THE ANALYSIS OF GATE OPERATION PROCESS MANAGEMENT FOR INLAND CONTAINER TERMINAL

By

SUTIJIT SUGANDHAVANIJA

A Final Report of the Six-Credit Course
SCM 7203 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
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Declaration of Authorship Form

I, Sutijit Sugandhavanija declare that this thesis/project and the work presented in it are my own and has been generated by me as the result of my own original research.

Project Topic: The Analysis of Gate Operation Process Management for Inland Container Terminal

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ABSTRACT

The service time is the main factor for container operations management in terminals. This research focuses on improving the service time of gate operation in the inland container terminal by using an analytical method and simulation software. The propose of this study is to investigate the current full container gate-in operations and then find the alternative to reduce the queuing time at the gate that is considered as the longest waiting time. The long waiting time occurs from most of the truck arriving in the same period, the long service time of inspection and registration while the inadequate staff and gate lane cannot accommodate these trucks in time.

The simulation is utilized in this research to simulate and analyze the current process to identify the operation problems. After that the results from the as-is simulation are validated and used for defining the alternative scenarios. Three scenarios are applied to the as-is simulation model. The first scenario emphasizes adding the gate and staff to increase gate lanes for truck services. The second scenario focuses on changing the inspectors and gate staffs' schedule. The third one focuses on adjusting work process flow. Many factor criteria from each scenario are compared to select the most appropriate solution such as average waiting time, average resource utilization, additional costs for improvement and average cycle time.

The results from the simulation indicated that the selected alternative can reduce the truck waiting time by adding four survey staff and processing the two activities: container inspection and registration at the same time instead of operating container inspection before registration. This causes cycle time reduction from 13.60 minutes to 9.76 minutes. Also, the average truck waiting time of this alternative is reduced from 8.40 minutes to 6.14 minutes.

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Date: August 26, 2014

CHAPTER I

GENERALITIES OF THE STUDY

International sea-freight container transportation has dramatically grown in recent years. Nowadays, container terminals are a key in the global shipping network in the way of being an important part in logistics and the supply chain network as a hub for transshipping inland transportation. With an increasing competitiveness among container businesses, greater efficiency of container operations is required in order to increase their service quality and to remain competitive (Vacca, Bierlaire, & Salani, 2007).

Good handling container operations are necessary because it is related to container terminal service performance. The operations of the container terminal are concerned with activities of receiving and delivering inbound and outbound containers from and to the storage yard. One of the important operations is the gate process where trucks move in and out of the container yard to pick-up or drop-off containers. Smooth container traffic flow of the gate process would also help to minimize the ship's turnaround time that is one of the main indicators for shipping companies. In addition, efficiency of gate operations affects the performance and reliability of carriers, shippers, and terminal operators. (Maguire, Ivey, Golias, & Lipinski, 2010). Therefore, improving the gate operation process is able to enhance the performance of the company.

1.1 Background of the Research

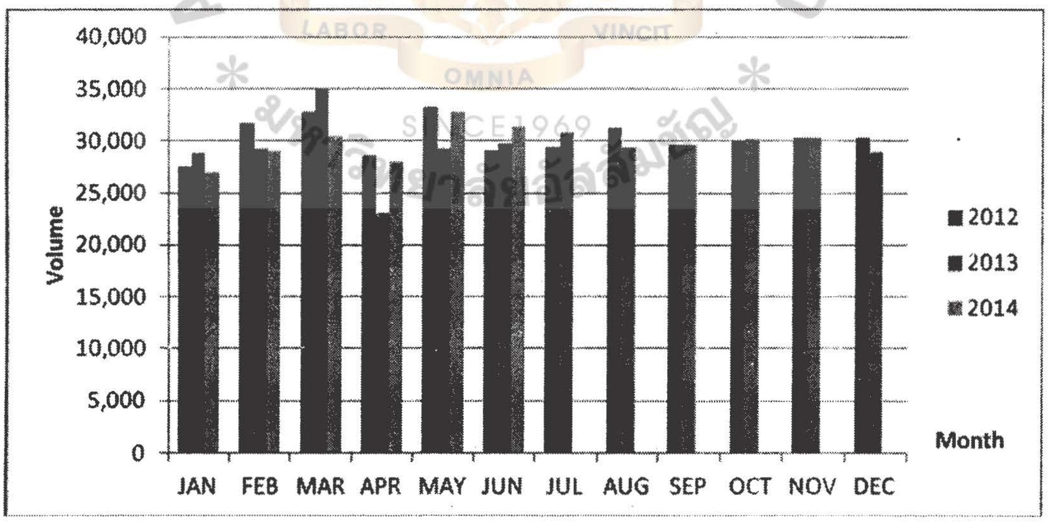
ABC Company is a subsidiary of XYZ international container terminal company, which acts as the agent of shipping line to operate container storage and handle shipping cargo containers for inbound and outbound. ABC was established in Thailand in 1983 and located in the Ladkrabang district area with the operation area of 127,000 M^2.

