

# Inbound Logistics Management for a PVC Resin Manufacturer

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A Thesis Submitted in Partial Fulfillment of the Requirements  
for the Degree of Master of Engineering in Engineering Management

(CU-Warwick)

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By	Miss Thunlapas Ruengrapeepun
Field of Study	Engineering Management
Thesis Advisor	Assistant Professor Pisit Jarumaneeroj, Ph.D.

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งานวิจัยนี้มีจุดประสงค์หลักเพื่อเพิ่มประสิทธิภาพการดำเนินงานด้านการขนส่งสินค้า  
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สินค้า พีวีซีบรรจุถุงกระสอบใหญ่ และพีวีซีผงที่บรรจุลงรถ Tank car จากการศึกษาประวัติการ  
ร้องเรียนของลูกค้าในปี พ.ศ. 2560 ที่ผ่านมา ผู้วิจัยพบว่า กว่าร้อยละ 90 ของการร้องเรียนทั้งหมด  
เกิดขึ้นจากการส่งมอบสินค้าล่าช้า อันเป็นผลมาจากสัดส่วนของเวลาที่ไม่เพิ่มมูลค่า (Non-Value  
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สินค้าที่มากเกินไป ผู้วิจัยได้นำเสนอแนวทางในการแก้ไขปัญหาดังกล่าว โดยนำเอา  
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จำลองสถานการณ์ Arena ทั้งนี้ ผู้วิจัยพบว่า แนวทางการปรับปรุงดังกล่าวสามารถลดเวลาใน  
กระบวนการขนส่งลงได้โดยเฉลี่ยกว่า 60 นาที (จาก 180 นาที เหลือเพียง 120 นาที) หรือคิดเป็น  
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ลายมือชื่อนิติ .....  
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The main objective of this research is to enhance logistics operation of a Thai PVC manufacturer located in Rayong, where we will focus more on the domestic part involving with three different PVC products, that is, Palletized PVC, Flexible-bag PVC, and Tank car PVC. Based on the historical data collected in 2017, over 90 percent of the complaints was identified as delivery delays caused by comparatively long non-value added activities within the inbound logistics process, such as waiting in weighting-in process and over processing steps in delivery paper generation. In order to address these issues, truck scheduling and throughput time improvement initiatives had been suggested, each of which was assessed by a simulation software named Arena. Based on these initiatives, the company could potentially reduce the throughput time, i.e. the time from which a truck arrived till its departure from 180 minutes to 120 minutes, or approximated one-third of the current practice.

Field of Study: Engineering Management Student's Signature .....

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background of the Research

Petrochemical industry plays an important role on the global economy as there are many organic chemicals and the material used to produce several of chemical products include plastics used in our daily life. For example, piping in construction sector, several electronic machines, home equipment, food and drink packaging and transportation part. Like other country, demand of plastic products in Thailand are directly concerned to demand for consumer products which is continue increase year after year.

With an increase of competition among plastic companies, customer satisfaction is the key to gain competitive advantage from other competitors. According to Christopher (2011), enhancing supply chain management system is a solution to improve customer satisfaction approaching to sustain long term competitive advantage of a business. Therefore, a good logistics management can help a company to fulfil customer's requirement in terms of on-time and in-full product and increase level of customer satisfaction.

Moreover, in order to be the leadership in a highly competitive environment, supply chain management is often considered to be implemented to optimise process and maximise profits. The aim of sufficient supply chain is to deliver as fast and inexpensively as possible without effect to quality. Cost reduction is a way to increase profits without having to reduce selling price to get sale volume. Instead, by eliminating redundant processes and unnecessary steps in every supply phases then separate the chain down into its essential processes allow company to achieve effective saving in supply chain costs.

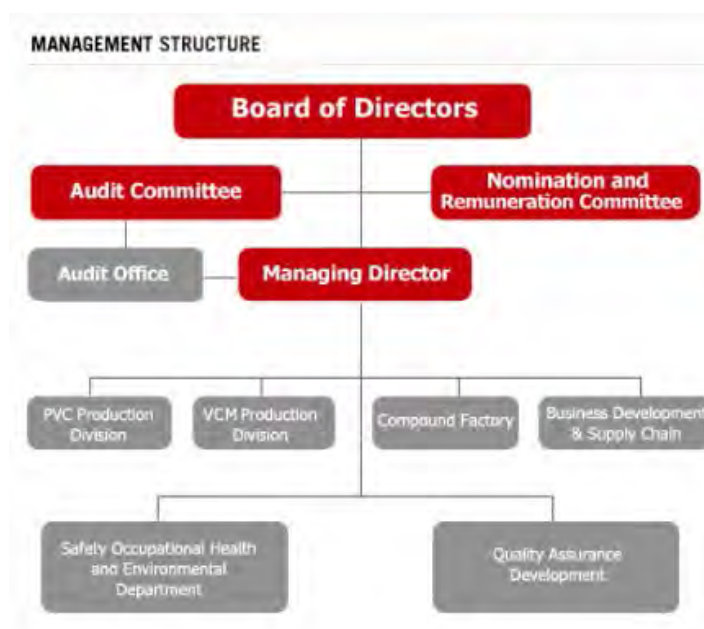
#### 1.2 Company Background

At present, The Siam Cement Public Company Limited is called Siam Cement Group (SCG) which was established in 1913 following the royal decree of His Majesty King Rama VI as the first cement company in Thailand. Firstly, SCG had only cement as their core business unit, but today SCG has three core business units which are SCG Cement-Building Materials, SCG Chemicals and SCG Packaging.

The company in this study is in SCG Chemicals business unit named Thai plastics and Chemicals PLC (TPC) which is Manufacturer and distributor of PVC resin and related products. As a leader PVC production in ASEAN, TPC is not only has subsidiary companies in downstream business like PVC pipe and fitting company and PVC compounding company, but also expands their manufacture into other countries in the Socialist Republic of Vietnam, and Indonesia. In Thailand, TPC has two manufacturers located in Rayong and Samutprakarn.

Vision: To be ASEAN leader in Vinyl Business

Mission: To grow by expanding its investment in the region and adding value through innovative products and services for sustainable development.



**Figure 1** TPC's Management Structure

In order to maintain leader of PVC business in ASEAN, TPC approaches to create higher-quality products and services to meet requirements of customers by developing the high-value-added products and environment friendly products, as well as improve their value chain process through activities which generate cost saving and increase business performance.

### 1.3 Problem Statement

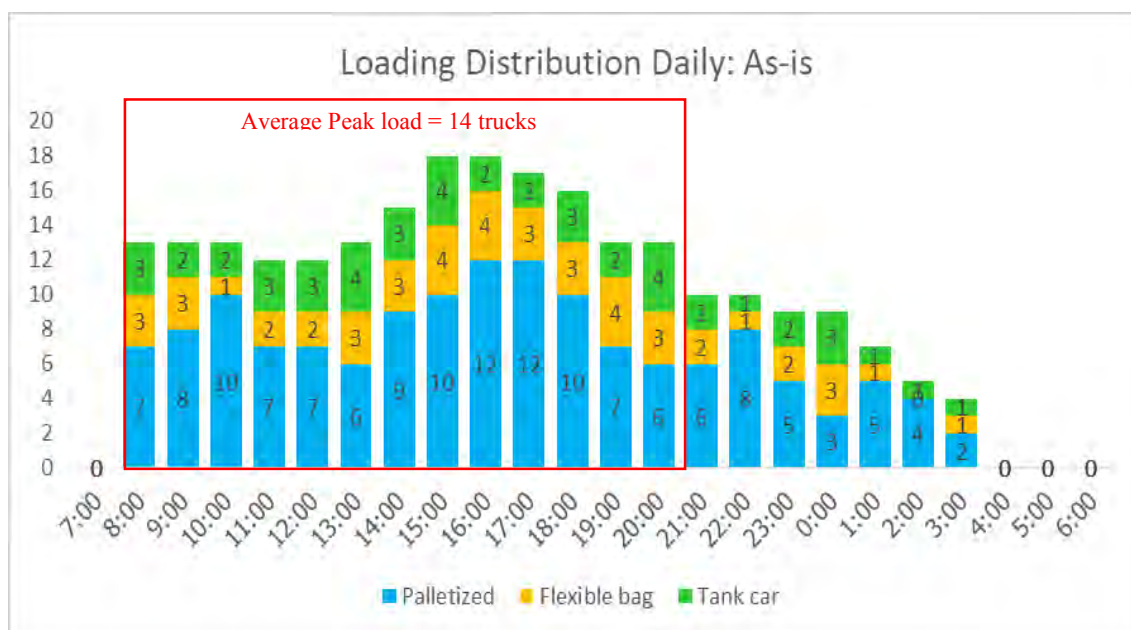
While a level of customer satisfaction is strongly related to competitive advantage of business. In order to stay competitiveness and maintain the company's position in the market, TPC recorded the number of customer service claim to monitor result of customer satisfaction.

Based on the number of customer service claim in 2017 showed that there are 90 percent of total claims caused by logistics operations which are delayed delivery, lag of working standard, driver issues, defected product from transportation and truck appearance.



**Figure 2** Number of customer service claim in 2017

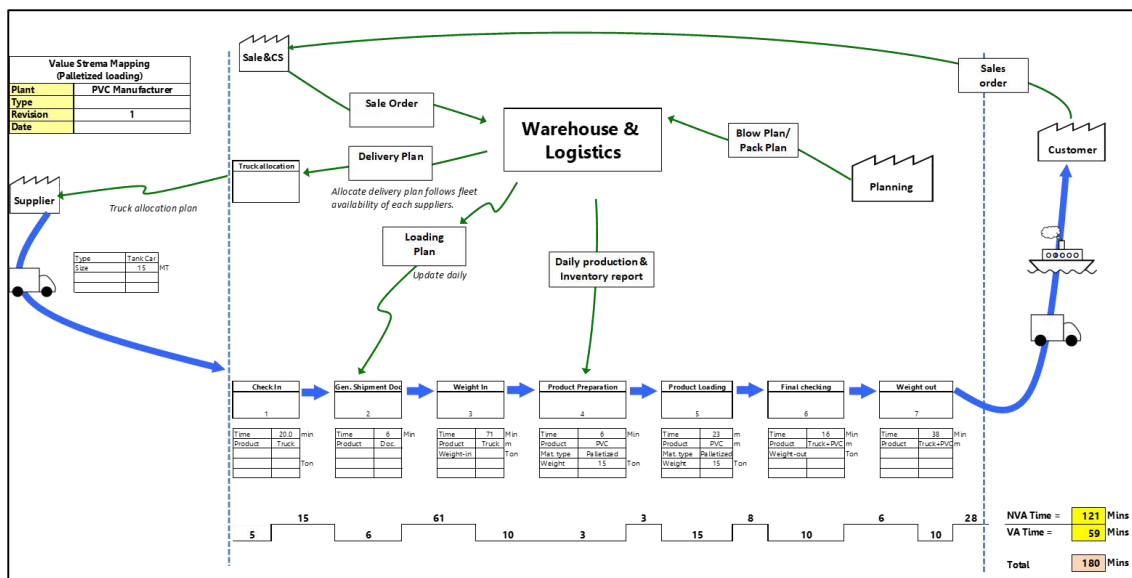
Referring to the **Figure 2**, major loss of customer satisfaction was caused by the problem of delayed delivery. There were many possible causes of delays include delay in product preparation, payment method, product loading process, information flow, system complexion and human error. Hence, the firm needs to identify the potential causes of delays in order to develop solution for improvement. Not only a higher customer service claim leads to increase customer dissatisfaction, but also increase logistics operation costs and decrease utilization of transport facilities.



**Figure 3** Loading distribution of domestic's truck

When focused on the customer claim from delayed delivery, the loading distribution of domestic's truck per hour was monitored as shown in **Figure 3**. Based on information of truck throughput time in manufacturer demonstrated that there was unbalance in loading distribution as trucks preferred to enter the manufacturer at the same time in the afternoon from 2 p.m. onward. The maximum number of loading capacity was up to 18 truck/hour while there was a few loading truck during morning and late night period. The loading capacity is limited at 12 truck/hour leads to have some waiting trucks in a yard, leading to delayed delivery to the end customers. The logistics distribution of working hour in a day can be demonstrated that working hours has peak and off peak in a day. The peak period consumed during 08:00a.m. - 9:00p.m. (13 hours per day) and the off peak hour was during 10p.m. – 7:00a.m. (11 hours per day). The traffic of truck in factory was crowned in day time while less in night time. During the peak period, some activities of operators from warehouse department and logistics department were duplicated. This work condition caused spending high overtime expense, reducing the rest time and morale for workers. As a result of unbalance loading distribution includes increased throughput time for inbound logistics operation, increased operating costs and insufficient capacity utilization of logistics facilities. In order to solve this problem, the organisation needs to have effective truck scheduling system and reduce throughput time of logistics operation.





**Figure 4** The Value Stream Mapping of PVC product

According to **Figure 4**, the Value Stream Mapping is applied in order to demonstrate the information flow and material flow representing the value-added time (VA) and non-value added time (NVA). The figure shows that an overall throughput time of the palletized PVC product was 180 minutes consisting of VA time 67% (121 minute) and NVA time 33% (59 minutes).

Normally, the PVC product is classified into two major types: made to stock and made to order. The lead time for product delivery after order summited is 24hours for made to stock product and 36hours for made to stick product. However, based the review of delivering record together with site observation, it is found that the actual lead time that is started from placing an order from customer until product delivered at customer factory, is varied from 22-26 hours for made to stock product and 33-40 hours for made to order product. While the process of order placing has time controlled and tracking process for payment within 12 hours, therefore, it can be implied that the company cannot effectively control the logistics process results in an extra lead time over than committed standard time.

#### 1.4 Research Objective

The objective of the research is to decrease inbound logistics throughput time by developing scenarios that leads to increase fleet utilization, decrease delivery time and

enhance company's performance. To achieve the target objective, the following tasks are addressed:

- 1) Study exist transport operations for PVC resin manufacturer.
- 2) Analyse process problems and define alternative solutions.
- 3) Develop logistics throughput time reduction scenarios approaching to increase productivity rate, reduce time and keep operating cost as low as possible.
- 4) Implement solution in simulation to monitor result and effect before implement in the real operation.

Based on research objectives, the following research questions are taken into account:

- 1) Does logistics management have a maximize profits management in terms of delivering time, product loading capacity and truck fleet utilization?
- 2) How will the company is able to enhance logistics efficiency in terms of throughput time reduction and increase customer's satisfaction?
- 3) What are limitations and risks of the selected solutions that need to be addressed to protect failure of the project?

### **1.5 Scope of the Research**

This research is concentrated on logistics management of a PVC resin manufacturer that approaching to improve customer satisfaction to maintain market positioning and to be the leader in cost reduction and maximize profits. As the company consists of 70 percent of domestic customers and 30 percent of export customers, the logistics management for domestic customer will be taken into consideration in order to maximize resources utilization and minimize cost of supply chain operations.

### **1.6 Expected Benefit**

- 1) Efficient logistics management encourage to maximize resources utilization that leads to minimize cost of supply chain operations.
- 2) Improve productivity rate by reducing logistics throughput time.
- 3) Reduce customer service claims and improve customer satisfaction level.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 The Benefits of Effective Logistics Management

According to Coyle et al. (2012), effective logistics management lead to improve a company's competitiveness, therefore, logistics management is an important competency for business that the company need to take into account. Effective logistics management has advantages for business in many aspects.

Firstly, an optimized logistics system result in cost saving for business by managing loading capacity, mapping type of vehicles and shipping routes to minimize logistics cost as well as managing resources to serve customer requirements with on time delivery (Harrison & van Hoek, 2005).

Secondly, sufficient logistics management has a direct impact on customer satisfaction. According to Zhang et al. (2005), the study of logistics flexibility effect on customer satisfaction. As the study demonstrated that firm that flexible to adjust their logistics process to capture the changed in customer demands will increase level of customer satisfaction.

Thirdly, based on environmental sustainability concerned, Carbon emission is resulted from logistics activities. An optimized logistics management is not only able to minimize total Carbon emission from their raw materials and finished goods transportation processes, but also promote environmental friendly awareness of business to customers (Carter & Rogers, 2008).

#### 2.2 Evaluate Value Stream Mapping for Lean Logistics

Value stream mapping (VSM) is a practical technique for various types of business approach to develop lean process. VSM can be applied to analyses working process that creates value to customers and provides effective solutions to improve decision making and re-process design (Arce, 2017). Based on lean thinking, a firm needs to manage their processes in order to develop products and services faster while improving a degree of performance and quality. VSM is considered to discover the wastes, idle process, non-valued added activities in a single approaching to develop framework that helps to minimize lead time (Tyagi, et al., 2015). With a higher work

in process and longer service time decrease service level and customer satisfaction, therefore VSM is applied as a visual tool approaching to increase service level (Yang, et al., 2015). As the lean logistics is an effective solution for improvement of the logistics operations, Transportation Value Stream Mapping (TVSM) is applied to achieve high levels of logistics distribution efficiency (Villareal, et al., 2012).

### **2.3 Enhance Logistics Distribution and Management by Truck Scheduling System.**

In logistics chain, the performance and effectiveness of logistics planning system has a direct impact with the satisfaction level of logistics service (Feng, et al., 2017). Therefore, logistics distribution management is one of the core activities approaching to increase flexibility of a business. Optimize designed logistics distribution encourages on time delivery and causing reasonable cost (Kovalsky & Micieta, 2017). Truck scheduling systems are practically approach to minimize vehicle turnaround times. By determining the number of appointments to delivery with concern to the total workload and free handling capacity in order to create optimized distribution scenario that minimize delayed delivery (Zehendner & Feillet, 2014).

### **2.4 Identifying Problem of Operation by Gantt chart**

In order to solve problems in the logistics process, an analysis tools are used to identify the problems first. A Gantt chart is a tool for following progress for project management as it allows user to identify what is the time usage in each stage of the process (Holtsnider & Jaffe, 2012). The Gantt chart tracks time if all tasks associated with a process, including the starting and ending time, the resources required and significant tasks that critical to an overall of the process. In addition, Gantt chart can be applied to assign resources and verify problems in resource management. Also, the tool can be used to the controlling process to support logistics management process (Wonchindaphan, 2014).



