fabric mill.

5.2.2 Garment factory opportunities

1. Fabric Inspection: Currently factories are inspecting at least 30% of all fabric they purchase. Fabric mill already inspected same fabric in same inspection criteria. This is a complete wasteful process. If fabric mill share their inspection report with garment factory with increased trust, this inspection process can be eliminated.

2. Fabric Testing: Fabric mill has same testing done at mill. Both fabric mill and garment factory can share same report. Testing fabric at garment factory is also wasteful process and should be eliminated.

3. Pre-production Sampling & Approval: Currently, factory spend 7 days for these activities. Fabric mill can send some sample fabric by air shipment to the garment factory. While bulk fabric is on transit, factory can finish this step. This can be parallel step, thus eliminated

4. Continuous Flow through Cutting to Sewing: By using lean manufacturing principles this can be achieved. Thus, all inventory amount eliminated between Cutting and sewing process.

5. Laundry Process: Currently, factory sends sewn garments to Laundry by full PO to avoid potential risk of PO mixing. Factory can use RFID tags inside garments before sending to laundry. RFID tags helps to sort garments by PO and size after washing in an automatic sorter. This will allow garment factory to send garments on split PO based on their daily output. This suggestion can reduce their inventory level before and laundry process.

6. Sewing & Finishing Process Improvement: A lot of non-value added activities have been identified in both sewing and finishing processes during factory walk through. For a simplified way to access the cycle time improvement potential, another manufacturers data was compared for same product. The other apparel manufacturer is in Egypt and producing same products for Sunrise Inc.

Table 5-1: Sewing and Finishing cycle time improvement potential

	Manufacturer in BD (min)	Manufacturer in Egypt (min)	Improvement Potential
Sewing Cycle Time	45	27	40%
Finishing Cycle Time	25	11	55%

These improvements will come from method improvements and individual incentive pay scheme.

7. Final Audit: Currently, 100% final audit is done by apparel buyer's auditors who handle multiple factory audits. This audit process require factory to send their audit request at least 3 days ahead of shipment date. In other countries and other brands, Factory Certified Auditors (CFA) are authorized to conduct final audits. This company may apply this kind of CFA program for final audits. This will reduce queueing time for Final Audits.

5.2.3 Brand's distribution center (DC) in USA

1. It has been observed during the visit to the brand's DC, that the finished goods there mostly sit idle for about a week. Only physical activity a garment is needed before shipping to retail stores or wholesale customers are adding hangers, or repacking by size assortment. These activities are called Value Added Service (VAS). Potentially, this VAS activities can be done at origin factories before shipping goods out of factories. For this brand needs to communicate proactively with their customers and garment factories for VAS requirement. If VAS is moved to origin factories, it can save 3 days at DC.

Considering above improvement opportunities, below Future State map is drawn. Facility level detailed Future State maps are available in Appendix D & E.