ABC has provided a wide range of services for container handling, equipment maintenance and trucking. Container yard management is the main business of the company. The service functions of ABC container yard management consist of:

(a) Yard operation: Managing for storing empty and full containers, providing equipment and facility for picking up and dropping off containers.
(b) Gate operation: The checking and registration point for gate-in empty containers, gate-in full containers, gate-out empty containers, gate-out full containers and empty chassis trucks for picking-up containers.
(c) Transportation: Providing truck and train transportation for all types of dry and reefer containers from and to Laem Chabang port.

ABC is the center for container logistics and transportation because of its location which is close to Leam Chabang port. Also, there is a crucial connection between different transport modes: by truck, by train and by sea. Therefore, the volume of import and export container traffic in the yard gradually grows.

Figure 1.1: Total Volume of Container Traffic in ABC Company



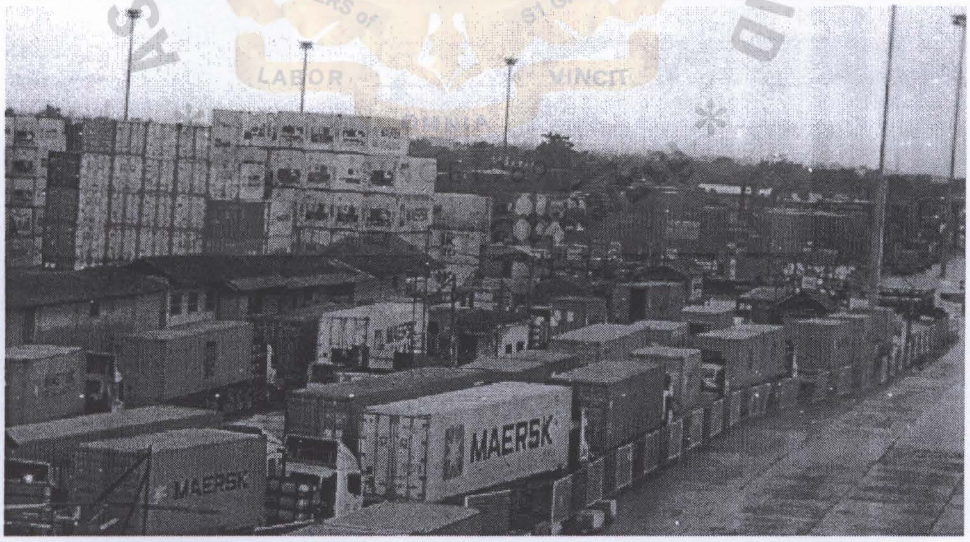
Source: Company data

The figure 1.1 illustrated the total volume of move-in and move-out containers from 2012 to 2014. The average volume is 30,000 containers per month. The trend in 2014 is higher than 2013 especially from April to June. With the growth of container volume, ABC needs to find the way to improve the operations in terms of service time to enhance the service quality for customers and successfully serve the increase of demand volume in the future.

1.2 Statement of the Problem

In the current situation, the increase of container volume of ABC leads to a problem of traffic congestion inside and outside the container yard. The Majority of the traffic congestion volume comes from gate-in full container trucks (see figure 1.2). Long queues of trucks in front of the gate results in the drivers' waiting in line to return containers into the container terminal. The drivers have to waste their time waiting for this and this may affect to their working schedule. Sometimes the long queue of trucks to return the containers leads to heavy traffic to the companies nearby.

Figure 1.2: The Traffic Congestion of Gate-in Full Container Truck



Source: Company data

There are two types of full containers:

(a) Full container gate-in import (I01). It is the process of receiving containers from Leam Chabang port before releasing to customers.

(b) Full container gate-in export (E02). It is the process of receiving containers returned from customer's stuffing cargo at factories. After that, ABC will tranship containers to Laem Chabang port by truck or by train.