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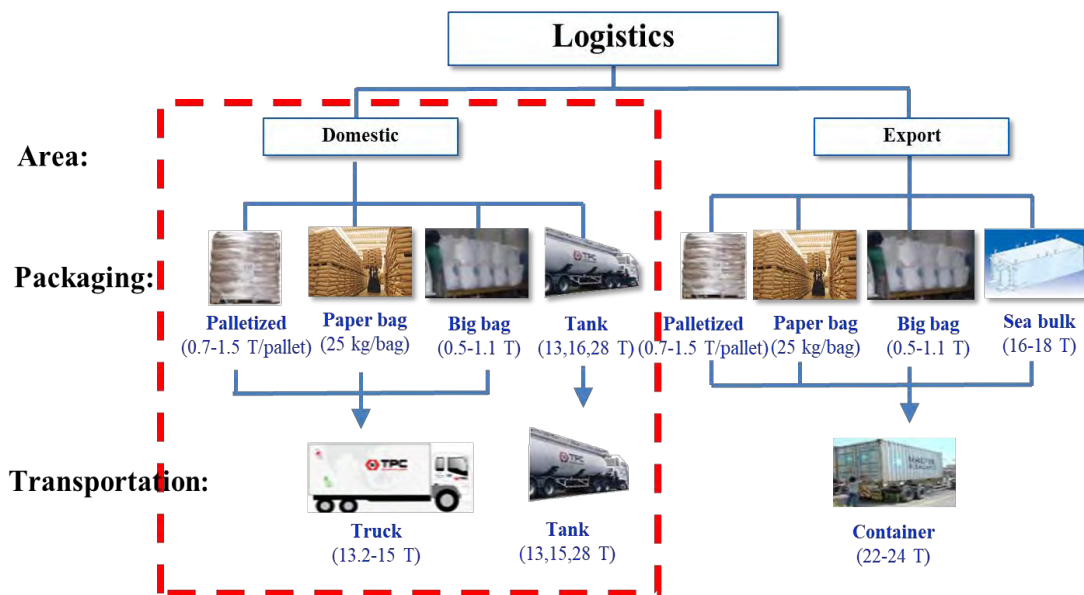
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## CHAPTER 3 METHODOLOGY

This section is purposed to initial describe the research approach on how this research is carried out in each stage. Then, the relevant information will be collected in order to be an input of the truck’s throughput time simulation model. Finally, the planned activities of the research are formulated.

There are five major steps in the research approach. The first step is to study an existing logistics operations of a PVC resin manufacturer together with collecting relevant data in order to identify gap for improvement. The second step is analyzing the collected information by the Value Stream Mapping to discover a bottleneck of the process. The third step is developing a simulation model from Arena software and validating model by using input information based on an exist operation. The fourth is creating scenarios and compare the results to find an approach solution. The last step is concluding result and preparing thesis report.

### 3.1 Studying an existing logistics operations and collecting relevant data.



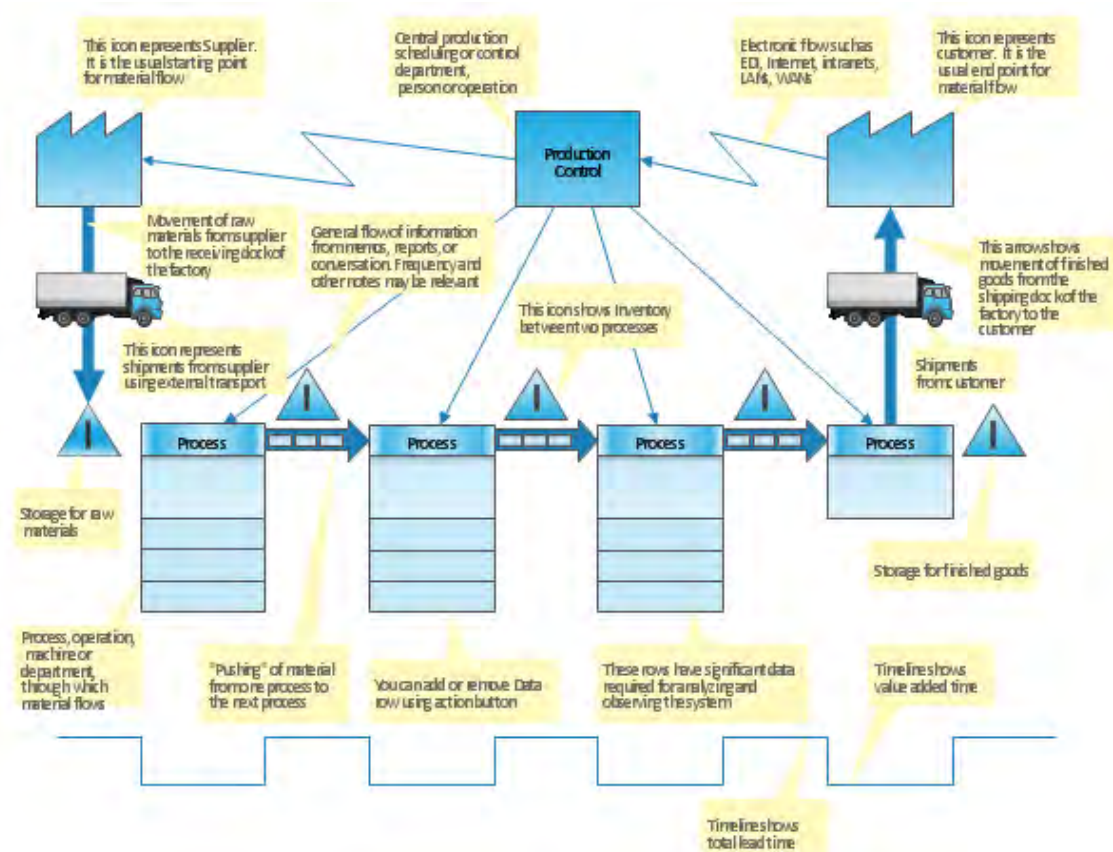
**Figure 5** TPC’s Logistics Operation

This step is focused on the current inbound logistics operations of a PVC manufacturer. According to the current domestic operations, there are two type of vehicles that are truck and tank car. Truck is purposed for deliver packaged PVC resin

product while tank car is used for unpacked PVC resin product. The different types of logistics facilities consequence of not only different of product preparation and loading processes, but also lead to have different of operating time and cost. Hence, the logistics work flow will be formulated in order to deeply understand the current situation and defines what is critical to customer ensuring that the objectives of the project have a right focused.

### 3.2 Analyzing the current operation by value stream mapping

According to a lean management principle, value stream mapping is used to analyse and design the materials and information flow while deliver a product to a customer which called “material and information flow mapping”. While VSM is often applied in lean approaching to identify and design material and information flows related with manufacturing, it can be applied in logistics and supply chain.



**Figure 6** Value stream mapping template

Before developing the Value Stream Mapping, the relevant information need to be collected in both quantitative data (e.g. number of manpower, operating time, product

loading procedures) and qualitative data (e.g. cause of delay, loading quality) by the following methods:

- Site observation

An observation is basically method for gathering exist data for both quantitative data (e.g. number of manpower, operating time, product loading procedures) and qualitative data (e.g. cause of delay, loading quality). According to Drury (2001), an observation is appropriate as initial stage of any processes in order to understand impact of the problem, collecting data from all sources and planning the next activity. Hence, the method is used to observe the real logistics operation as well as the root cause of delayed delivery. Data that planned to be gathered are as following:

- Product loading processes
- Loading capacity and time usage in different packaging
- Order management system
- Operation work flow of related functions
- Number of manpower

- Interview with concerned functions

Interview is a tool to collect qualitative data. The targeted interviewers are consisted of Sales and customer services, logistics and warehouse department. The purpose of this activity is to understand the problem that leads to define the root cause of delay delivery. The collected data will be used as initial input data of simulation modelling to create an improvement scenarios for throughput time reduction which later be applied into the day-to-day operation.

### **3.3 Developing simulation modelling through Arena software**

Approaching to design inbound logistics operation for a PVC manufacture, Arena software will be used as a tool to predict throughput time usage and delivery rate of land vehicles by simulating the movement and relation of concerned variables. Developing logistics modelling through Arena software as a baseline model that will be validated through data from actual logistics operations. Then, the different scenarios will be developed with different input variables. The results of scenarios



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will be evaluated compared with a baseline to determine its effect on the logistics loading time. Scenarios will be created by comparing different inbound logistics aspects include re-design work flow, eliminate and reduce throughput time, re-schedule logistics operation.

### 3.4 Creating scenarios and finding an approach solution

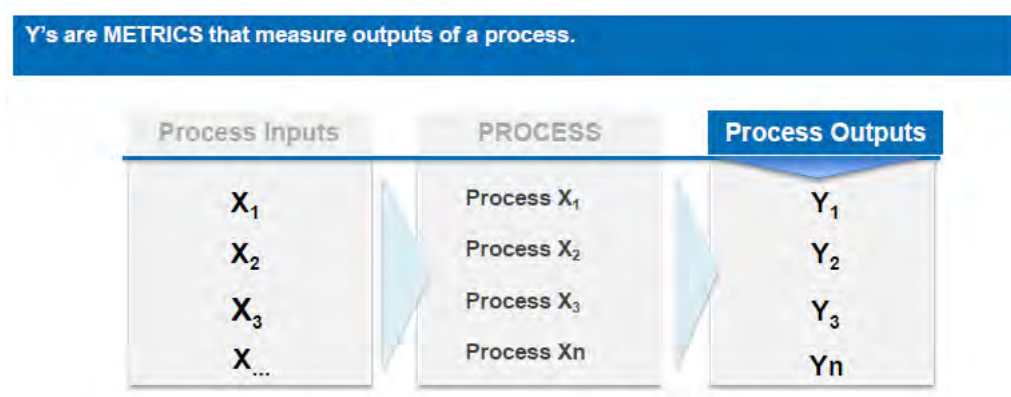
In this step, the five phases of DMAIC is applied to identify key factors that concerned to logistics distribution as well as creating scenarios for improvement.

#### *Define Phase*

The Define phase aims to identify potential factors that lead to delayed delivery of inbound logistics of a PVC manufacture. Primary, data that collected in the previous step will be determined and analysed through the Value Stream Mapping. Then, the identification of potential factors that cause delay will be defined including quantitative and qualitative factors.

#### *Measure Phase*

The main purpose of this phase is to identify what should measure as an output of the process (Y) that would be able to describe dimension, quantity, capacity, performance of the logistics distribution process.



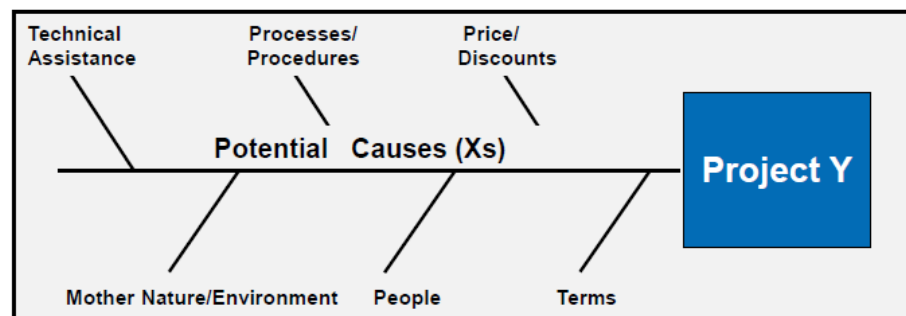
**Figure 7** The project's "Y" (SCG Chemicals, 2018)

#### *Analyse Phase*

According to the output of the process (Y) is a function of an input of process variation (X). Therefore, the analysis tools are applied to identify X's for the project Y.



By determining the key process inputs from observation and concerned functions interviews, All of X will be filtered out to remain some X that have the most critical impact on variation in the project Y. By using simulation modelling through Arena software, the different scenarios will be created through experimental runs with different variable Xs. Then, the optimal scenario will be evaluated and selected to implements.



**Figure 8** Identifying the project variation X (SCG Chemicals, 2018)

### ***Improve and Control Phase***

When the best solution from analyse phase is selected, results of data will be collected. By repeated running scenario to verify that input data during formulate the simulation model is accurate and sustain for a long run. As a result, the selected scenario will be implemented in a real operation in small scale to monitor and understand an effect before implement in a full scale. The comparison between pre-implementation and post-implementation will be concludes as the benefits of the project.

In control phase, the output form implementation will be analysed as well as method for sustain results in full scale implementation. The possible threats will be identified and the countermeasure will be provided to prevent that threats.

### **3.5 Conducting Thesis Report**

There are three main activities in this step that are solution reporting, preparing thesis report and developing the manuscript.

### ***Solution Reporting***

In this stage, theoretical concepts, research assumptions, input variables as well as results of scenarios are presented. The results of logistics scenarios will be compared in terms of direct and indirect benefits. Then, the best scenario will be concluded.

### ***Preparing Thesis Report***

Firstly, the sections of thesis will be outlined following the guideline of the University of Warwick includes introduction, literature review, methodology, results and conclusion. Secondly, the thesis book should be prepared since start developing simulation model in order to ensure that all contents are written. Also, proofreading will be conducted to make sure that all contents in the thesis book are comprehensive to readers.

### ***Developing the Manuscript (if any)***

The manuscript will be written following to the guidelines of the journal or conference where the manuscript is planned to submitted for publication. Prove-writing will be performed to make sure that the manuscript meet the journal or conference standards.

## CHAPTER 4

### IMPLEMENTATION AND RESULT

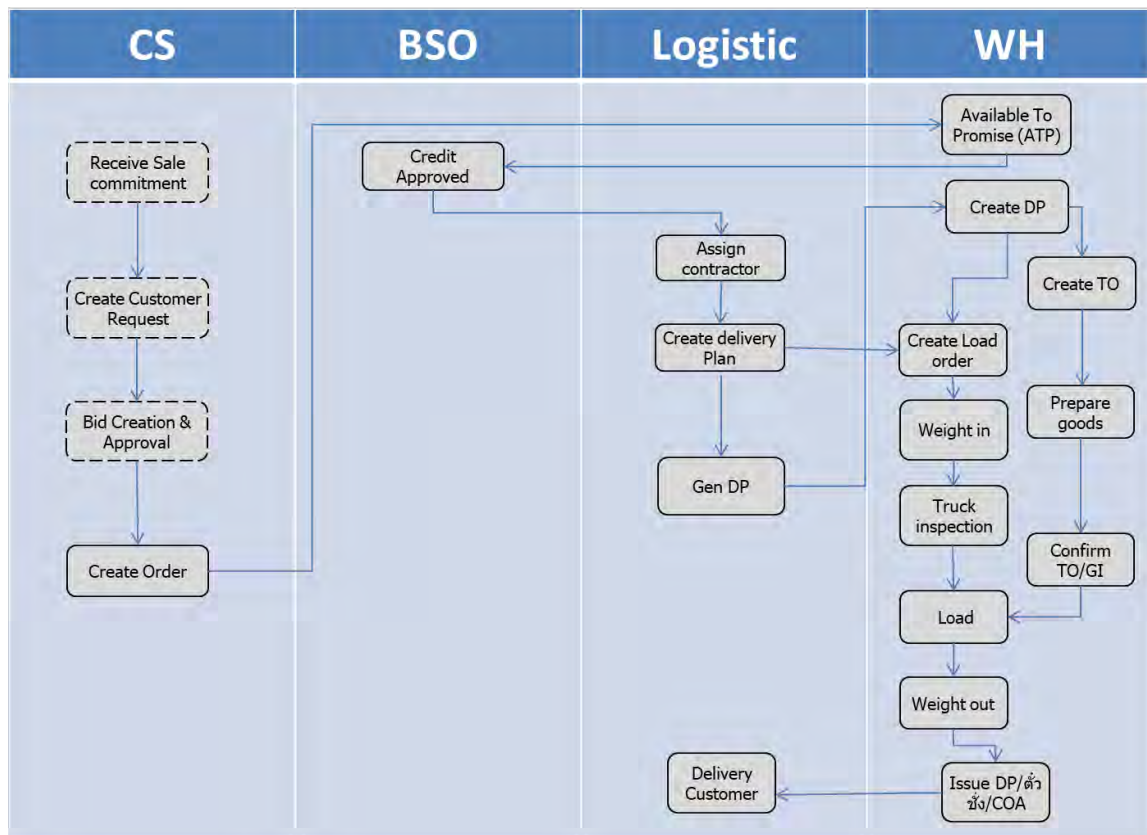
#### 4.1 Inbound Workflow Operation for a PVC Manufacture

According to inbound logistics operation of a PVC manufacture, there are consist of four main functions working together which are Customer Service (CS), Back Service Office (BSO), Logistics and Warehouse. The current working processes start with Sale inform committed order to CS who responsible to create customer order requested. Before the request is initiated, CS have to verify that the product is available in warehouse or not. Then, the requested will be submitted to BSO for payment process. All of orders have to completed payment process before passing to the next functions. Afterward, the order is sent to logistics for truck scheduling. The company use third-party subcontractors to manage all activities concerned to inbound and outbound logistics operation. The reasons of using outsource logistics provider is the needs to minimize cost of logistics operations like the cost of vehicles, cost of driver and cost of annual maintenance. By turning non-core functions over outsourcing leads company to manage the resources for core activities approaching to increase business competitiveness (Shahraki & Yazdanpour, 2007).



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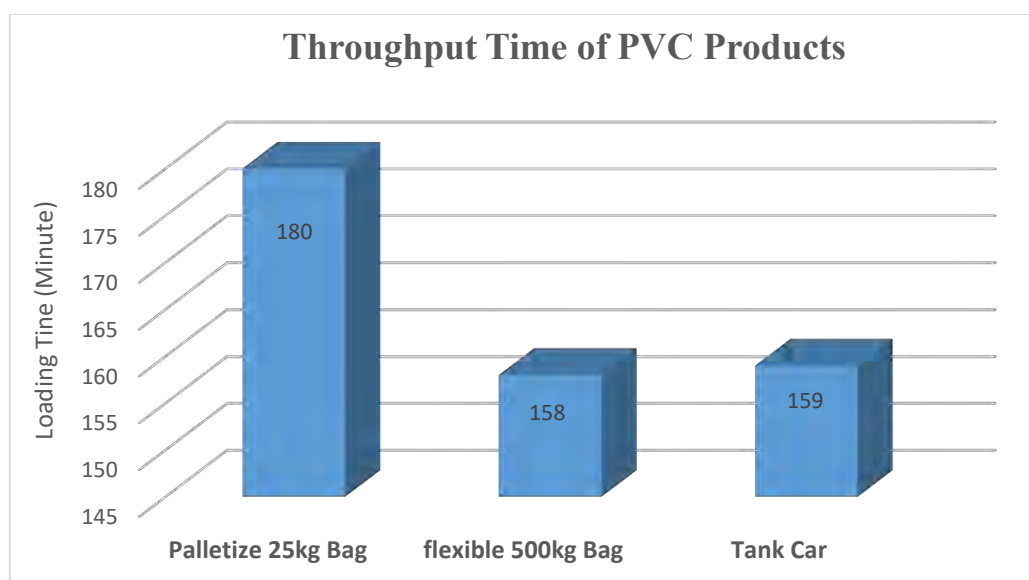
**Figure 9** A Current Logistics Workflow Operation of PVC Manufacturer

However, the company have logistics officers who responsible for manage and allocate order to all sub-contractors. They receive orders in the morning and create order plan for each supplier before 2 p.m. Then, the Delivery Paper (DP) is generated and submitted to warehouse for dispatching process preparation. Based on current operation, the company have warehouse inside the manufacturer that they are able to manage cost of warehousing and inventory level. The product dispatching activities are as below:

- Create Transfer Order: Create product transfer lists to communicate on-site officer.
- Create Loading Order: Create loading order to truck driver
- Preparing Product: Arrange the product and transfer to loading dock.
- Truck Weight-in: Empty truck is weight before products are loading-in
- Truck Loading: The products are loaded to the truck and final inspect before truck closing

- Weight-out: The truck is weighted to measure the product's weight which indicated in delivery paper.

According to the current inbound logistics operations of a PVC manufacturer, there are two type of vehicles which are 10 wheel truck and tank car. The truck is used to carry packaged PVC resin which are paper bag 25 kilograms and flexible bag 500 kilograms, while tank car is used for bulk PVC product. The different types of PVC products lead to have different loading processes that results in different of logistics throughput time as follow.