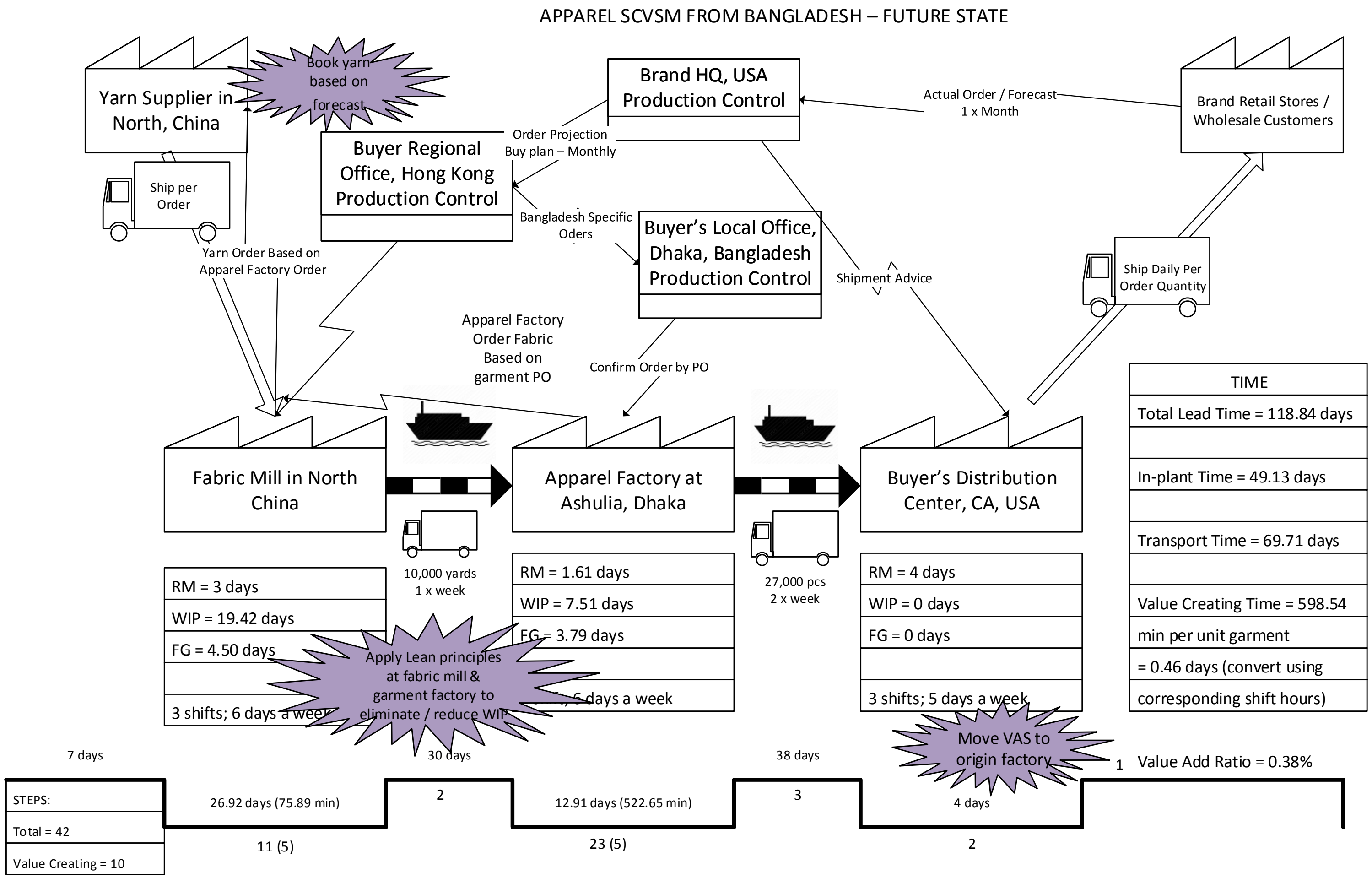


Figure 5-1: Overall Supply Chain VSM - Future State

5.2.4 Future state summary

The information from Future State map has been shown in below table. In future state, total lead time has been reduced to 118.84 days where value creating time is only 0.38% which is still shockingly low.

Table 5-2: Future State Summary

	Current State	Future State
Total Lead Time	162.75 days	118.84 days
Value % of Time	0.31%	0.38%
Value % of Steps	20%	24%

5.3 Result Comparison

Comparison of key parameter between current state and future state supply chain maps has been shown in below table. There is a 27% total lead time improvement opportunity shown in future state map.

Table 5-3: Result comparison

KEY PARAMETERS	CURRENT STATE	FUTURE STATE	IMPROVEMENT
Total Lead Time (days)	162.75	118.84	27%
In-plant Time (days)	93.04	49.13	47%
Transport Time (days	69.71	69.71	0%
Value Creating Time per unit garment (min)	630.3	598.54	5%
days (convert using corresponding shift hours)	0.51	0.46	10%
Value Add Ratio	0.31%	0.38%	23%

The major improvement potential came from material inventory time, delays and work in process inventory. There is also potential to reduce cycle times in sewing and finishing which impacted value creation time. All those improvement ideas have been discussed elaborately earlier in this chapter.