According to table 1.1, the total volume of gate-in containers is increased from September 2013 to December 2013. In 2014, the total volume is starting grow especially the E02 container volume due to the company planning to find more customers. However, this trend affects the traffic of trucks in the terminal.

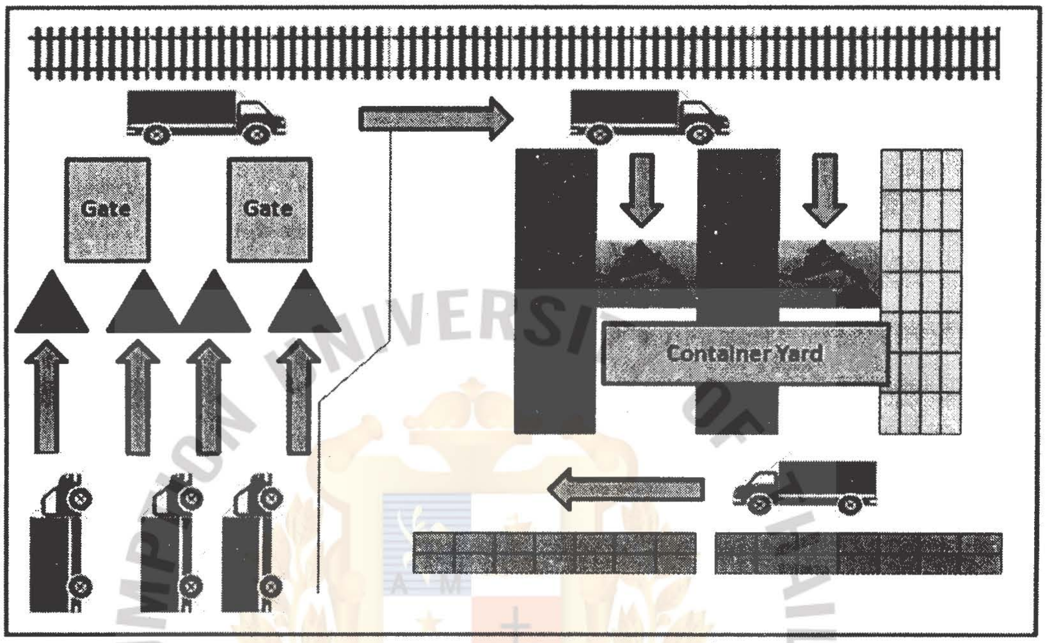
Table 1.1: Total Full Container Gate-in Volume of ABC Company

Month	I01	E02	Total Quantity
Jan-13	3,210	7,433	10,643
Feb-13	3,139	7,820	10,959
Mar-13	3,315	9,234	12,549
Apr-13	2,728	6,872	9,600
May-13	2,985	8,805	11,790
Jun-13	3,437	8,512	11,949
Jul-13	4,276	8,908	13,184
Aug-13	3,291	8,482	11,773
Sep-13	6,358	9,223	15,581
Oct-13	5,694	10,009	15,703
Nov-13	6,783	8,947	15,730
Dec-13	6,561	9,478	16,039
Jan-14	3,528	7,923	11,451
Feb-14	2,913	9,836	12,749
Mar-14	3,004	9,907	12,911

Source: Company data

The figure 1.3 is the layout of terminal that indicates the flow of full container trucks. All trucks need to come into the terminal and will stop at the gate for inspection at the first step. The red triangles represent the bottlenecks that usually happen at the entrance of gate before the trucks move into the terminal yard for returning the containers.

Figure 1.3: Process Flow of Gate-in Full Container Truck



Source: Adapt from company data.

There are two terminal gates to receive full containers. Normally, the gates accommodate up to 800 trucks per day at the maximum. In fact, the operation is still delayed at the gate when the trucks arrival is in the peak period. Each truck is queuing up for inspection and registration which takes at least 10 minutes before going to further steps. One of the problems is the high volume of gate-in export containers (E02), which comes in about the same period as the vessel cut-off time. Mostly, the peak period starts from Tuesday to Thursday because the main weekly vessel cut-off time is Friday evening. Consequently, if there is no improvement of gate-in operation process time, the operations time of transport planning to deliver full container to Laem Chabang port will be postponed. If the transport operation is delayed, it will affect the shipment schedule.