**Figure 10** Logistics Throughput Time of PVC Products

According to Just-in-time (JIT) principle, which is the common approach to increase quality, productivity and efficiency, enhancing cost and waste management (Lai and Cheng, 2019). Therefore, the PVC manufacturer is applied JIT in logistics area to achieve cost and service advantages through these following core elements:

- Customer services includes the deliver performance which the processes of products and services are conducted results in the right product deliver to the right customer at the lowest cost.
- Order Processing is about all working tasks in order cycle includes order gathering, order checking, and information transferring. The information from activities concerned to order processes provide helpful data to a firm such as

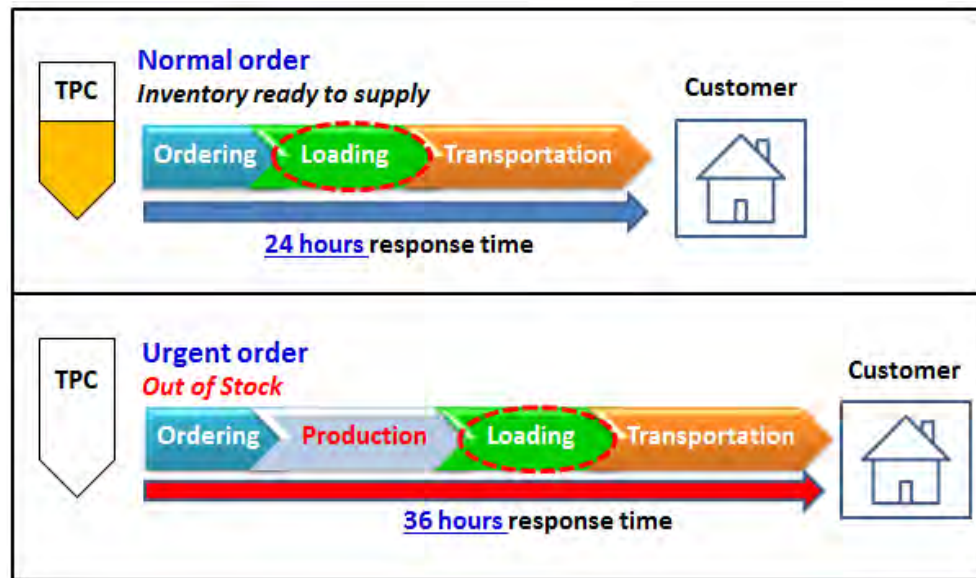
market trend, financial forecast, production scheduling and logistics management.

- Inventory Management is related with design an appropriate level of inventory balancing between customer service level and warehouse operation costs.
- Transportation is about the method to transfer physical thing like materials and finished goods to the destination in a value chain.

The company desires to implement JIT concept in order to manage the value chain activities especially for logistics. Normally, the PVC product is classified into two major types: made to stock and made to order. The lead time for product delivery after order summited is 24hours for made to stock product and 36 hours for made to order product as shown in **Figure 11**. Hence, logistics loading time is an activity that affects to order response time. Improvements in logistics loading time, not only, reduce time but also increase safety in warehouse area. Reduction of time that trucks are in factory area leads to better of traffic condition and lower risk of an accident. Moreover lower waiting time also increases satisfaction of truck drivers.



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**Figure 11** Order Response Time of PVC Manufacturer

According to Wilson (2003), one of the most visualization tool to demonstrate project timeline is Gantt chart. It shows an overall timeline for processes and their individual activities. Each of activities is presented with a bar chart showing beginning and ending. Hence, the length of the bar displays the time usage for activities to finish. Therefore, based on inbound logistics process. The Gantt chart is used to display the duration of main activities concerned to product dispatching activities as shown in **Figure 12-14**.

The different type of packaging leads to different loading time. The Figures show that the palletized 25 kilograms bag took a longest throughput time 180 minutes follow by 500 kilograms flexible bag 159 minutes and tank car 158 minutes, respectively. Based on an average time for three different types of products, the truck weighting-in and weighting-out are the longest time spent for all types of products that can be indicated that this activities should be the first focused in order to reduce total logistics throughput time.



Throughput Time of Palletized 25 kilograms Bag PVC

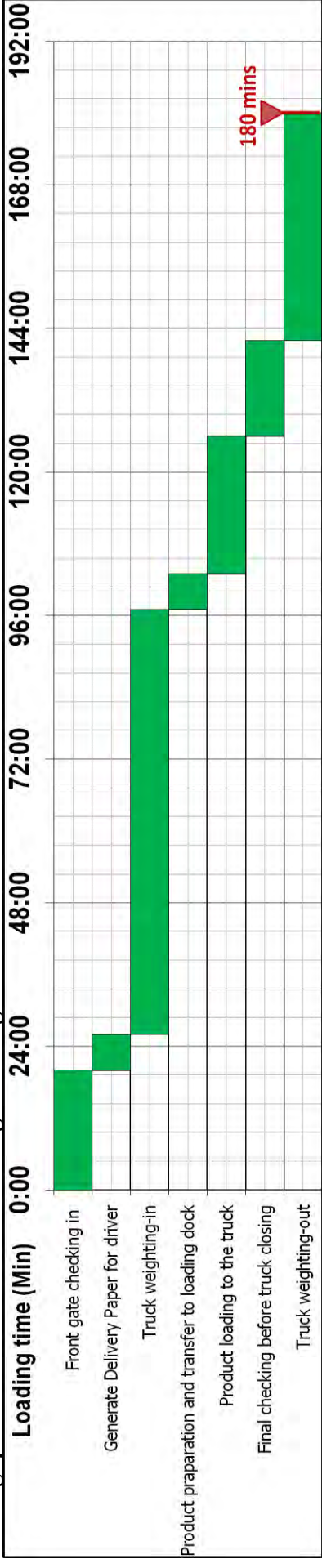


Figure 12 Gantt chart of Palletized 25KGs Bag

Throughput Time of 500 kilograms Flexible Bag PVC

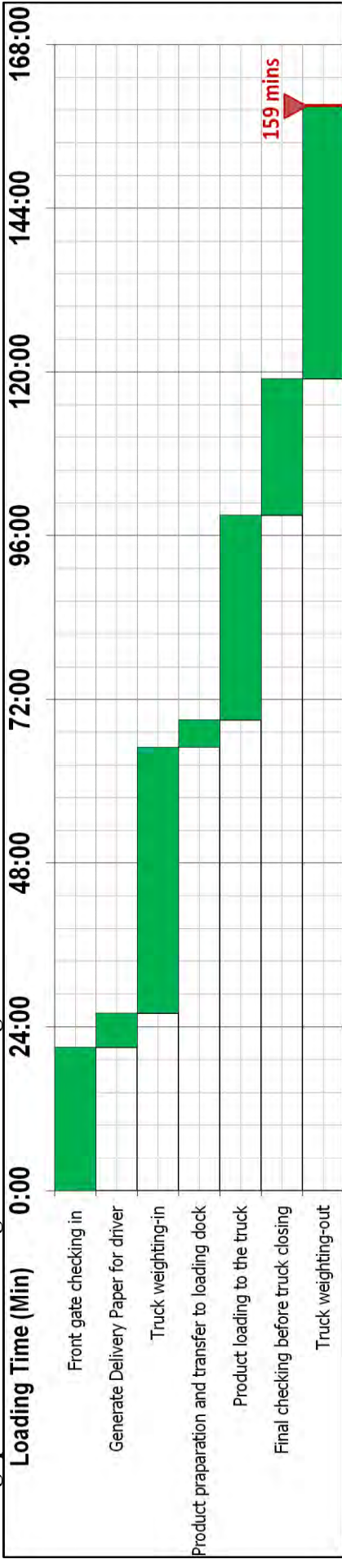


Figure 13 Gantt chart of 500KGs Flexible Bag



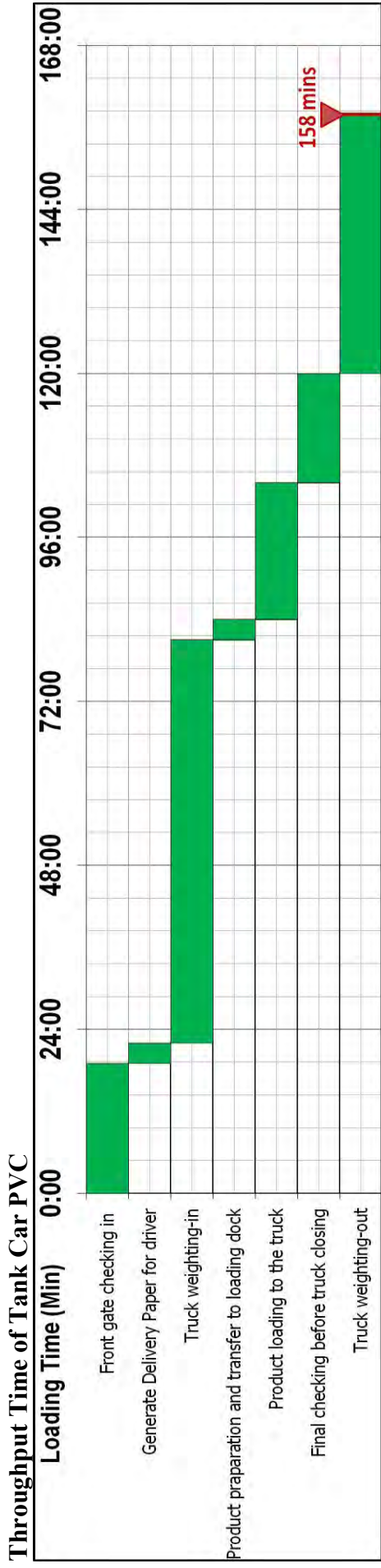


Figure 14 Gantt chart of Tank Car

## 4.2 Analysing the Exist Operation by Using Value Stream Mapping

The measurements of service providing are where the value of the overall processes. The value is what the customer needs. The company desired to analyse what valuable their logistics processes are. The Value Stream Mapping (VSM) is applied to demonstrate the flow of materials, and products. In addition a VSM also shows the flow of information and usage time between the stages in the process where Value Added Time (VAT) and Non Value Added Time (NVAT) are calculated.

According to inbound logistics loading process of PVC manufacturer, it consists of seven stages which are:

1. Front gate checking in.



**Figure 15** Truck Checking in

2. Generate delivery paper for driver: Delivery paper is generated follows daily loading plan that have information of assigned truck, targeted customer, certificate of analysis (COA), packaging type of product and product quantity.
3. Truck weighting in



**Figure 16** Truck Weight-in

4. Product preparation and transfer to loading dock



**Figure 17** Loading Dock

5. Product loading to the truck



**Figure 18** Product Loading to Truck

6. Final checking before truck closing



**Figure 19** Final Check before Truck Closing

7. Truck weighting out: The weight of PVC product is a different weight between weighting-in and weighting-out.

According to current inbound logistics operation of a PVC manufacturer, the Value Stream Mapping (VSM) is used for analyse logistics operation approaching to find the solutions to improve their services. The VSM of different types of PVC product are showed in **Figure 20-22**. There are seven key activities for inbound logistics operation. All of activities will start when order summited by customers and confirmed that there are stock to serve. The VSM is used to analyse the time usages in each activity which classified into two specific types of Value Added Time (VAT) and Non Value Added Time (NVAT).

Moreover, the VSM is demonstrate both material and information flow of the process start from sale receive order from client via monthly bidding for regular customer and via email for spot customer. The order will be sent to customer service team to check the quantity of product in stock and inform business service office team (BSO) to verify payment term. Afterward, the order will be placed to warehouse and logistics team. Normally, the warehouse and logistics officer receives order information from email twice a day: morning before 9 a.m. and afternoon before 2 p.m. Then, the warehouse officer will checks inventory and assigns lot of the product to warehouse operator in order to prepare for delivery follow daily loading plan. At the same time, logistics officer will schedule delivery plan with the third-party logistics suppliers. Normally, the product that have plan for loading today have to deliver to customer's site tomorrow morning.