5.4 Further Improvement Potential

In Future State, improvements are made mainly through eliminating non-value added processes and eliminating or reducing excessive inventory between processes within facilities. After making significant improvement in Future State, still 59% of total Lead Time is related to transportation time between fabric supplier to apparel manufacturer to distribution center in USA, which are another type of waste. (Jones & Womack, 2002) introduced another state called 'Ideal State' in their book titled *'Seeing the Whole Value Stream'*. Per (Jones & Womack, 2002), next level of improvement will come from Compressing the Value Stream.

"Because it appears that most of the remaining waste and time are due to the need to move the product between many facilities and over long distances a logical next step is "value stream compression" to relocate and co-locate value-creating activities so they can be performed raster with less effort." – (Jones & Womack, 2002)

By using ideal state methodology, further improvement potentials in Sunrise Inc.'s supply chain are below:

- Source woven fabric within Bangladesh from a vertically integrated mill, ideally located next to apparel manufacturing facility. This can dramatically reduce fabric procurement lead time
- Set up laundry facility next to apparel manufacturing factory which can reduce transportation as well as queuing time by using levelled pull between those two facilities
- Since value added services (VAS) moved to origin factories in Future State map, the logical next step to seek opportunity to bypass DC storage operation. A cross docking facility can help to consolidate and distribute shipments This can save time taken at DC in terms of transportation and processing delays

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The objectives of this project work were to map current state of overall supply chain of made in Bangladesh apparel products for USA market from a foreign buyer's perspective, then find ways to improve it. To achieve this, all steps from yarn procurement to finished apparels at brand's retail store have been tracked with time consumed at each step as well as identified value added and non-value added steps. Based on this a Current State supply chain map has been drawn followed by a Future State supply chain map with the suggested improvement opportunities.

This study showed 27% improvement opportunity on entire supply chain lead time of the case study buyer to procure woven apparel products from Bangladesh for USA market. This result is mainly from potential elimination or reduction of non-value added activities found throughout different tiers of apparel supply chain of the case study brand. In the proposed Future State, still 59% of total lead time are spent on transportation which is also non-value added time in terms of customers' perspective. Further improvement potential also suggested in this study on how to compress those transportation links and further reduce total supply chain lead time.

Shorter lead time reduce financial risk for the apparel brands or retailers by reducing blind orders or safety stocks. It also generates better sales since it allows more time for brands to have better forecast of orders. With all those benefits, the apparel brands should be able to invest on reducing total supply chain lead time. On the other hand, considering the importance of apparel industry Bangladesh Government needs to come forward to help infrastructure related issues like port efficiency, road conditions and bureaucratic difficulties in export and import goods. These are things add more time total supply chain of foreign buyers in terms of transport times but both Bangladeshi manufactures and foreign buyers can help a little to solve those infrastructure issues.

6.2 Recommendations

The improvement suggestions in this project work, did not consider the actual business cases, even though those were in line with lean manufacturing principles. Further research is recommended to test those improvement suggestions made on this study by considering business case situation.

This case study was done with one apparel brand, one apparel manufacturer and with one fabric suppliers. Another similar study is recommended which may cover multiple brands, more manufactures and fabric suppliers to have more representative result for Bangladesh situation as well as for apparel products' entire value supply chain by market.