The limitation of the truck lane is also related to the traffic flow. In other words, it will be impossible for the truck to move out of its path. In addition, the container returning process at Latkrabang terminal requires a lot of time to perform each step especially the inspection process that is considered the first step of the process. The inspection needs to be conducted in the assigned area due to safety concerns. This is the one of the causes of traffic problems at the front of the gate and the operations delay in the container returning process.

The traffic congestion becomes a critical issue because it affects the operation of ABC and related parties such as shipping lines, loading port and customers. Gate is a transferring point for container movement to the operation yard so; improvement of gate operation is required. However, any plans to change the gate configuration needs to be considered carefully because gate operations influence the service performance of the terminal.

In order to solve the traffic congestion problem, the important thing is to decrease the trucks waiting in the queue. The average of the process time for each activity is illustrated as per table 1.2. The activities at the bottleneck are the maximum and are needed to be improved.

Table 1.2: Average Waiting Time of Full Container Gate-in Process

Activity	Average waiting time (minutes)	
Inspect containers	4.86	Bottleneck
Registration and check document	4.08	
Planning drop off container position	1.52	
Drop off container	2.55	

This research focuses on improving the bottleneck of the gate-in process in order to lower the trucks' waiting time and enhance the productivity under the research question **"How to reduce the trucks' waiting time of full container gate-in operations in ABC Company?"**

1.3 Research Objectives

1.3.1 To study the current operations of the full container gate-in process.

1.3.2 To identify the alternatives to reduce trucks' waiting time of full container gate-in process via simulation.

1.4 Scope of the Research

The research emphasizes the process of full container gate-in operations specifically for ABC Company. The process flow investigation starts when trucks move into the container yard, get inspected at the gate, pay a fee, drop off containers and move out of the yard.

The information collected for analysis involves the process time, the number of staff and relevant resources in each process and a time schedule of staff. All information in this research is under a regular circumstance. The process is studied from the company layout while the operations time is observed from the starting point to the finish. The simulation will be used for evaluating the results of current and alternative processes.

1.5 Significance of the Research

This study will be significant in enhancing an efficiency of the container operation gate-in process. It attempts to identify the factors of the problem and the methods that should be applied to fix it. If the container traffic congestion is not improved, it will effect to the delay of other operations in the terminal and also the loss of the customers' reliability. The customers will use different places to return their containers.

Additionally, this research will be helpful to the container terminal business in the way of providing the strategies or the policy when they manage the container operations to enhance their service performance. The improvement of operation will reduce the traffic flow problems while the company can service more trucks when the demand increases. The company would get customer satisfaction from the customers and an increase in profitability.

1.6 Limitations of the Research

Due to the limitation of data collection, the number of truck arrivals in this study is collected from the historical data of the company only in the peak period from December 2013 to February 2014. This aids in finding the alternatives to improve operations performance during the high traffic volume.

Moreover, the scope of improvement will consider only the process of truck arrivals to truck departures from the gate due to such controllable variables as the number of staff as well as process time. Details of operations after this will not be discussed.

Lastly, this study focuses on only ABC Company and its full container returning process.

1.7 Definition of Terms

Container Terminal	The place for storing empty and full containers before being transshipped by different transport modes (Nishimura, Imai, Janssens, & Papadimitriouc, 2009).
Container Traffic	The movement of containers in and out of the container terminal (Nishimura et al., 2009).
Cut-off Time	The deadline of when containers must arrive at the loading port (Guan & Liu, 2009).

Gate Operation Process	The process of checking conditions, checking data and registration for any container moving in or moving out of the gate.
Shipping Line	The company who provides marine transportation service for international trade (Vacca et al., 2007).
Truck Turnaround Time	The length of time between trucks arriving at one point and departing from that point (Goodchild & Daganzo, 2004).

CHAPTER II

REVIEW OF RELATED LITERATURE

The literature review in this chapter covers the details of the container operation background and gate operation service. The first section is the concept of container operation management. Another section in this study discusses about the key performance indicators of gate operation efficiency. The last section is the simulation method, the software being used in this research and literature review of the previous studies using simulations to improve container operation problems.

2.1 Container Terminal Operation and Operation Management

2.1.1 Container Operation and Gate Operation

Container terminals are a link of interfaces among rail road, sea and trucks (Steenken, Voß, & Stahlbock, 2004; Maguire, Ivey, Golias, & Lipinski, 2010; Moini, 2010). Gate operations is the channel of container terminals for trucks carrying containers to move in or out of the container yard. Gates are also the important part of where technical and administrative modes take place. Moreover, the overall efficiency of a terminal depends on the efficiency of subsystems like gate operations (Steenken et al., 2004; Zhao & Goodchild, 2010).