## Value Stream Mapping of Palletized PVC Product

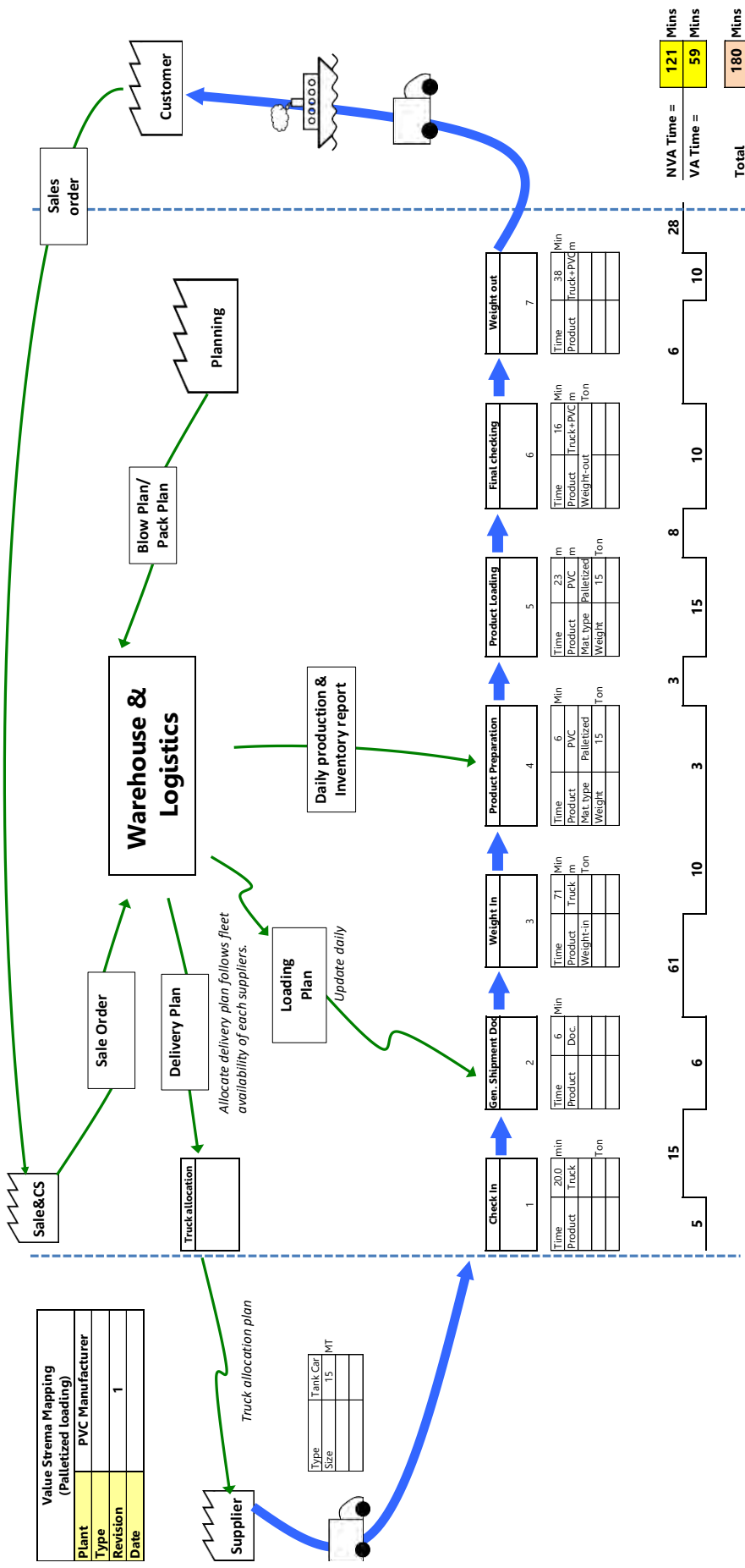


Figure 20 Value Stream Mapping of Palletized PVC Product

### Value Stream Mapping of Flexible Bag PVC Product

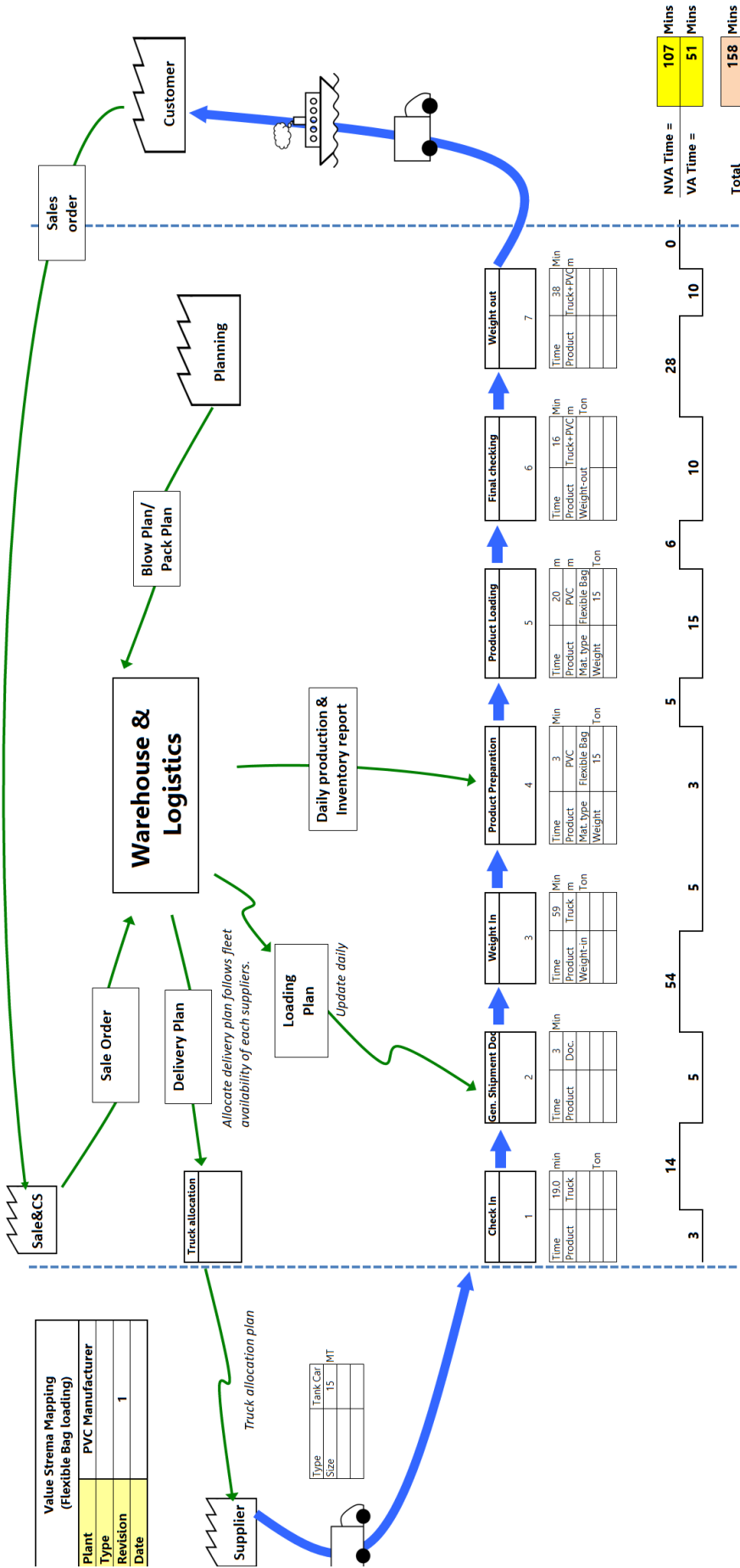


Figure 21 Value Stream Mapping of Flexible Bag PVC Product

### Value Stream Mapping of Tank Car PVC Product

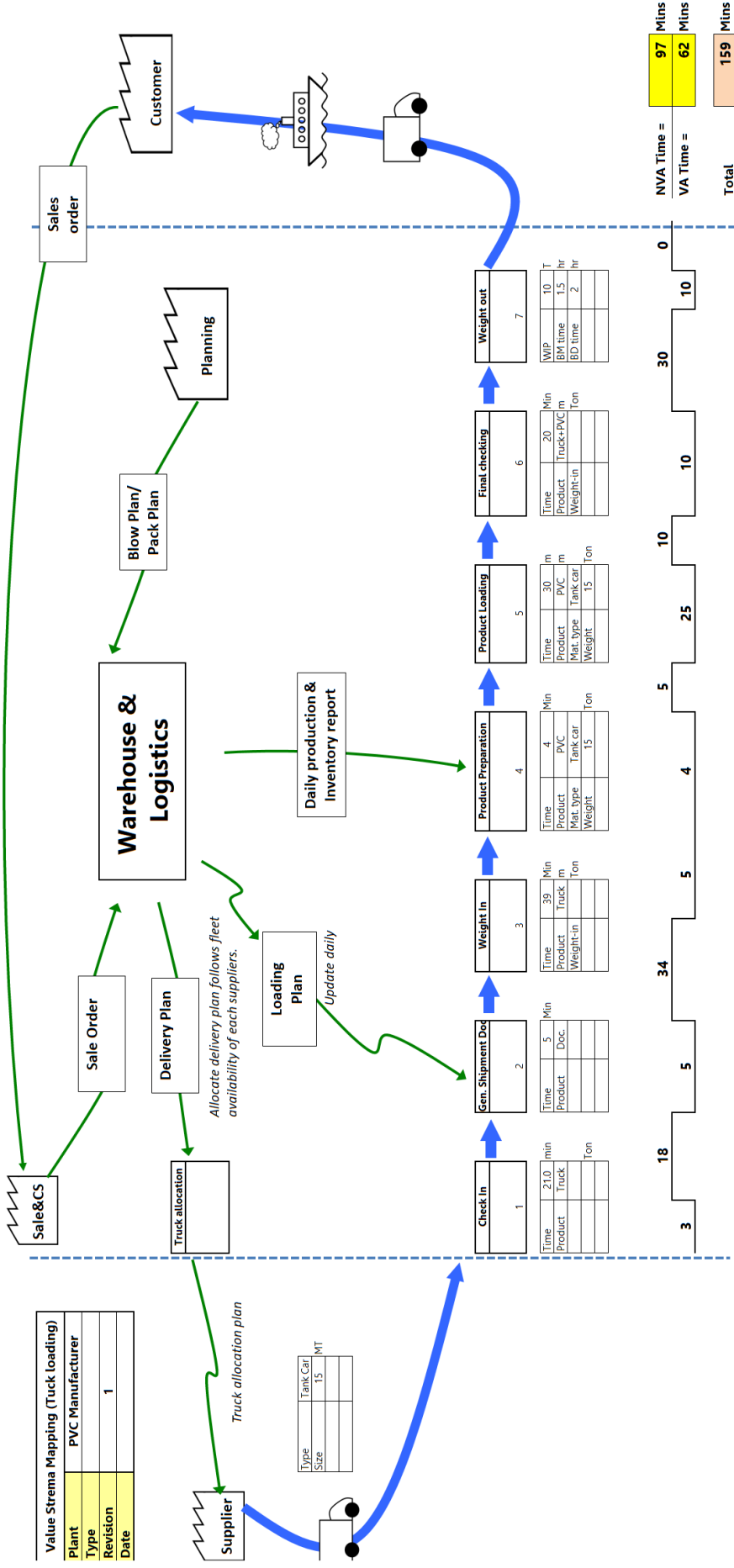


Figure 22 Value Stream Mapping of Tank Car PVC Product

According to the VSM analysis, the palletized used the longest loading time average 180 minutes/truck follows by Tank car 159 minutes/truck and Flexible-bag 158 minutes/truck, respectively. As the palletized is the main portion with approximately 60% from total domestic sale volume results in using the longest waiting time as considered for NVA time in front gate check-in, truck weight-in and truck weigh-out activities. In order to improve efficiency of inbound loading operation, the company decides to reduce loading time of all domestic packaging. Because, when the process has the waste of waiting time, this will impacts both products and workers (Villareal, 2012).

**Table 1** Value Added and Non Value Added Time of Inbound Loading Activities

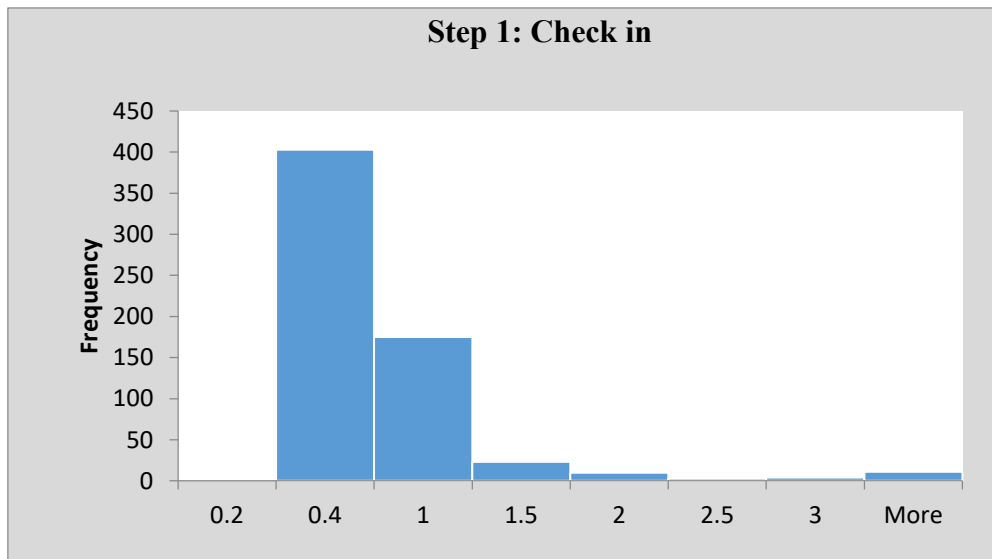
Product Type	Activities	Time (Minute)	
		VA	NVA
Palletized (Total time = 180 minutes)	1. Front gate check-in	5	15
	2. Generate delivery paper for driver	6	-
	3. Truck weighting in	10	61
	4. Product preparation and transfer to loading dock	3	3
	5. Product loading to the truck	15	8
	6. Final checking before truck closing	10	6
	7. Truck weighting out	10	28
Flexible Bag (Total time = 158 minutes)	1. Front gate check-in	3	14
	2. Generate delivery paper for driver	5	-
	3. Truck weighting in	5	54
	4. Product preparation and transfer to loading dock	3	-
	5. Product loading to the truck	15	5
	6. Final checking before truck closing	10	6
	7. Truck weighting out	10	28
Tank Car (Total time = 159 minutes)	1. Front gate check-in	3	18
	2. Generate delivery paper for driver	5	-
	3. Truck weighting in	5	34
	4. Product preparation and transfer to loading dock	4	-
	5. Product loading to the truck	25	5
	6. Final checking before truck closing	10	10
	7. Truck weighting out	10	30



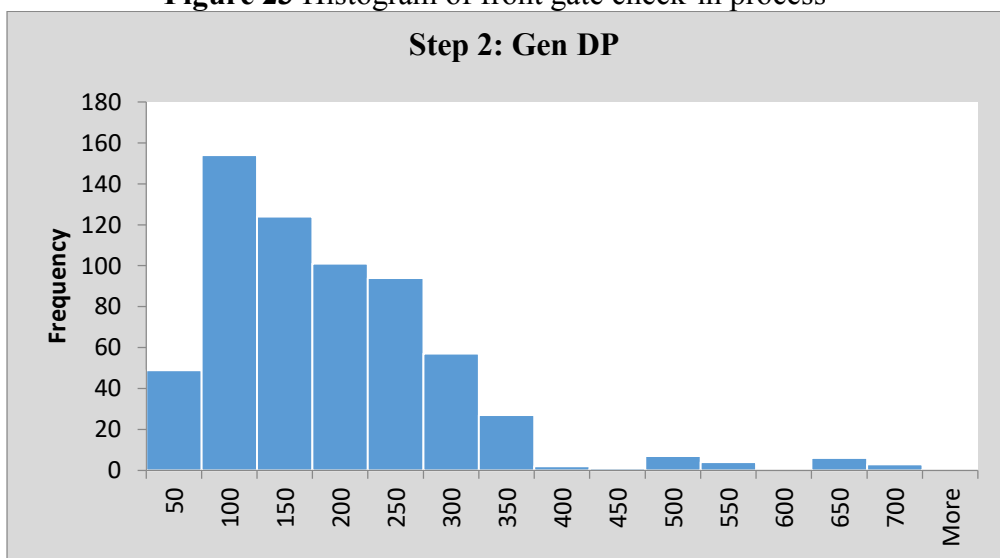


### 4.3 Determining Distribution Profile of Inbound Loading Activities

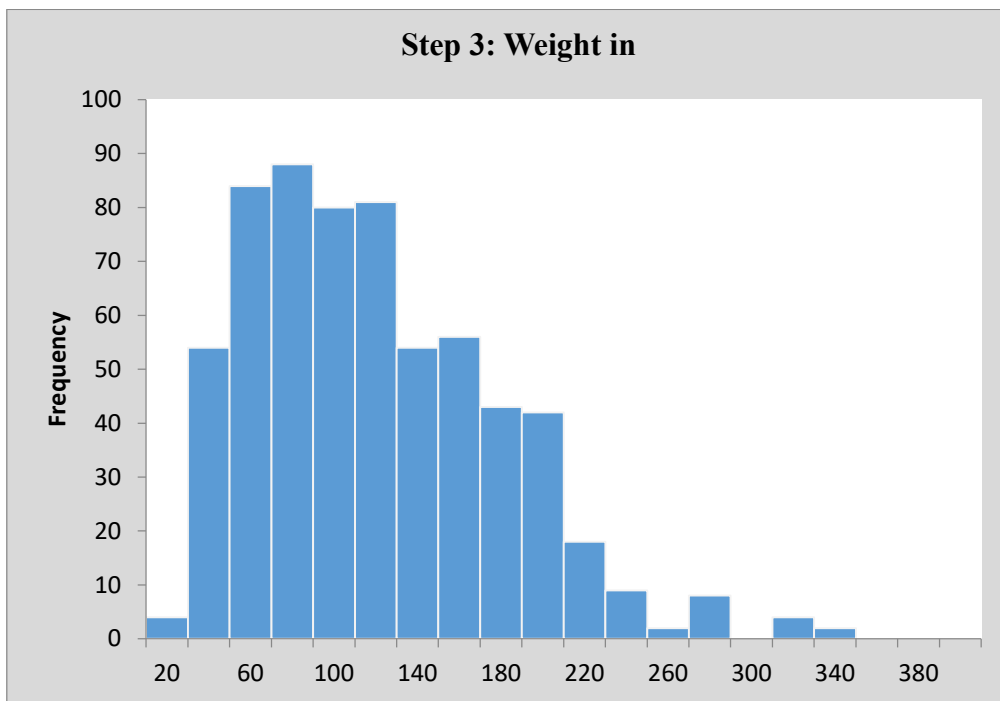
In order to analyse what is the type of data distribution in each product loading activities, not only real data for every loading operation at the logistics was collected in the real time for a week period, but also interviewing with the logistics officer and the truck drivers has been organized in order to understanding of an individual processes. As a result, actual time of each step of three types of PVC packaging were measured (Appendix A). The time usage and the frequency is used for making histogram. Then, the histogram are plotted and see the shape of the data distribution which relating to the data set as following:



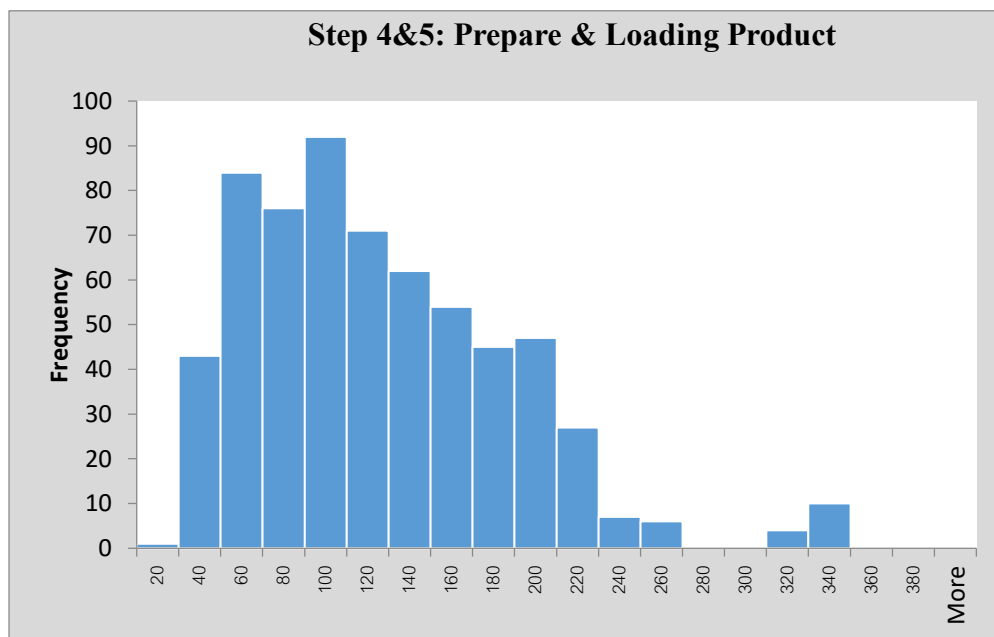
**Figure 23** Histogram of front gate check-in process



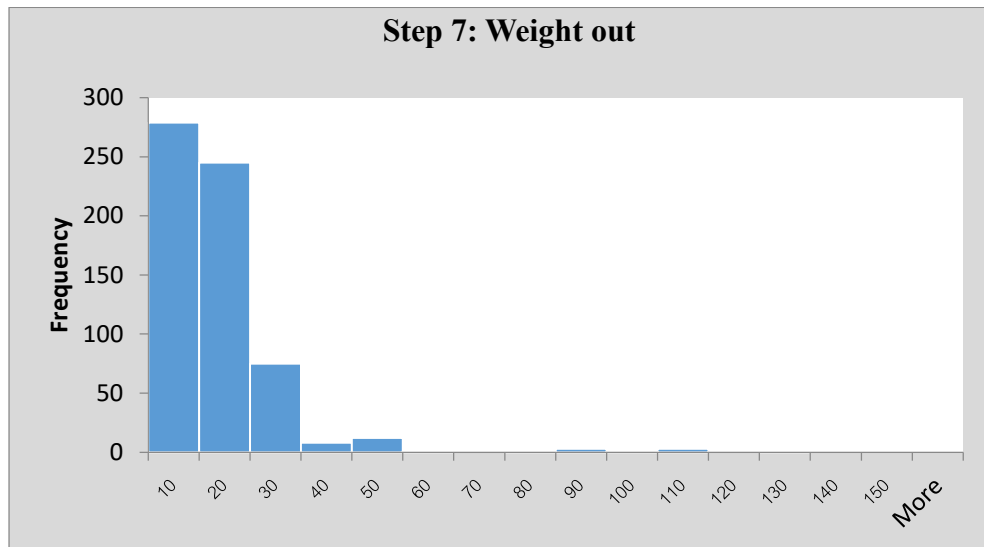
**Figure 24** Histogram of generate delivery paper for driver process



**Figure 25** Histogram of truck weight-in process



**Figure 26** Histogram of product preparation and product loading process



**Figure 27** Histogram of truck weight-out process

According to the histogram, most of histograms which are truck check-in, generate delivery paper for driver, truck weighting in, product preparation and loading to the truck and weight out show a skewed distribution to the right as the distribution has a large frequency of occurrences in the lower time usage or left side and little in the upper time usage of right side. While the step of final checking after product loading show a uniform distribution, in which each type of packaging has about the same time of checking at average 15 minutes.

The distributions for each step of inbound logistics loading times for PVC manufacturer were fitted based on data collect for a week. The distributions and the input parameters are demonstrated in **Table 2**.

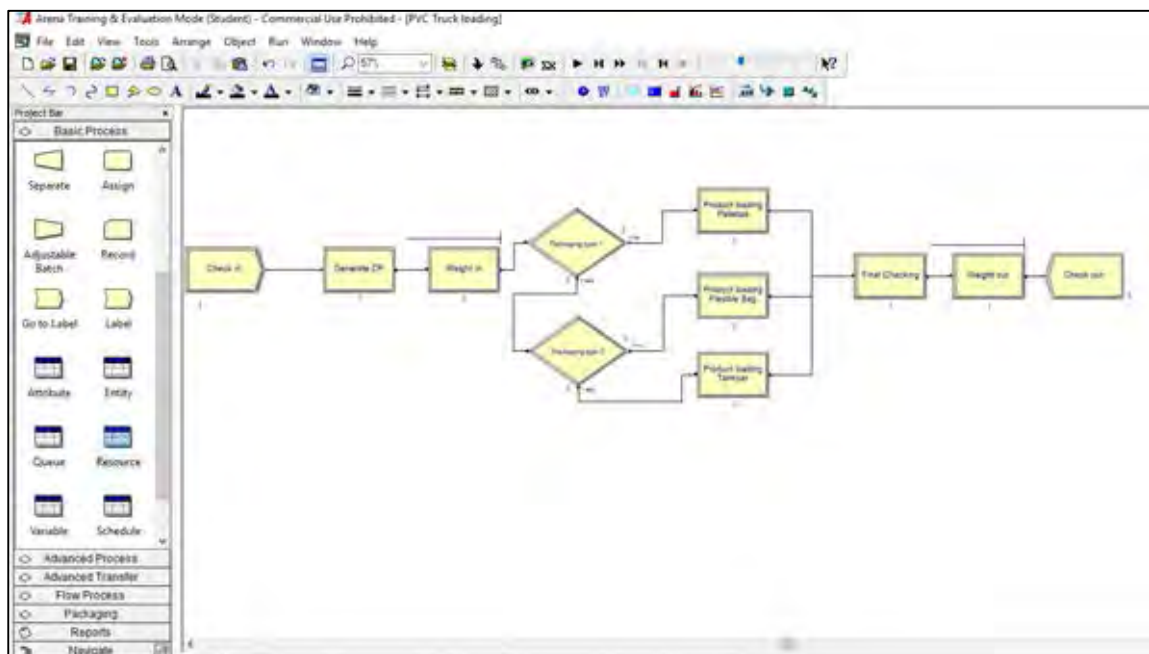
**Table 2** Distribution of Truck loading Processes

Step	Distribution	Expression
Generate DP	Normal	$N(20,20)$
Weight in	Triangular	$TRIA(14,60,150)$
Preparation & Loading: Palletized	Triangular	$TRIA(20,60,228)$
Preparation & Loading: Flexible bag	Triangular	$TRIA(17,27,399)$
Preparation & Loading: Tank car	Triangular	$TRIA(24,100,416)$
Final checking	Uniform	15
Weight out	Triangular	$TRIA(1,14,122)$

#### 4.4 Developing Model through Arena Software

The simulation model were crested using Arena software. An initial simulation model of inbound logistics loading of PVC manufacturer is developed in **Figure 28**. An input parameters must be entered into the flowchart window to model of each loading process as show in **Figure 29-33**. Start with check in dialog, the time between arrivals is Random with a value of 120 minutes. The unit of all processes are set to minutes. The entities per arrival is 5 based on actual data measurement found that each arrival is usually arrive of five separate trucks rather than one.