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APPENDICES

Appendix A: Physical Activity Table for Current State

	Steps	Value Creating Steps	Total Time per Unit Flow	Value Creating Time per Garment
Yarn Supplier in North China				
	1. Yarn procurement		10 days	
Transport Link 1				
	2. Direct ship to fabric mill in North China		30 m	
2nd Tier Supplier Fabric mill in North China				
	3. Unload yarn rolls & store		3 days	
	4. Yarn preparation	1	3.6 hour	
	5. Store - waiting for report and plan		17.28 days	
	6. Weaving – per bale	2	6.4 hour	0.48 min
	7. Store - waiting for report dyeing plan		3 days	
	8. Heat Cleaning / De-sizing	3	2.2 hour	0.24 min
	9. Store - queue, dyeing formula		4.8 days	
	10. Dyeing – per lot	4	2.25 hour	75 min
	11. Store - dry time		1.5 days	
	12. Finishing	5	1 hour	0.15 min
	13. Packing		1.6	1.6 min
	14. Store - shipping documents		3.7 days	

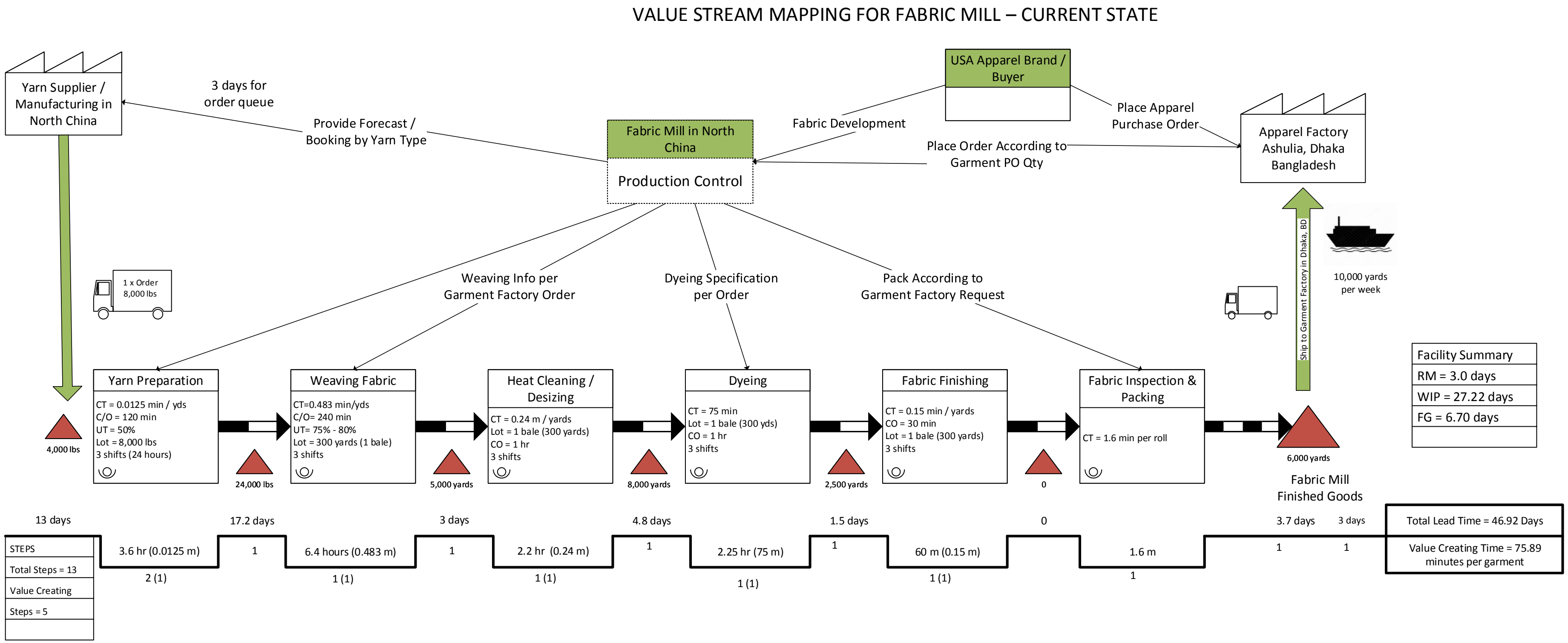
	Steps	Value Creating Steps	Total Time per Unit Flow	Value Creating Time per Garment
	15. Shipping to port		3 days	
Transport Link 2				
	16. Ship from Tianjin, CN port to Chittagong		28 days	
	17. Chittagong port to Ashulia, Dhaka		2 days	
1st Tier Supplier Garment factory, Ashulia Dhaka				
	18. Unload fabric		5 hour	
	19. Store fabric - queue		1.1 day	
	20. Fabric Inspection		7.5 hour	
	21. Fabric Testing		7 days	
	22. Pre-production sample making & approval		7 days	
	23. Store – queue		1.67 days	
	24. Cutting – per cut	6	6 hour	1.5 min
	25. Store – queue			
	26. Numbering		1.5 hour	
	27. Store – queue		1.11 days	
	28. Sewing – per PO	7	4 days	45 min
	29. Store – queue		1 day	
	30. Load in truck		1 hour	
Transportation Link 3				
	30. Ship to Washing plant in Manikgonjg		8.5 hour	