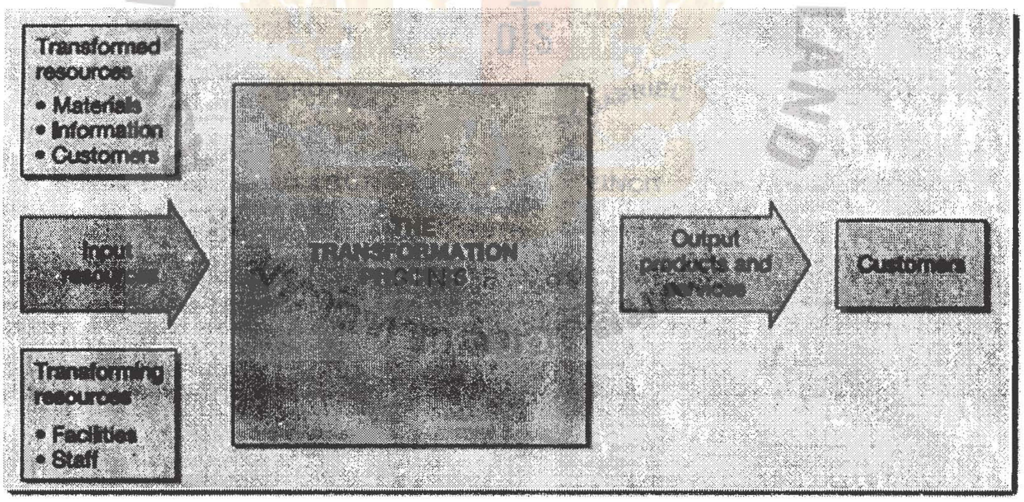
In general, the container terminal operations require real-time decisions and optimization because most activities which occur in the terminal are not predictable. In terms of gate operations, the truck arrival time at the transition point cannot be forecasted precisely. Traffic volume is changeable all the time. Therefore, the optimization needs to be flexible and fast (Steenken et al., 2004).

2.1.2 Operation Management

Operations management is the mission of the organization. Its function concerns with converting physical resources into outputs, in order to serve customers' needs. Materials, information, human and managing processes are involved. Operations can be classified into manufacturing operations and service operations. Manufacturing output is usually tangible in the form of products, but service output is usually intangible (Kumar & Suresh, 2008).

One set of inputs is transformed resources in the operations process such as materials, information and customers. The other set of inputs is transforming resources which work on the transformed resources such as facilities and the people who operate, plan and manage the operations as per the model in figure 2.1.

Figure 2.1: Operation Management Transforming Process



Source: Adapt from Slack, Chambers & Johnston (1998)

The main objective of operations management is to fulfill customer requirements in terms of cost and timing. Therefore, the operation system needs to satisfy the customer by providing the right thing at the right price and the right time. Operations

2.1.2 Operation Management 4233 e.1

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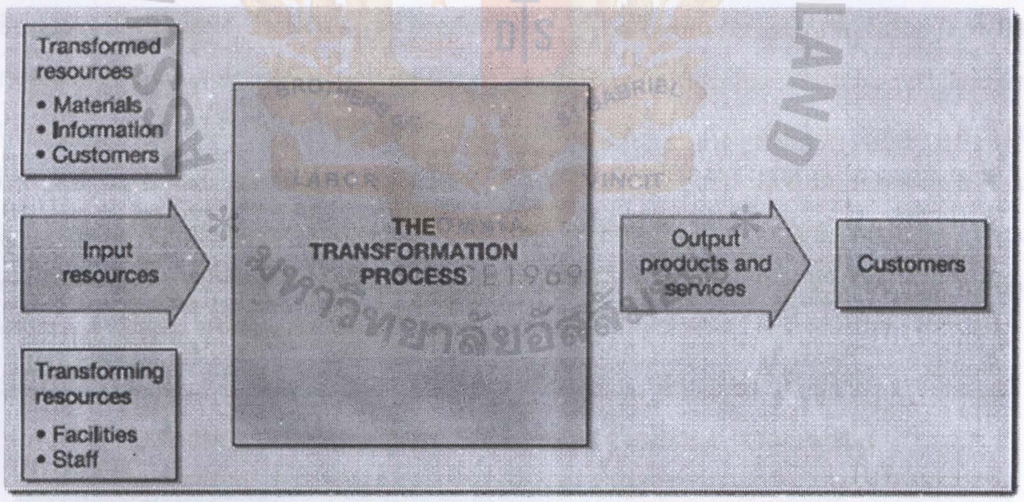