According to Kelton (2007), the process module consists of four possible action logic: Delay, Seize delay, Seize delay release, and Delay release. The Delay action does not require a resource. However, if the process requires the use of an equipment or machine, the Seize delay should be applied together with the resource should be assigned in order to allow for waiting and queuing until the specified machine is available for the next entity. Therefore, the process of weight in and weight out are assigned an action of Seize delay due to the process has limit of one truck scale for weight in and one truck scale for weight out.



**Figure 28** Model Window of Truck Loading Processes

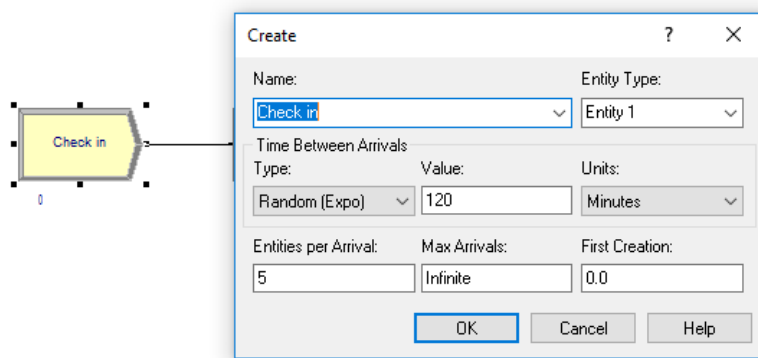


Figure 29 The Completed truck Check in Dialog

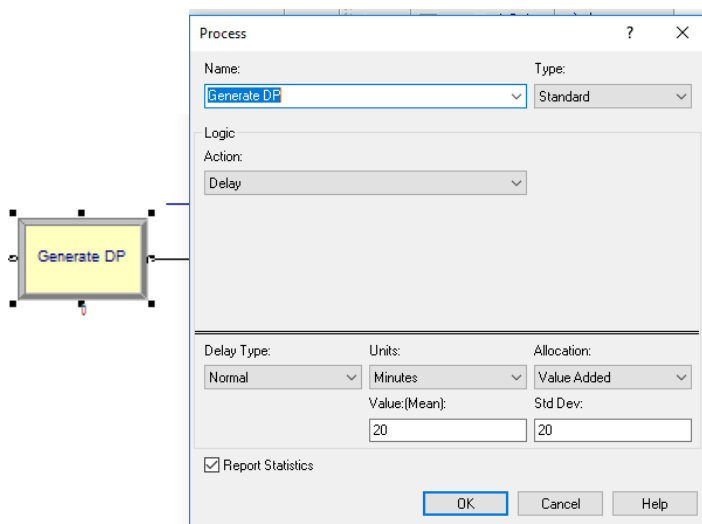


Figure 30 Completed Generation Delivery Paper Dialog

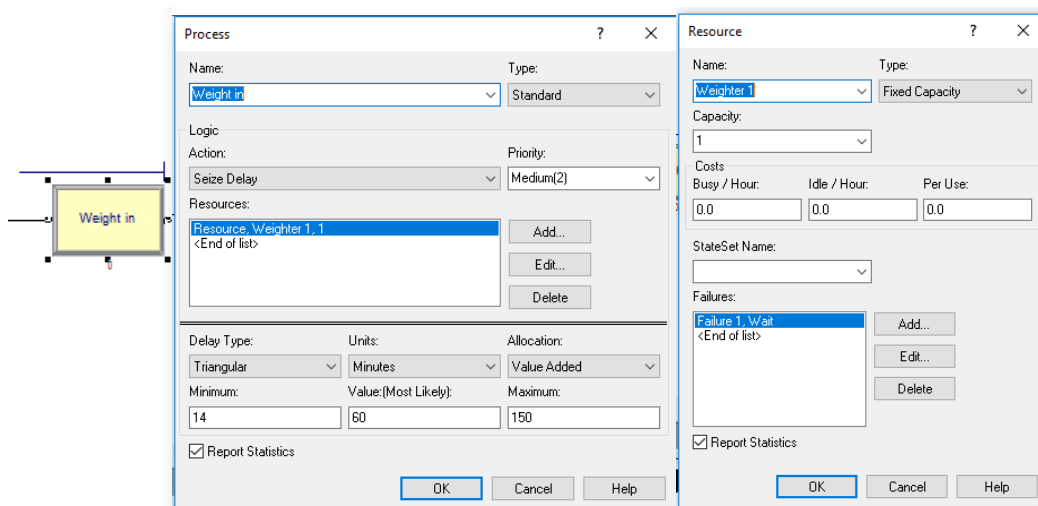


Figure 31 Completed Weight in Dialog and Resource

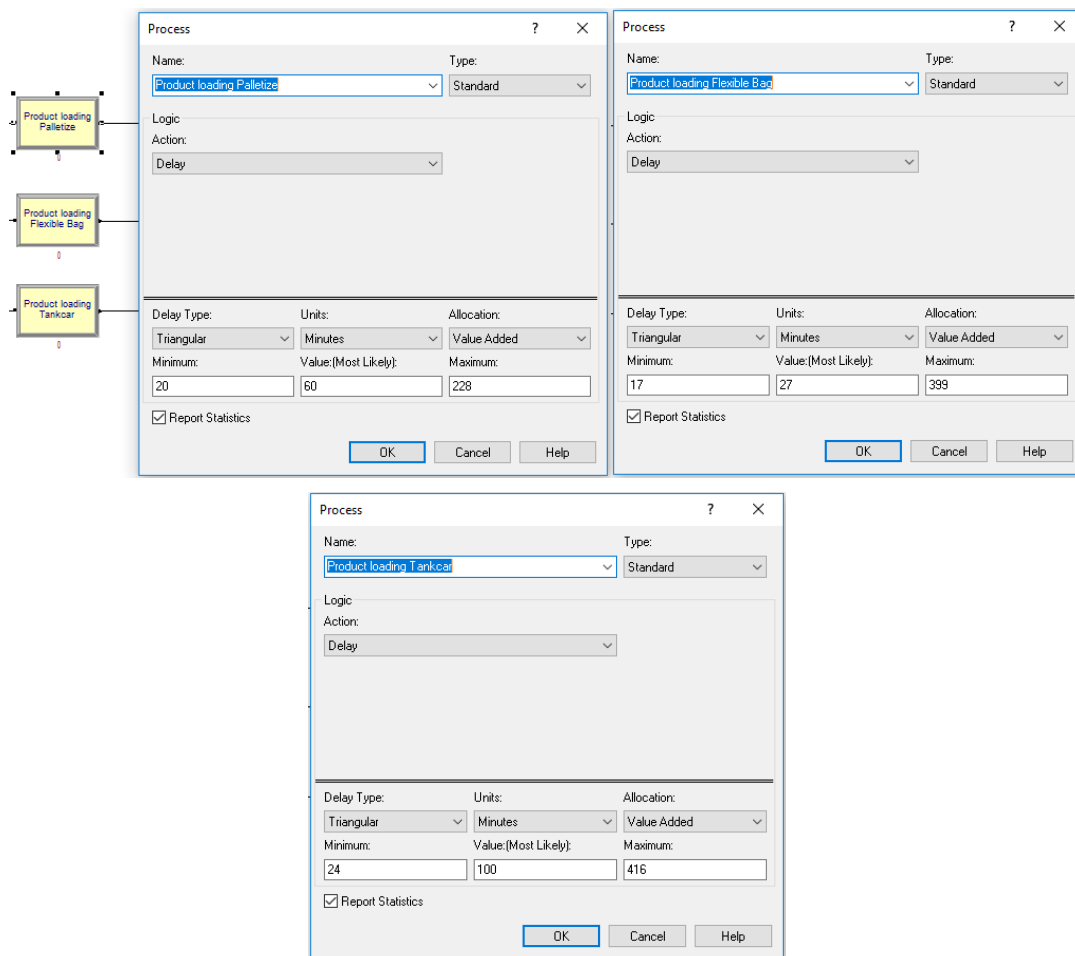


Figure 32 The Completed Product Preparation and Loading Dialog

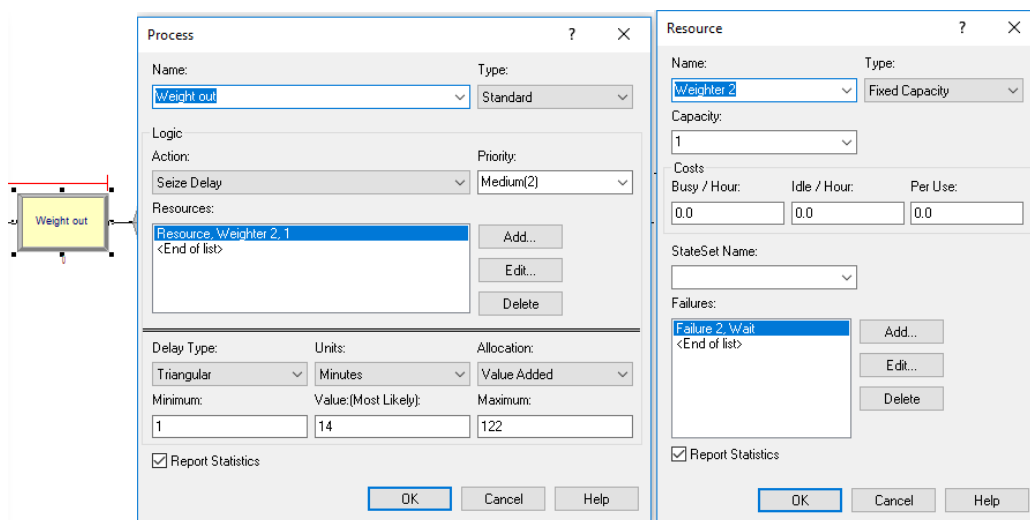


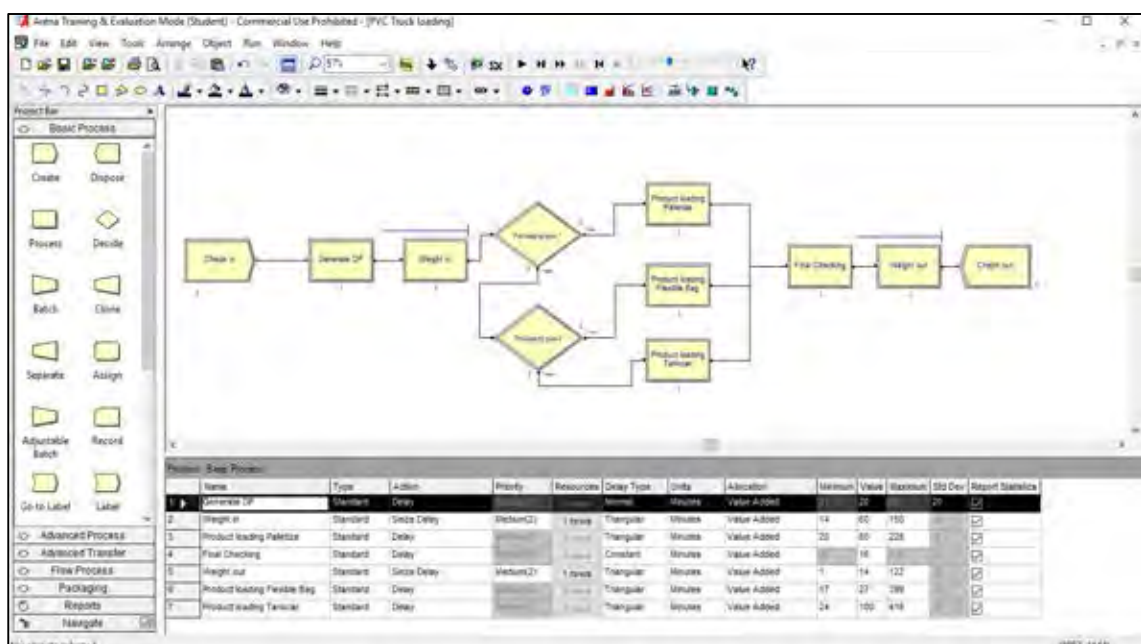
Figure 33 The Completed Weight out Dialog and Resource

#### 4.5 Verification and Validation of the Model

According to Kelton et al. (2007), the important process in the system improvement are the input verification and validation of the model. Verification is the way of ensuring that the developed models function following to the intended design process, also validation is the process of ensuring that the developed models function follows as actual process. In practically, an acceptance of validity tolerance is 10% since the tolerance level is defined that given simulation output should not different more than 10% of the real output. The validity level can be calculated in a percentage of error as follows (Liong, C.-Y&S.E.LOO, and CAREEN. 2009):

$$\text{Percentage of error} = \frac{\text{Output (simulation)} - \text{Output (actual data)} \times 100\%}{\text{Output (actual data)}}$$

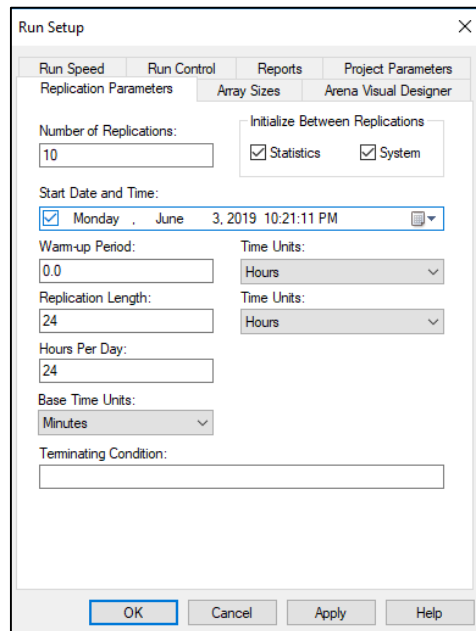
Where output (simulation) is the usage time of each loading process by the designed model and the output (actual data) refers to the usage time from actual observation.



**Figure 34** Simulation Model of Inbound Logistics Loading Operations

According to Kelton et al. (2007), the more number of replication of running model results in more corrective results for the simulation model in which preferred in real situation. However, the simulation model is developed using student version of Arena which limited only 10 replications as maximum running. Replication period is designed based on an actual period to process all step in logistics loading for PVC manufacturer.

For the simulation model, the replication period is 24 hours since the real operation operated 24/7.



**Figure 35** Run Setup Dialog for Inbound Loading System

The result of simulation model for truck loading of PVC manufacturer were demonstrated in the format of SIMAN report. The partly results are shown in **Table 3** in unit of time is in minutes (full report in Appendix B).

**Table 3** demonstrates that average residence time of each step of truck loading process of PVC product for one day. An average total time for truck transfer from supplier' warehouse to manufacturer and from manufacturer to customer were excluded in this simulation due to in the real situation, the time usage for delivering goods between the manufacturing and customer' destinations are well scheduled based on customers' location results in no waiting time occurrence.

**Table 3** Results of Simulation Model

Total Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Final Checking	16.0000	0.00	16.0000	16.0000	16.0000	16.0000
Generate DP	21.8168	1.94	18.8530	28.6282	0.00	84.1617
Product loading Flexible Bag	20.2117	35.17	0.00	153.11	0.00	153.11
Product loading Palletize	43.2571	32.41	0.00	136.50	0.00	136.50
Product loading Tankcar	25.3083	40.98	0.00	170.79	0.00	170.79
Weight in	77.7176	23.67	37.5028	129.95	37.5028	129.95
Weight out	41.1035	18.72	5.2971	80.3183	5.2971	80.3183



The average times for generate delivery paper, truck weight in and truck weight out process in the simulation model are quite similar as the real situation of 21.82 minutes, 77.71 minutes and 41.10 minutes respectively. Truck's drivers waited for a long period of time in these processes due to there are very congestion as the process has just one truck scale for weight in and one truck scale for weight out. Moreover, there are complicated process of delivery paper generation that take a long time to complete. Product preparation and loading for Palletized, Tank car and Flexible bag in simulation model were 43.25 minutes, 25.30 minutes and 20.21 minutes. The Palletized PVC take the longest loading time due to it is the main portion of domestic's orders about 60% from total domestic volume. Moreover, this longest service time was probably be caused by lack of manpower and loading facilities.

In order to verify results of simulation whether the average time of each process is likely to an actual data from field measurement or not. The hypothesis testing is apply for testing which t-Test type is selected due to the number of sampling are less than 30 and likely to be normal distribution. The t-Test is applied by Excel in order to test the null hypothesis that the means of two sets of data are equal.