	Steps	Value Creating Steps	Total Time per Unit Flow	Value Creating Time per Garment
Washing / Laundry Plant				
	31. Unload truck		30 min	
	32. Put wash tag		100 min	
	33. Queue		8 hour	
	34. Washing	8	3.5 hour	480 min
	35. Unload from washer		30 min	
	36. Dryer		2 hour	
	37. Store		6 hour	
	38. Ship to Sewing factory		8.5 hour	
Garment factory, Ashulia Dhaka				
	39. Unload from truck		2 hour	
	40. Store		2 days	
	41. Finishing process	9	3.4 days	25 min
	42. Store - waiting for audit schedule		2.78 days	
	43. Final Audit		4 hour	
	44. Store		1 day	
	45. Ship to port		1 days	
Logistics Company (APLL)				
	46. Shipping consolidation		3 days	
	47. Ship to USA port		30 days	
	48. Port to DC		5 days	
Distribution Center				

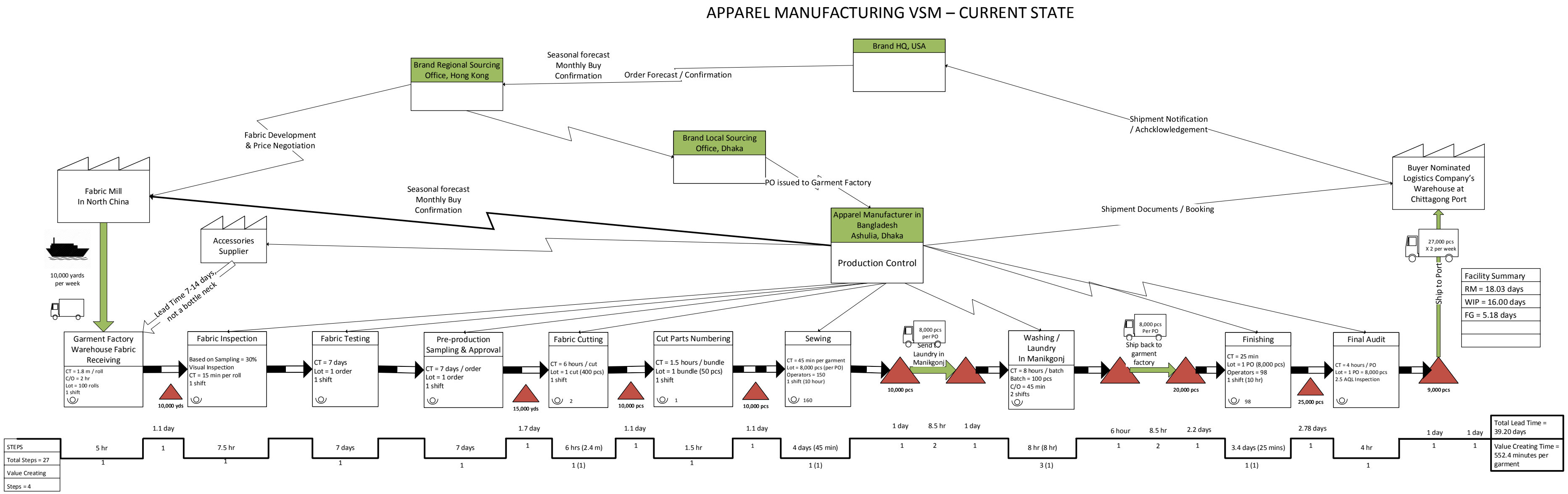
Steps	Value Creating Steps	Total Time per Unit Flow	Value Creating Time per Garment
49. Receiving & scanning 50. Store - waiting for routing 51. Pull, VAS and Ship to retail store	10	1 min 7 days 1.02 days	2 min