Source: Adapt from Slack, Chambers & Johnston (1998)

The main objective of operations management is to fulfill customer requirements in terms of cost and timing. Therefore, the operation system needs to satisfy the customer by providing the right thing at the right price and the right time. Operations management is also involved with resource utilization. Ineffective customer service and inefficient resource utilization leads to a drop of company performance.

Container terminal operation is categorized as a service operation. Utilization of available process time, operation area, cost of movement and resource utilization needs to be considered in order to satisfy customers and improve the performance of the terminal.

2.2 Efficiency of Gate Operation

The efficiency of gate operations is essential in order to enhance the performance of the container terminal. The efficiency indicators vary depending upon the terminal's characteristics such as its area size, number of resources and equipment.

2.2.1 Productivity

Maximizing productivity of handling container operations is one of the efficiency indicators. For gate operation, its productivity is measured by gate throughput or the number of container trucks moving out of the gate per hour, that of trucks per lane for the operations while work performance of each staff is indicated in table 2.1. The internal factors of productivity of gate operation can be controlled in terms of capital investment for resources and staff while the external factors such as container trade volumes and pattern of shipment are uncontrollable (Le-Griffin & Murphy, 2006; Vacca, Bierlaire, & Salani, 2007).

Table 2.1: Productivity Measure of Container Operation

Element of Terminal	Productivity	Measure
Yard	Storage Productivity	TEUs/Storage Acre
Gate	Gate Throughput Truck Turnaround Time	Containers/hour/lane Truck Time in Terminal
Resource	Labor Productivity	Number of moves/man-hour

Source: Le-Griffin & Murphy, 2006

However, the biggest challenge for container terminals is how to obtain the reliability from customers and maintain the consistency of the productivity. Therefore, the container terminal needs to adopt the appropriate system to evaluate the productivity.

2.2.2 Utilization of Resource

Tahar and Hussain (2000) identified that the terminal facilities require high investment. Thus, the under-utilization and insufficiency of terminal facilities causes the delay of operations and the loss of capital and customers. The full utilization of resources and the appropriate operations management are critical objectives for container operations. The objectives would be achieved if the terminal can manage resource utilization such as the balance of resources and facilities, as well as the minimization of re-handling time.

2.2.3 Service Quality

Another efficiency of gate operations is the service quality which is measured by gate service time or total time that trucks are still in the terminal. This also indicates the performance of staff and the terminal.

The service quality should not be overlooked because the container terminal represents the hub for many market players who engage in maritime transportation for trading their business (Vacca et al., 2007).

2.3 Simulation Method

Simulation is a method to imitate the actual situation by creating computer models for analyzing a complex system and experimenting with the model to improve the future operations. Simulation is widely used for analyzing container operation systems because most container operations are too complex to use a simple analyzing tool. Moreover, the experiment in the actual system needs a high investment, high risk and wastes more time to evaluate the results (Tahar & Hussain, 2000). Additionally, simulation methods are flexible and can be applied in many dimensions. It is easy to adjust or add more details to describe the behavior closer to the actual system (Bazghandi, 2012).

2.3.1 Problem Formulation and Data Collection

Simulation modeling is a series of well-defined activities or steps that need to be followed in a specific order and usually work repeatedly in an interaction. The first step of creating a simulation model is to define and analyze a problem. Then gather the information, identify input parameters, variables and performance metrics. After that is finding the baseline values for these metrics. The information is represented as flow diagrams or any other means. When adequate information is gathered, the problem can be analyzed and the solutions can be set down. (Altiok & Melamed, 2007; Kelton, Sadowski, & Sturrock, 2010).

2.3.2 Simulation Model Building

When the problem is analyzed and the data is collected, the analyst can create the model by using a computer program. There are many computer programs for simulation purposes such as Arena, Promodel, GPSS. The good model specification is to design the model that meets the objectives. The analyst needs to consider data structure or constraints, the type of analysis, the type of animation, knowledge of the system and input all data into the models. Also, the potential impact of the solutions should be considered.