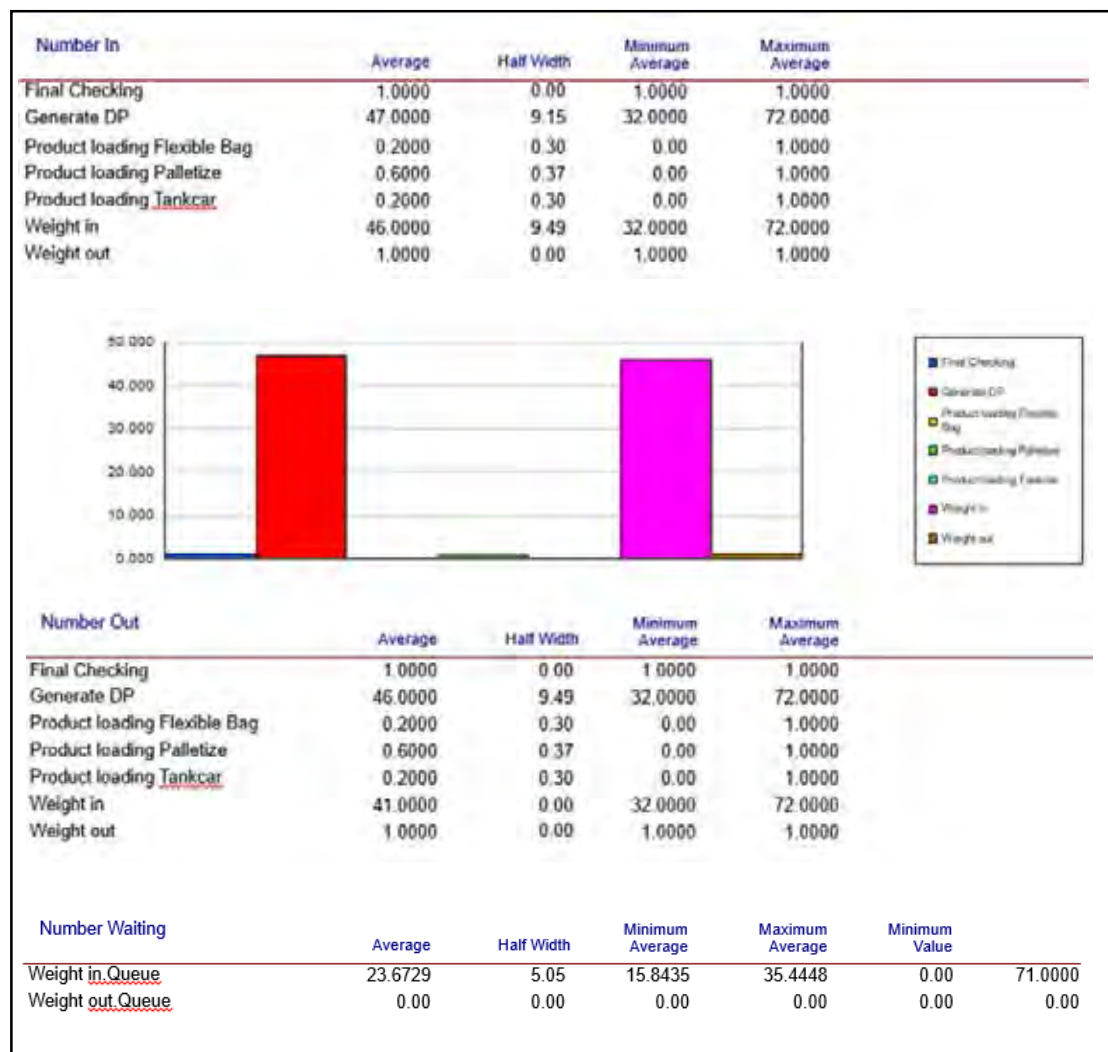
The null hypothesis,  $H_0: \mu_{Act} - \mu_{Model} = 0$

The alternative hypothesis,  $H_a: \mu_{Act} - \mu_{Model} \neq 0$

Actual Data (mins)		Model		t-Test: Two-Sample Assuming Unequal Variances	
Time	Weight in	Replication	Output		
10:00-11:00	50.14	1	78.3454		
11:00-12:00	66.49	2	76.348	Mean	50.1356 78.3454
12:00-13:00	73.08	3	77.3343	Variance	79.774878 76.8807
13:00-14:00	87.33	4	76.8743	Observations	157.70542 0.239309
14:00-15:00	79.35	5	77.3235	Hypothesized Mean Difference	9 9
15:00-16:00	94.20	6	77.3665	df	0
16:00-17:00	90.95	7	77.2524	t Stat	8
17:00-18:00	95.35	8	76.9675	P(T<=t) one-tail	0.6908661
18:00-19:00	63.79	9	76.2244	t Critical one-tail	0.2545977
19:00-20:00	67.43	10	76.2354	P(T<=t) two-tail	1.859548
				t Critical two-tail	0.5091954
					2.3060041

**Figure 36** The Hypothesis Testing Result

After do t-Test (unequally), the null hypothesis can be rejected if  $t \text{ Stat} < -t \text{ Critical two-tail}$  or  $t \text{ Stat} > t \text{ Critical two-tail}$ . However, the null hypothesis is true since the result demonstrated that  $-2.306 < 0.691 < 2.306$ . As a result, the testing shows that the time simulated by modelling are quite likely to the actual time.



**Figure 37** Result of Number Truck in and Truck out

According to simulation results, it was found that there were 47 customers' truck which enter generate delivery paper process but 46 truck had passed. Similarly, there were 46 customers' truck which enter the truck scale for weight in process but only 41 trucks had left. Also, the result shows that the average queue for weight in process is 23.67 minutes. It can be seen that these are bottlenecking processes that have to be solved. However, all the rest processes involved in the truck loading system, the average number in and number out are 1 due to there has no limit of resources.

## 4.6 Improvement Scenarios for Inbound Logistics Process

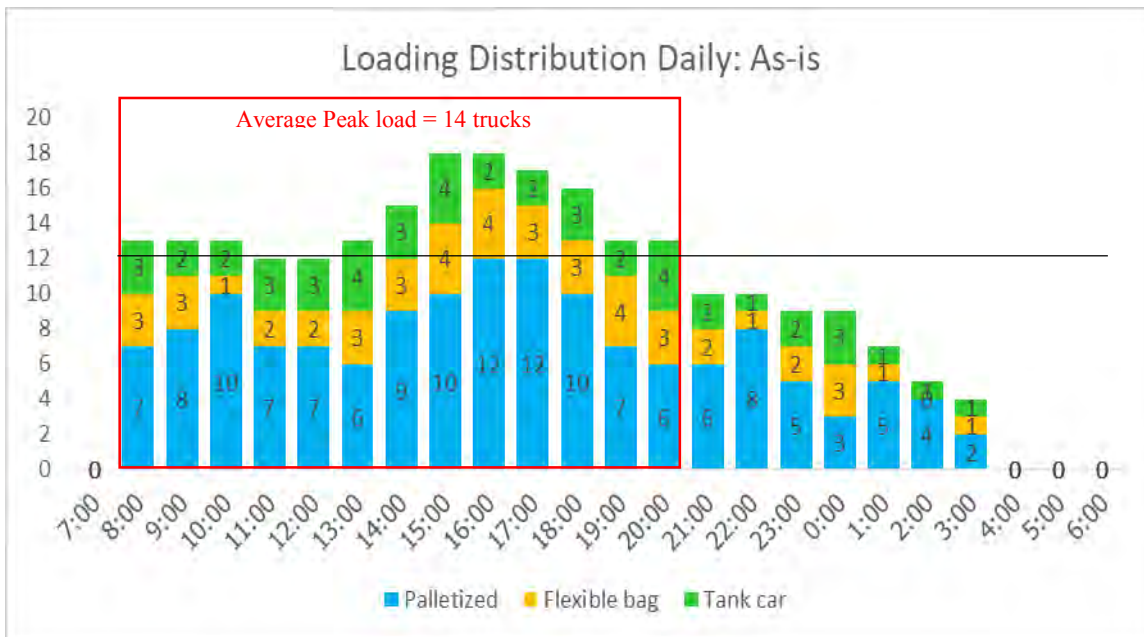
Based on the bottleneck processes in exist simulation model leads to analyse what are in-process wastes. The wastes are identified by using ECRS concept – eliminate, combine, rearrange, and simplify, some improvement scenarios have been proposed for enhance system which are as following:

### 4.6.1 Implement Truck Scheduling

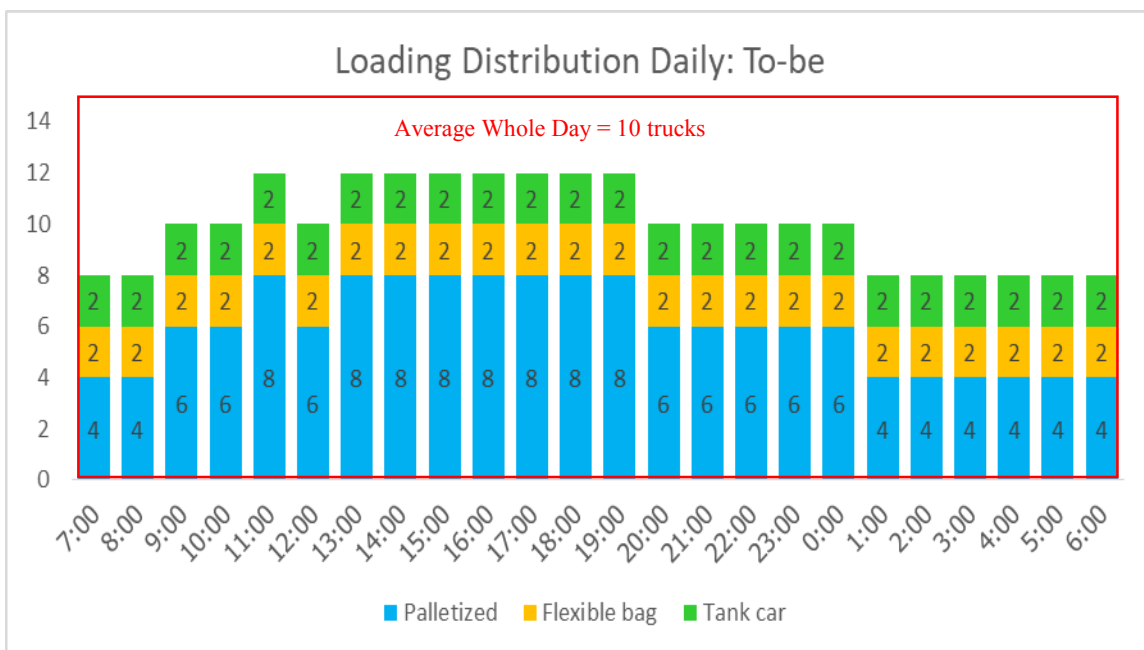
In order to reduce logistics loading time for PVC manufacturer, the arrival time of customers' truck should be scheduled first. Logistics management can schedule arrival time for each truck that reduce the congestion of truck at the same period of time. Based on existing operation, logistics officer who responsible to manage and allocate order to all sub-contractors. They receive orders in the morning and create order plan for each supplier. However, there is no time specified for each truck results in having truck congestion in some period in the afternoon.

The logistics distribution of working hour in a day is shown in **Figure 38** and founding that working hours has peak and off peak in a day. The peak period consumed during 08:00a.m. - 9:00p.m. (13 hours per day) and the off peak hour was during 10p.m. – 7:00a.m. (11 hours per day). The traffic of truck in factory was crowned in day time while less in night time. During the peak period, some activities of operators from warehouse department and logistics department were duplicated. This work condition caused spending high overtime expense, reducing the rest time and morale for workers.

Balanced by ECRS technique, Re-arrange the schedule of trucks in a day by leveling number of trucks in each hour of a day. New schedule will reduce the peak load from 14 trucks per hour in day time to 10 trucks per hours in whole day as shown in **Figure 39**.



**Figure 38** As-is Loading Distribution Daily



**Figure 39** To-be Loading Distribution Daily

The scheduled of truck loading daily and other materials concerned to product loading activities will be shared within related functions which are customer services, planning, warehouse and logistics. By creating a centre data file for logistic contractor leaders to match truck with product receiving plan. Warehouse shift supervisor

provides a daily excel file for logistics contractor leader to match their trucks with product receiving plan and available time.

LOCAL			Domestic Loading Schedule													DELIVERY DATE : 10/4/2019								
CUSTOMER	ORDER NO.	TYPE	QTY (Kg.)	Order No. SCG	REMARK	Contracter						ผู้รับมอบหมาย		รถบรรทุก		QTY (Mt.)	วันที่รับ	เวลา	หมายเหตุ					
						RPP	STN	INTER	M.O.L	SCG	CUS	SUB	รถบรรทุก	D/O	SHIPMENT									
RIKEN (THAILAND) CO.,LTD.	1087566	SM760GF1B1000	48.00	23045437	# 777 Flexy bag 1 # 111 # 1 Pallet	2	2						RPP	70-3609	260295	94935	12	15	14	16.11				
NAWA PLASTIC INDUSTRIES CO.,LT	1087535	SF580GF1B1100	26.40	27473348		2							STN	71-0598	260296	94959	12	/	14	17.00				
NAWA PLASTIC INDUSTRIES CO.,LT	1087554	SF580WF1B1100	59.40	27473872	RPP 221 NY 13 2'2 นิ้ว 11	2		2					INT	71-0532	260307	94962	13.2	/	14	16.01				
NAWA PLASTIC INDUSTRIES CO.,LT	1087553	SF580OF1B1100	1.10	27473872	LOT 06130894	0							RPP	70-3478	260310	94940	1.1	/	14	18.07				
REHAU CO.,LTD.	1087529	SG610GP211500	4.50	27472616		1							RPP	70-3595	260313	94941	4.5	/	14	17.31				
NAWA PLASTIC INDUSTRIES (SARAB)	1087540	SP660GP111500	30.00	27473433		2							STN	71-0472	260316	94950	15	/	14	15.12				
			<b>439.40</b>			<b>13</b>	<b>10</b>	<b>6</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>30</b>												

Figure 40 Daily Truck Scheduling Form

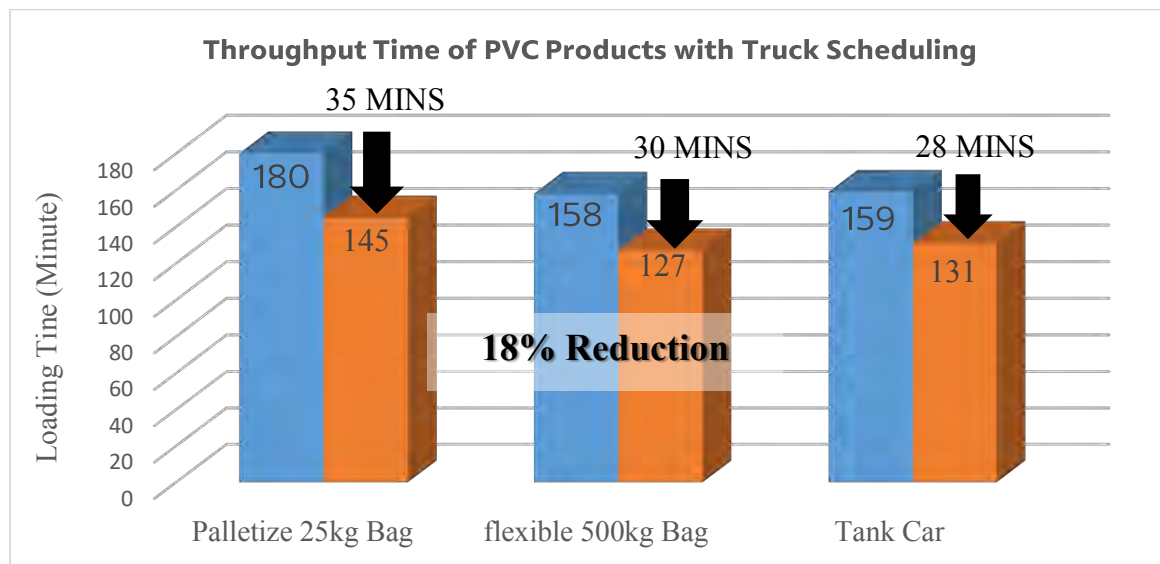


Figure 41 Throughput Time of PVC Products with Truck Scheduling

By implementing truck scheduling, the activities that contain Non-value Added time are focused and reduced by 18% which are front gate check-in, truck weighting in, final checking before truck closing and truck weighting out.

**Table 4** Value Added and Non Value Added Time of Inbound Loading Activities

Product Type	Activities	Time (Minute)	
		Before	After
Palletized (Total time = 145 minutes)	1. Front gate check-in	20	5
	2. Generate delivery paper for driver	6	6
	3. Truck weighting in	71	56
	4. Product preparation and transfer to loading dock	6	6
	5. Product loading to the truck	23	23
	6. Final checking before truck closing	16	11
	7. Truck weighting out	38	28
Flexible Bag (Total time = 128 minutes)	1. Front gate check-in	17	7
	2. Generate delivery paper for driver	5	5
	3. Truck weighting in	59	54
	4. Product preparation and transfer to loading dock	3	5
	5. Product loading to the truck	20	20
	6. Final checking before truck closing	16	11
	7. Truck weighting out	38	28
Tank Car (Total time = 131 minutes)	1. Front gate check-in	21	7
	2. Generate delivery paper for driver	5	5
	3. Truck weighting in	39	34
	4. Product preparation and transfer to loading dock	4	4
	5. Product loading to the truck	30	30
	6. Final checking before truck closing	20	15
	7. Truck weighting out	40	36



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The pros and cons of the truck scheduling are as follow:

Pros:

- Based on the manufacturer has 24/7 operation. The truck scheduling improves the logistics process by balancing workload of machines such as forklift, tank car loading machine.
- During the peak period in day time, the workers in day shift work harder than the worker in night shift which results in lower efficiency. The truck scheduling increases efficiency of logistics operators.
- Real time monitoring and tracking for logistics providers by monitoring in scheduling web browser.

Cons:

- Investment for scheduling system is approximately 0.5MB.
- Computer skill required for working team

#### **4.6.2 Reduce Logistics Throughput Time**

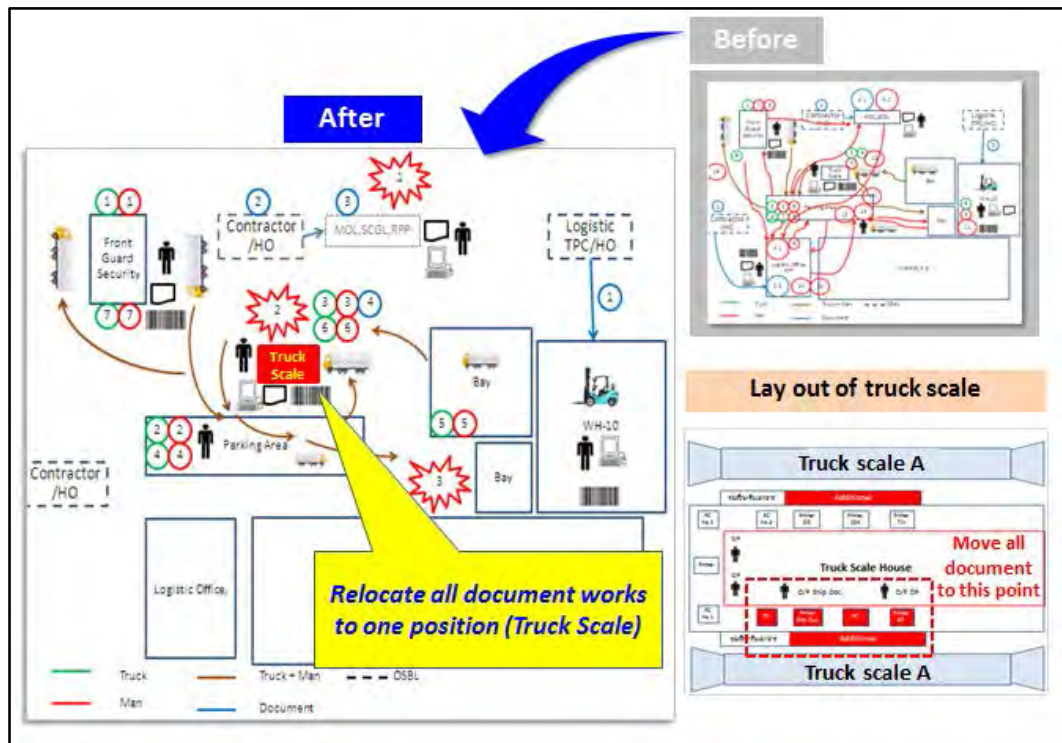
Logistic loading time is an activity that affects to order response time. Improvements in logistic loading time, not only, reduce time but also increase safety in warehouse area. Reduction of time that trucks are in factory area leads to better of traffic condition and lower risk of an accident. Moreover lower waiting time also increases satisfaction of truck drivers.