Note: 3 steps in Laundry (highlighted) merged into 1 step for simplifying cycle time capturing

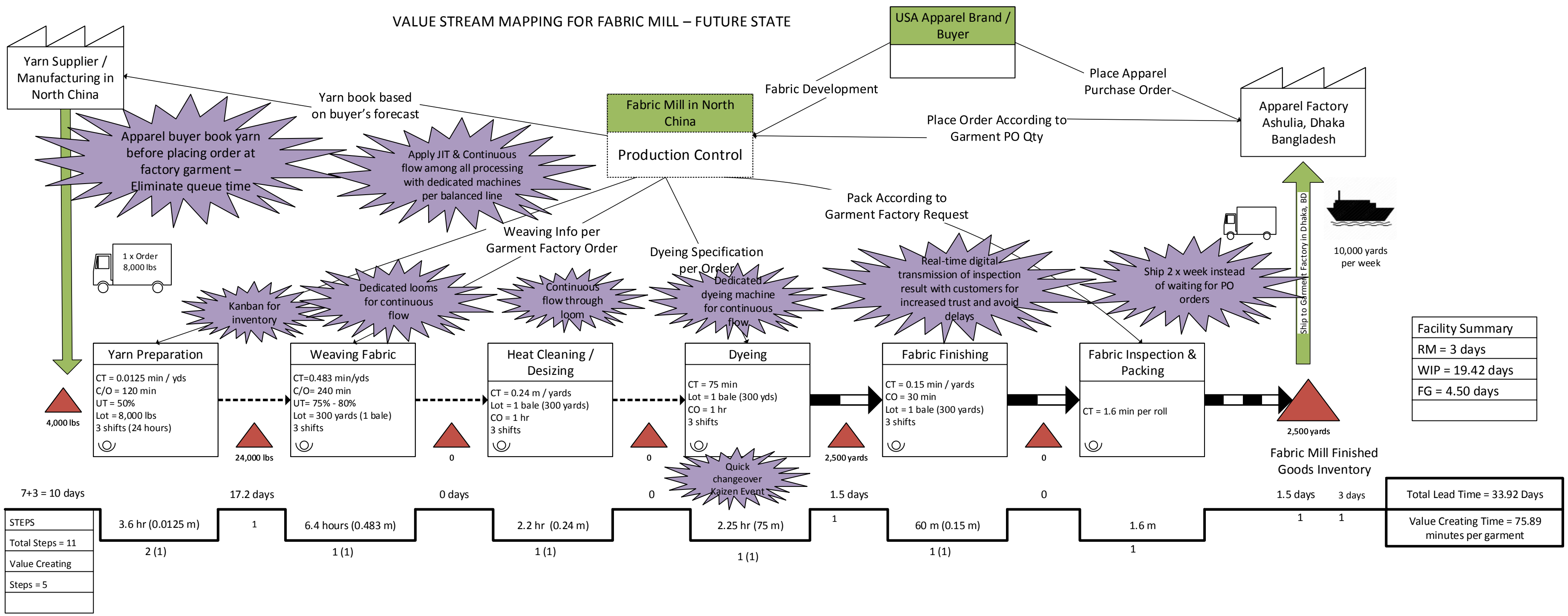
Appendix B: Current State – VSM – Fabric Mill



Appendix C: Current State – VSM – Apparel Manufacturing Facility



Appendix D: Future State – VSM – Fabric Mill



Appendix E: Future State – VSM – Apparel Manufacturing Facility