In order to reduce logistics lead time, the combination of improvement of logistics processes are included as the cause of delay usually comes from all functions related in the same value chain not from one department. The cause of long logistics lead time includes delays of materials flow and information flow. Hence, an existing logistics process were analysed to define an in-process wastes by using fishbone diagram and ECRS principle – eliminate, combine, rearrange and simplify. Improvement activities to reduce logistic loading time are as follows:

- **One stop service for document**

Applying spaghetti chart to analyse work flow of loading activities distinguish the confusion. Many document works at different locations cause work flow very

complicated as shown in **Figure 42**. To reduce this mess, all document works are combined and move to only one location.



**Figure 42** Improvement of Document Flow Process

- Use ECRS concept to eliminate unnecessary work

ECRS concept was applied to eliminate unnecessary work and rearrange work steps such as preparation of goods in advance for loading before trucks arrive.



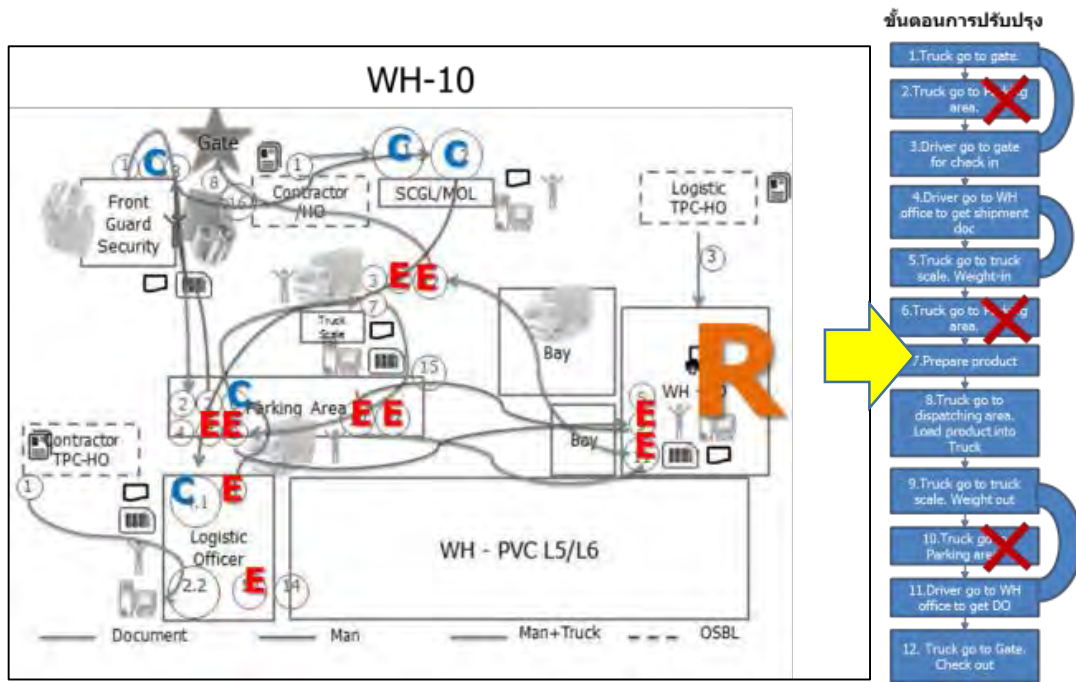


Figure 43 ECRS Analysis for Logistics Operation

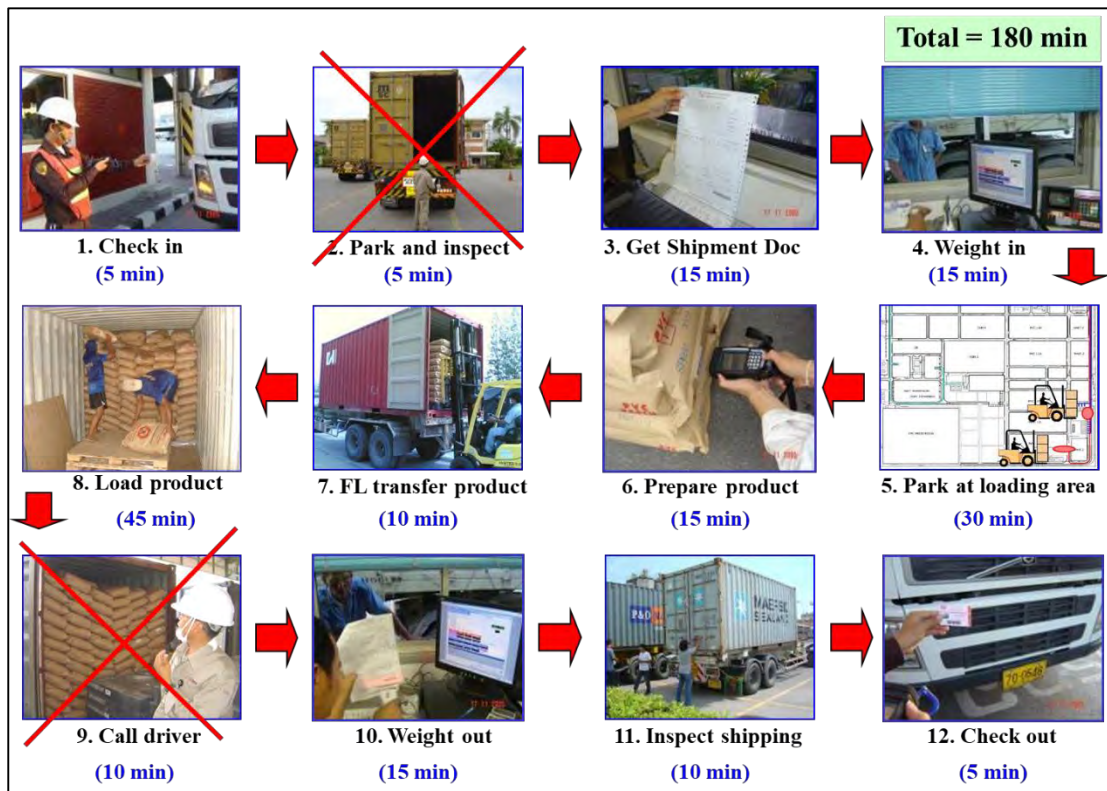


Figure 44 Eliminated Warehouse & Logistics Work flow Operation

Combine the activities of dispatching finished goods by merging team of the warehouse department and the logistics department to only new one team and improve their capability of multi-skill.

After remove wastes process from the current work flow operation, dispatching work consisted of 11 activities and was done by operators from 2 departments which are warehouse and logistics as shown in **Figure 45**. After combining some activities and assigning operators to responsible for an expanded jobs more than existing as shown in **Figure 46** results in steps of work are reduced from 11 steps to 7 steps. However, for achieving an efficient work, all operators have to be trained to build up skill for an expanded activities.

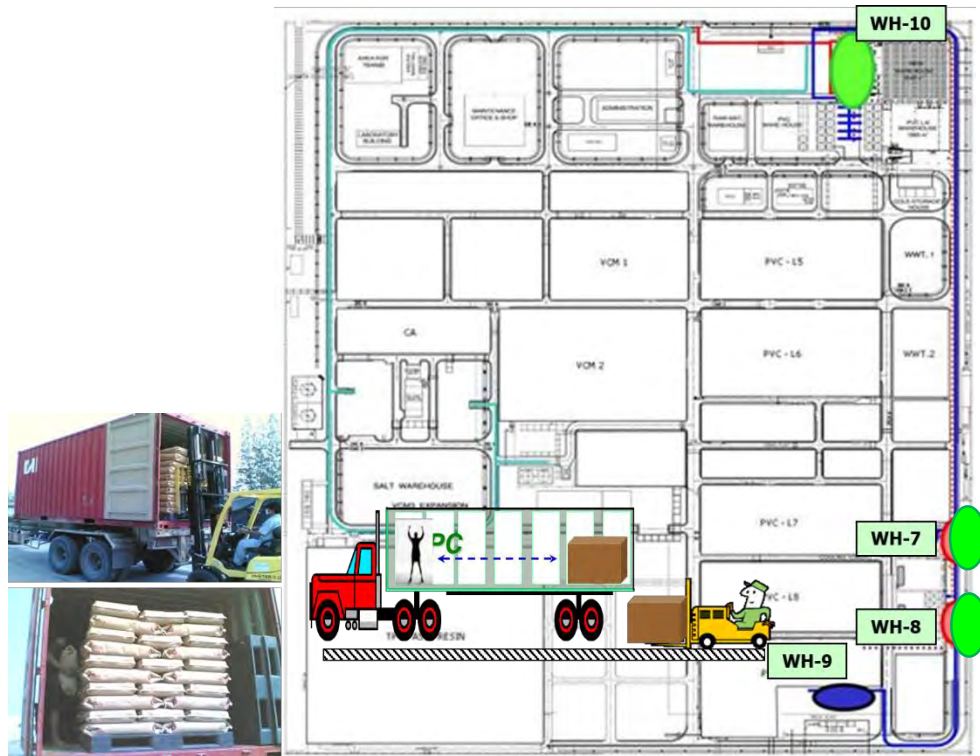


**Figure 45** As-is Dispatching Operation



**Figure 46** To-be Dispatching Operation

In addition, the dispatching location is also considered as another important point for loading time reduction. Based on current operation, there was only one product dispatching point at warehouse number 10 which results in truck congestion during day time. Therefore, warehouse number 7 and 8 are prepared for alternative product dispatching points in order to reduce truck waiting time.



**Figure 47** Increase Product Dispatching point

- **Improve accommodation of the driver**

Improve accommodation for the driver during waiting for loading and communicate to drivers via questionnaire to receive feedback in term of customer information and improvement idea.

According to all improvement activities, site observation method is used to measure time used in each activity. The major lead time reduction activities are front gate check in, product loading to the truck, final checking before truck closing and truck weighting out. The testing results are shown in below table:

**Table 5** Testing Results of Logistics Throughput Time Reduction

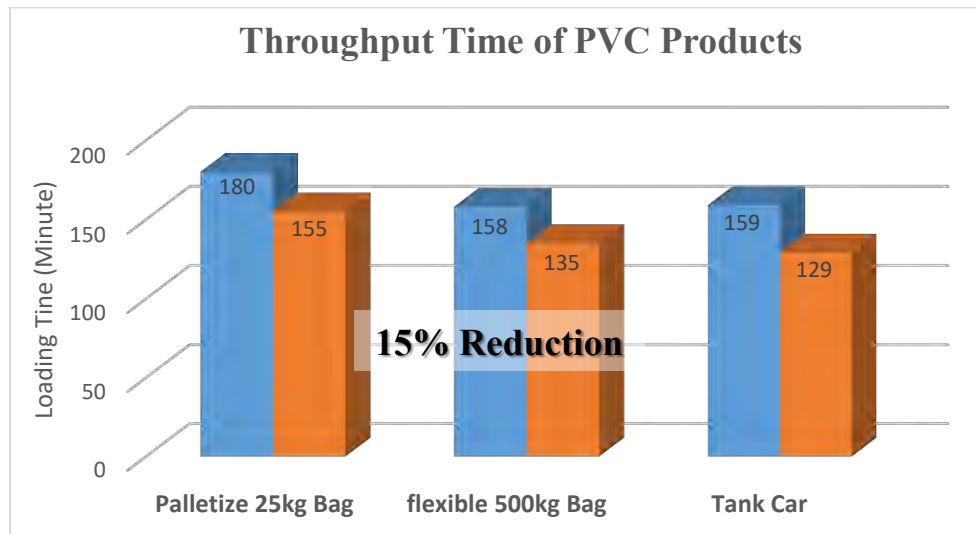
Product Type	Activities	Time (Minute)	
		Before	After
Palletized	1. Front gate check-in	20	15
	2. Generate delivery paper for driver	6	6
	3. Truck weighting in	71	71
	4. Product preparation and transfer to loading dock	6	6
	5. Product loading to the truck	23	18
	6. Final checking before truck closing	16	11
	7. Truck weighting out	38	28
	Total	180	155
Flexible Bag	1. Front gate check-in	17	12
	2. Generate delivery paper for driver	5	5
	3. Truck weighting in	59	59
	4. Product preparation and transfer to loading dock	3	3
	5. Product loading to the truck	20	15
	6. Final checking before truck closing	16	13
	7. Truck weighting out	38	28
	Total	158	135
Tank Car	1. Front gate check-in	21	16
	2. Generate delivery paper for driver	5	5
	3. Truck weighting in	39	39
	4. Product preparation and transfer to loading dock	4	4
	5. Product loading to the truck	30	20
	6. Final checking before truck closing	20	15
	7. Truck weighting out	40	30
	Total	159	129

By this solution, an overall logistics loading time reduction by packaging type are shown in **Figure 48**.



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**Figure 48** Result of logistics loading time improvement each packaging

Key success factor of all logistics loading time reduction activities is the good collaboration of the warehouse department and the logistics department because there was re-organization by combining activities and increasing multi-skill of operators in both departments for achieving new procedure of dispatching finished goods.

The pros and cons of Logistics Throughput Time reduction is determined as follows:

Pros:

- No investment.
- Short lead time for implementation
- Increase morale of truck' drivers due to less queuing

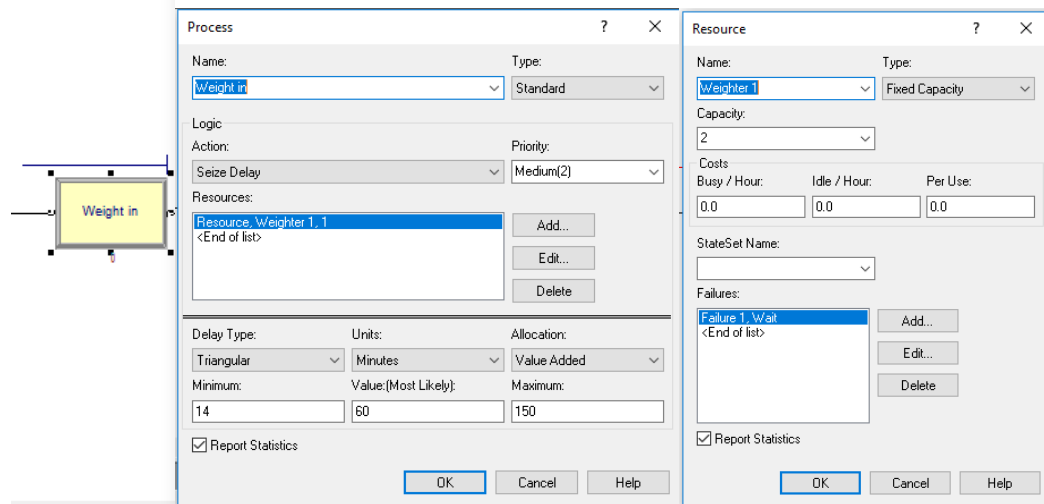
Cons:

- Required border skills for worker in both logistics and warehouse operations

#### 4.6.3. Additional Truck Scale

According to result of current operation in section 4.6, one of the major bottleneck of the process is truck scale as the average waiting time for weighting in process were high, namely 77.71 minutes. The truck drivers waited for a long period of time due to the congested of truck. One truck scale for weighting in process results in there were 46 customers' truck which enter the truck scale for weight in process but only 41 trucks had completed. In addition, the average queue for weight in process is 23.67 minutes.

Therefore, addition truck scale is needed in weighting in process since the average value of truck scale utilization is very high. The recommendation is to invest an additional truck scale to acquire weighting in process. By using the same condition of original operation, the model of additional truck scale is created as following:

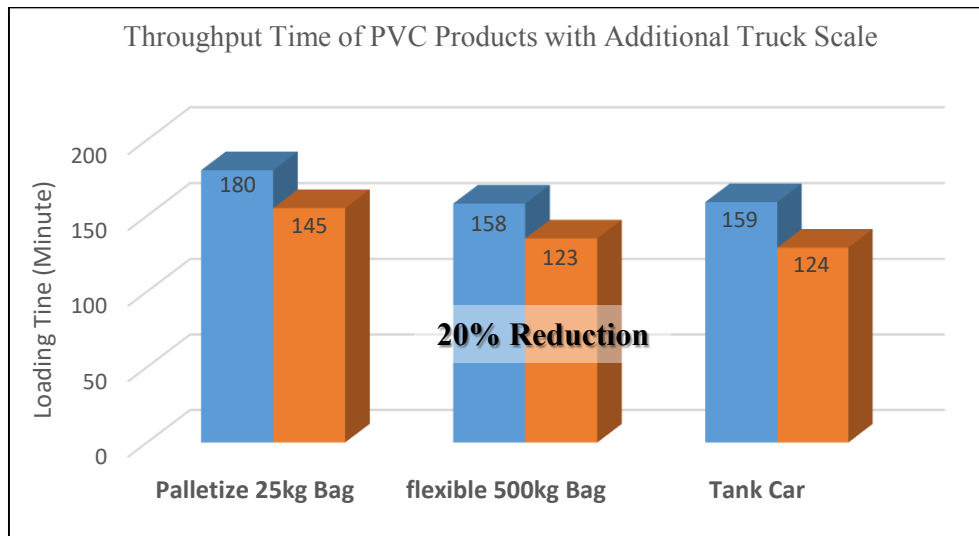


**Figure 49** The Completed Weight in Dialog and Resource with Additional Truck Scale

The results of simulation after adding number of truck scale to 2 are shown in **Table 6**. An average time for weight in is reduce 35 minutes or 45 percent reduction from existing model. Additional truck scale can remove the bottleneck of weight in process as it can serve all trucks as the number of truck in and truck out is the same. In addition, it is clear that the average value of utilization is decrease by 23%.

**Table 6** Results of Weight in process by Addition Truck Scale

Model	No. of Truck Scale	Average Time	No. of Truck in	No. of Truck out	Utilization
Existing	1	77	25	21	0.99
Additional Truck Scale	2	42	25	25	0.76



**Figure 50** Result of logistics throughput time improvement each packaging

The pros and cons of Logistics Throughput Time from additional truck scale is determined as follows:

Pros:

- Biggest throughput time reduction of 20% for all packaging.
- Support an expansion of sales in the future.

Cons:

- Investment for new truck scale by 2MB.
- Required construction period around 8-10 months.



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## CHAPTER 5

### CONCLUSION

#### 5.1 Conclusion

This case study focuses on an inbound logistics management for a PVC manufacturer. A major process improvement concerns reduction of inbound logistics throughput time that approaching to improve customer satisfaction to maintain market positioning and to be the leader in cost reduction and maximize profits. In order to find the best solution, the problem were analysed by using Gantt chart, Value Stream Mapping to define the Value Added time and Non-Value Added time of inbound logistics process. After though, simulation of truck loading process that includes all types of PVC packaging product has been formulated using Arena. After the Non-Value Added time of the process has been identified, the three improvement scenarios have been purposed in order to minimize the logistics throughput time.

Based on purposed solutions, the first and the second solutions which are implement truck scheduling and reduce logistics throughput time should be implemented due to two major benefits, first-it has low investment and second-it is found that throughput time has significant decreased by 33 percent (15 percent from implementing truck scheduling and 18 percent from improving logistics throughput time). Moreover, the truck scheduling decreased the number of truck during the peak daytime from 14 trucks per hour to 10 trucks per hours. The throughput time reduction results in decreasing of delay delivery which is the major claim and complaint case of the company. Although, the third solution have an investment for an additional truck scale but this solution targeted for improve weighting-in approaching to support an increasing of the business expansion in the future. Therefore, it is worth considering this solution in future operation.

#### 5.2 Recommendation and Further Study

The operation improvement in this study is only focused on domestic's customers which was the major portion of sale volume of the company. There are export's customers who have different modes of transport includes land and water transport. The operation of export logistics should also be determined. The boundary of throughput time should be specified in order to remove uncontrolled factors according to different



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locations. Also, the customer's requirements should be maintain positive in order to keep business competitiveness for the long term. The further study should be considered external factors relating to the implementation result which are seasonal demand, traffic of land transport and transport regulation.

Furthermore, the new technology like RFID should be studied in order to minimize human error and decrease logistics throughput time in processes of truck entering and product loading. The concept of lean logistics should be taken into account in order to eliminate wastes in the value chain.



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APPENDIX A
Truck Loading Report

Load Order Report: Palletized PVC Product
Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., หน่วยงาน, บริษัท, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, เลขที่ใบ, เลขที่ใบงาน, อนุมัติ, อนุมัติงาน, อนุมัติ, อนุมัติงาน, อนุมัติ, อนุมัติงาน, อนุมัติ, อนุมัติงาน, Order Type

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Load Order Report: Palletized PVC Product

Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., หมายเหตุ, บริษัท ควบคุม, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลจทเป็น, ระบุส่งของ, อนุมัติ, ส่งค่า, อนุมัติ TO, ส่งค่า, รวมค่า, Order Type. Contains multiple rows of order data.

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Load Order Report: Palitized PVC Product

Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., หน่วยงาน, บริษัท ทรน.ขนส่ง, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลจ.ข.ม.บ., รพ.ข.ม.จ., ภูมิภาค, ปลายทาง, ระยะเวลา, Order Type. The table contains 320 rows of detailed order data.

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Load Order Report: Palletized PVC Product
Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., หมายเลข, บริษัท สม.ขนส่ง, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลมเย็บ, ระบุช่องจ่าย, ยืนยืน เติ้มจ่าย, ฝั่งซ้าย, ยืนยืน To, ฝั่งขวา, ระยะเวลา, Order Type. The table contains multiple rows of data for various PVC products and their shipments.

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Load Order Report: Palletized PVC Product
Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., เลขใบขอ, บริษัท ขอ, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลอจิสติกส์, ระบุตู้บรรจุ, จำนวนตู้บรรจุ, จำนวนตู้บรรจุ, จำนวนตู้บรรจุ, จำนวนตู้บรรจุ, จำนวนตู้บรรจุ, จำนวนตู้บรรจุ, Order Type. The table contains a large number of rows with detailed order information.

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Load Order Report: Palletized PVC Product
Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., หน่วยงาน, บริษัท เสม.ขนส่ง, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลงทะเบียน, ระบุช่องจ่าย, ยืนยัน เสร็จเรียบร้อย, ส่งเข้า, ใบบิน TO, ส่งกลับ, รวมเวลา, Order Type. Contains multiple rows of order data.

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Load Order Report : Flexible Bag PVC Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., T/O No., หน่วยบรรจุ, บริษัท ผสม.ขนส่ง, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลงทะเบียน, รวม, ของงาน, มีเงิน, ต้นเงิน, ค่า, มีเงิน TO, ใช้อย่าง, รวมค่า, Order Type. Contains 100 rows of detailed order data.

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Load Order Report : Flexible Bag PVC
Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., T/O No., หมายเลขรถ, บริษัท ผสม.ขนส่ง, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลงทะเบียน, รวม, ชั่งจก, ต้นทุน, ต้นทุน, ชั่งเข้า, ต้นทุน, ชั่งออก, ราคา, Order Type. The table contains multiple rows of load order data.

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CT Thesis 5971217821 thesis / rev: 01082562 22:43:27 / seq: 6

Load Order Report: Tank Car  
Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., ทะเบียนรถ, บริษัท/กรมขนส่ง, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลอหะเบียน, ระบุขบวน, ยืนยันรถบรรทุก, ฝั่งขา, ยืนยัน TO, ฝั่งกลับ, รถมล, Order Type. The table contains 100 rows of data.

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Load Order Report: Tank Car  
Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., หมายเลข, บริษัท กรม.ขนส่ง, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลงทะเบียน, ระบุ, ต้นทุน, ต้นทุน TO, ราคาค, ราคา, Order Type. The table contains 320 rows of detailed load order data.

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CD Ithesis 5971217821 thesis / rev: 01082562 22:43:27 / seq: 6

Load Order Report: Tank Car  
Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., หมายเลขรถ, บริษัท, ครอม.ขนส่ง, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลอหทะเบียน, ระบุถังส่งขาย, ยืนยันเริ่มขาย, ส่งขาย, ยืนยัน TO, ส่งกลับ, รวมผล, Order Type. Rows 321-430.



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Load Order Report: Tank Car  
Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., ชนิดรถ, บริษัท, กรม.ขนส่ง, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลงทะเบียน, ระบุ ผงจาก, ต้นฉบับ, ต้นฉบับ, ฝั่งเข้า, ต้นฉบับ TO, ฝั่งออก, รวมเข้า, Order Type. Contains 60 rows of order data.



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Load Order Report: Tank Car  
Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., LoadOrder No., หน่วยงาน, บริษัท ทรน.ขนส่ง, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลงทะเบียน, ราคานับ, ต้นทุน, ต้นทุน TO, ราคาคง, ราคา, Order Type. The table contains 100 rows of data for tank car load orders.

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CD Thesisis 5971217821 thesisis / recv: 01082562 22:43:27 / seq: 6

Load Order Report: Tank Car

Date 01/8/2018 0:00:01 To 31/08/2018 23:59

Table with columns: No., Load Order No., หมายเลข, บริษัท. กรม.ขนส่ง, ชื่อลูกค้า, Material No., Batch, Qty (Tons), วันที่, ลงทะเบียน, ชม. ชั่งงาน, ต้นทุน, ต้นทุน, สั่งเข้า, ต้นทุน TO, ชั่งงาน, รวมเวลา, Order Type. The table contains multiple rows of order data with various numerical and text values.

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CD IThesiss 5971217821 thesiss / recv: 01082562 22:43:27 / seq: 6

## APPENDIX B

### B.1 Truck Loading Report before Improvement

12:35:49AM

#### Category Overview

June 15, 2019

*Values Across All Replications*

#### Truck loading simulation

Replications: 10      Time Units: Minutes

#### Process

##### Time per Entity

VA Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Final Checking	16.0000	0.00	16.0000	16.0000	16.0000	16.0000
Generate DP	21.8168	1.94	18.8530	28.6282	0.00	84.1617
Product loading Flexible Bag	20.2117	35.17	0.00	153.11	0.00	153.11
Product loading Palletize	43.2571	32.41	0.00	136.50	0.00	136.50
Product loading Tankcar	25.3083	40.98	0.00	170.79	0.00	170.79
Weight in	77.7176	23.67	37.5028	129.95	37.5028	129.95
Weight out	41.1035	18.72	5.2971	80.3183	5.2971	80.3183

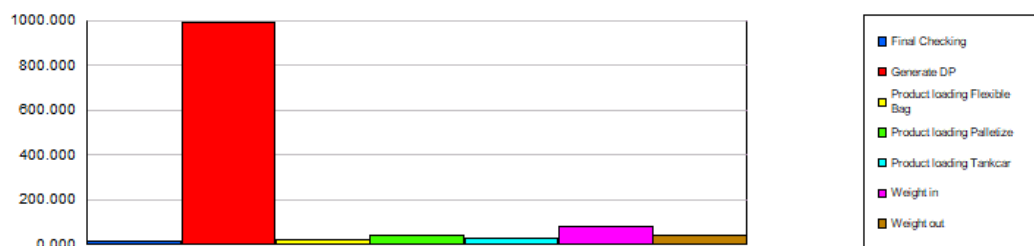
  

Wait Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Weight in	0.00	0.00	0.00	0.00	0.00	0.00
Weight out	0.00	0.00	0.00	0.00	0.00	0.00

#### Process

##### Accumulated Time

Accum VA Time	Average	Half Width	Minimum Average	Maximum Average
Final Checking	16.0000	0.00	16.0000	16.0000
Generate DP	994.05	200.32	656.15	1505.27
Product loading Flexible Bag	20.2117	35.17	0.00	153.11
Product loading Palletize	43.2571	32.41	0.00	136.50
Product loading Tankcar	25.3083	40.98	0.00	170.79
Weight in	77.7176	23.67	37.5028	129.95
Weight out	41.1035	18.72	5.2971	80.3183



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12:35:49AM

Category Overview

June 15, 2019

Values Across All Replications

Truck loading simulation

Replications: 10 Time Units: Minutes

Process

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Final Checking	1.0000	0.00	1.0000	1.0000
Generate DP	26.8000	9.15	16.0000	42.0000
Product loading Flexible Bag	0.2000	0.30	0.00	1.0000
Product loading Palletize	0.6000	0.37	0.00	1.0000
Product loading Tankcar	0.2000	0.30	0.00	1.0000
Weight in	25.9000	9.49	16.0000	22.0000
Weight out	1.0000	0.00	1.0000	1.0000



Number Out	Average	Half Width	Minimum Average	Maximum Average
Final Checking	1.0000	0.00	1.0000	1.0000
Generate DP	25.9000	9.49	32.0000	72.0000
Product loading Flexible Bag	0.2000	0.30	0.00	1.0000
Product loading Palletize	0.6000	0.37	0.00	1.0000
Product loading Tankcar	0.2000	0.30	0.00	1.0000
Weight in	21.0000	0.00	1.0000	1.0000
Weight out	1.0000	0.00	1.0000	1.0000

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Weight in Queue	0.00	0.00	0.00	0.00	0.00	0.00
Weight out Queue	0.00	0.00	0.00	0.00	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Weight in Queue	13.6729	5.05	5.8435	35.4448	0.00	38.0000
Weight out Queue	0.00	0.00	0.00	0.00	0.00	0.00

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12:35:49AM

**Category Overview**

June 15, 2019

*Values Across All Replications*

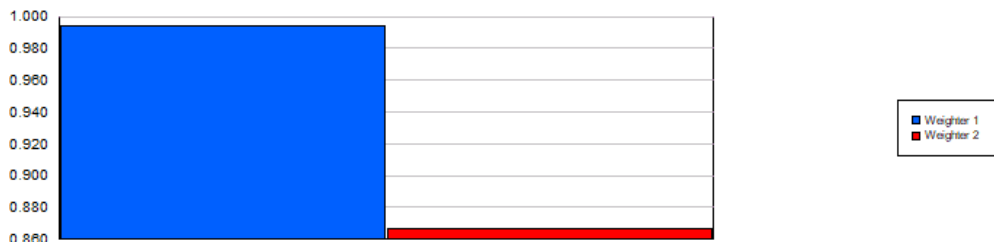
**Truck loading simulation**

Replications: 10 Time Units: Minutes

**Resource**

**Usage**

Instantaneous Utilization						
	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
<u>Weighter 1</u>	0.9938	0.00	0.9840	1.0000	0.00	1.0000
<u>Weighter 2</u>	0.8671	0.03	0.8067	0.9273	0.00	1.0000
Number Busy						
	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
<u>Weighter 1</u>	0.9938	0.00	0.9840	1.0000	0.00	1.0000
<u>Weighter 2</u>	0.8671	0.03	0.8067	0.9273	0.00	1.0000
Number Scheduled						
	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
<u>Weighter 1</u>	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
<u>Weighter 2</u>	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Scheduled Utilization						
	Average	Half Width	Minimum Average	Maximum Average		
<u>Weighter 1</u>	0.9938	0.00	0.9840	1.0000		
<u>Weighter 2</u>	0.8671	0.03	0.8067	0.9273		



**Resource**

**Usage**

Total Number Seized				
	Average	Half Width	Minimum Average	Maximum Average
<u>Weighter 1</u>	1.0000	0.00	1.0000	1.0000
<u>Weighter 2</u>	1.0000	0.00	1.0000	1.0000



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## B.2 Truck Loading Report: Additional Truck Scale

11:18:12AM

### Category Overview

June 20, 2019

*Values Across All Replications*

#### Truck loading simulation for PVC Manufacturer

Replications: 10      Time Units: Minutes

#### Process

##### Time per Entity

VA Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Final Checking	16.0000	0.00	16.0000	16.0000	16.0000	16.0000
Generate DP	22.8321	2.01	19.0965	27.3580	0.00	75.7906
Product loading Flexible Bag	22.1884	72.81	0.00	121.88	0.00	121.88
Product loading Palletize	45.61	31.76	0.00	141.66	0.00	141.66
Product loading Tankcar	27.0556	61.20	0.00	270.56	0.00	270.56
Weight in	41.8325	20.54	23.1435	62.42	18.3545	67.14
Weight out	41.2577	16.14	18.5441	92.9438	18.5441	92.9438

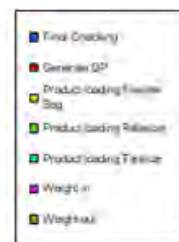
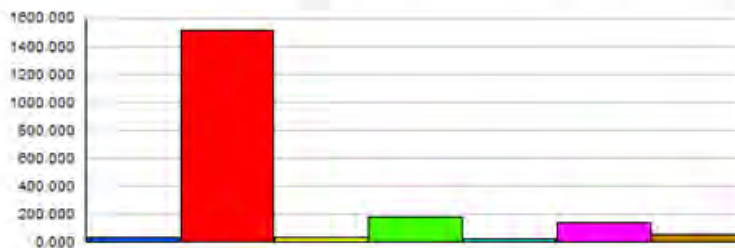
  

Wait Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Weight in	0.00	0.00	0.00	0.00	0.00	0.00
Weight out	0.00	0.00	0.00	0.00	0.00	0.00

#### Process

##### Accumulated Time

Accum VA Time	Average	Half Width	Minimum Average	Maximum Average
Final Checking	32.0000	0.00	32.0000	32.0000
Generate DP	1517.97	285.96	874.70	2100.36
Product loading Flexible Bag	32.1884	72.81	0.00	321.88
Product loading Palletize	178.33	65.10	86.6873	363.32
Product loading Tankcar	27.0556	61.20	0.00	270.56
Weight in	143.66	41.09	46.2871	224.84
Weight out	51.2577	16.14	18.5441	92.9438



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11:18:12AM

Category Overview

June 20, 2019

Values Across All Replications

Truck loading simulation for PVC Manufacturer

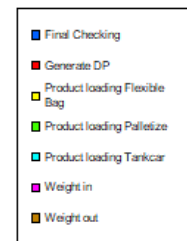
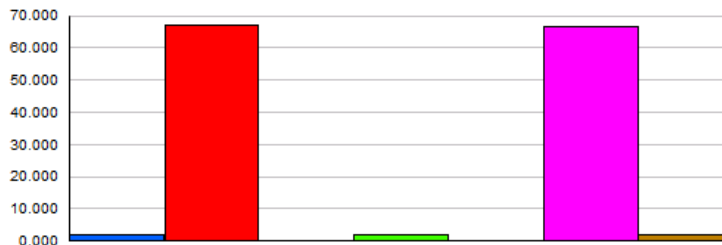


Replications: 10 Time Units: Minutes

Process

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Final Checking	24.5000	0.00	2.0000	2.0000
Generate DP	27.0000	12.41	45.0000	105.00
Product loading Flexible Bag	0.2000	0.23	0.00	1.0000
Product loading Palletize	0.6000	0.30	1.0000	2.0000
Product loading Tankcar	0.2000	0.23	0.00	1.0000
Weight in	25.0000	12.41	15.0000	45.00
Weight out	25.5000	0.00	15.0000	43.00



Number Out	Average	Half Width	Minimum Average	Maximum Average
Final Checking	24.5000	0.00	2.0000	2.0000
Generate DP	26.5000	12.41	45.0000	105.00
Product loading Flexible Bag	0.1000	0.23	0.00	1.0000
Product loading Palletize	1.8000	0.30	1.0000	2.0000
Product loading Tankcar	0.1000	0.23	0.00	1.0000
Weight in	25.0000	12.40	15.0000	45.0000
Weight out	25.0000	0.00	15.0000	43.0000

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Weight in Queue	0.00	0.00	0.00	0.00	0.00	0.00
Weight out Queue	0.00	0.00	0.00	0.00	0.00	0.00

Other

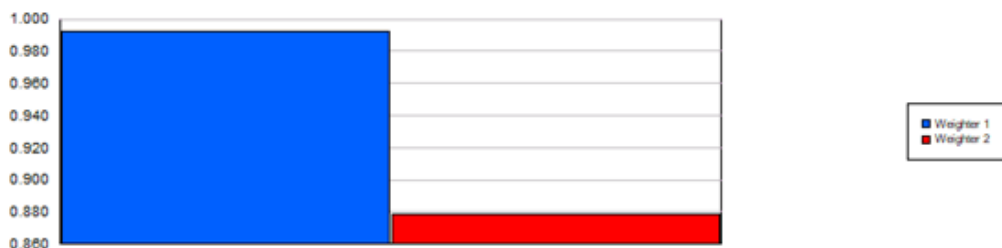
Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Weight in Queue	16.6577	7.98	6.3341	28.6554	0.00	73.000
Weight out Queue	0.8188	0.05	0.7254	0.9143	0.00	1.0000

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**Resource**

**Usage**

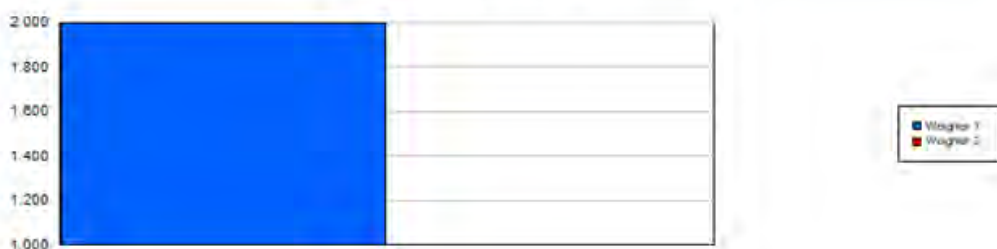
Instantaneous Utilization		Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Weighter 1		0.7621	0.00	0.6817	1.0000	0.00	1.0000
Weighter 2		0.8784	0.03	0.7982	0.9299	0.00	1.0000
Number Busy		Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Weighter 1		0.7642	0.01	0.7634	1.0000	0.00	1.0000
Weighter 2		0.8784	0.03	0.7982	0.9299	0.00	1.0000
Number Scheduled		Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Weighter 1		2.0000	0.00	2.0000	2.0000	2.0000	2.0000
Weighter 2		1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Scheduled Utilization		Average	Half Width	Minimum Average	Maximum Average		
Weighter 1		0.7621	0.00	0.6817	1.0000		
Weighter 2		0.8784	0.03	0.7982	0.9299		




**Resource**

**Usage**

Total Number Seized		Average	Half Width	Minimum Average	Maximum Average
Weighter 1		2.0000	0.00	2.0000	2.0000
Weighter 2		1.0000	0.00	1.0000	1.0000



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## REFERENCES

 CD IThesis 5971217821 thesis / recv: 01082562 22:43:27 / seq: 6  
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