2.3.3 Model Verification and Model Validation

The objective of model verification is to ensure that the model complies with its specification and performs as intended. Model validation is the way to ensure that the performance measures from the model match with the results in the actual system. However, the validation would be possible when the actual system exists and the required measurement is available. In addition, if the model is more complicated, it will be more difficult to do a validation.

2.3.4 Model Testing

The simulation model is designed to evaluate the results and aid in solving the project's problems. The number of scenarios should be considered and the replication of scenarios should be suitable to make model running adequate. Also, review the model running replication to reach the sufficient statistical reliability of performance measures.

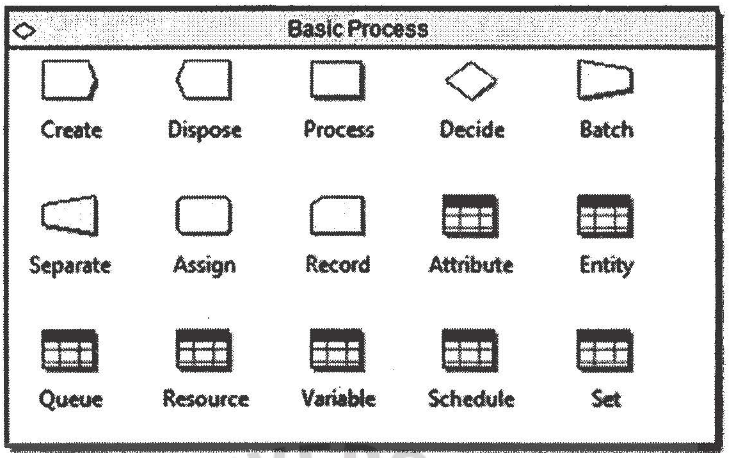
2.3.5 Output Analysis

A statistical analysis would be used to determine one of the alternatives with better performance measures and the best one is selected. The output analysis is the final step to formulate the alternative for the project's problem. It is a part of writing a report.

2.4 Arena Simulation Software

Arena simulation software was first released in 1993. It is a component of graphical modeling features, called modules, which are in template panels such as Basic Process, Advance Process and Advance Transfer. Each module can be combined to be a simulation model (Huynh, 2005). Arena can be applied in various activities such as manufacturing, transportation, distribution and also applied in the service business such as banks or hospitals.

Figure 2.2: Arena Basic Process Panel



The Basic Process panel consists of a set of flowchart modules and data modules as illustrated in figure 2.2. Flowchart modules are nodes or places where entities arrive or leave the model. Each icon of flowchart module has a different shape. In the Advance Process and Advanced Transfer panel, there are many additional kinds of modules (Kelton et al., 2010).

The data modules in the Basic Process template define the data of various entities, queues and resources. They can also define values, expressions and conditions in a model. Icons of data modules look like spreadsheets. They consist of Attribute, Entity, Queue, Resource, Variable, Schedule and Set (Kelton et al., 2010).

Arena implements a programming paradigm that combines visual and textual programming. The flowchart module is connected to each other to indicate the physical flow paths of transactions and logical flow paths of controls. Parameters of modules or elements are done using a text editor (Kulak, Polat, & Guenther, n.d.; Rossetti, 2010).

This study uses the Arena based simulation model because it is easy to use and serves as an efficient tool to analyze the process and evaluate the results. The model can be analyzed by many criteria such as average productivity, average waiting time and bottleneck in the process.

2.5 Previous Study of Simulation Applied in Container Terminal

There are many case studies related to improving operations in container terminals by using the simulation model. Most researchers emphasized improving operation time, reducing the waiting time with the effective cost in order to increase the efficiency of service performance.

According to Karafa (2012), the key problem is a delay in operations at the entrance gate and air pollution in Newark, Elizabeth port. Simulation software is applied in this case. The solution is to extend gate operation hours and create the appointment system to control the truck arrivals before the next container movement. However, the appointment system method causes problem in the next operation because of the variability of other transactions and the lack of good planning from the operator.

Guan and Liu (2009) applied the simulation method to analyze the inbound truck waiting at the terminal gate. They suggested two approaches to improve the truck congestion: increasing the number of gates and increasing gate productivity. The other one focused on a truck appointment system to define the truck arrival times. The objective is to reduce gate operation costs and increase a balance between the number of trucks and the gate capacity.

Yu, Jin, and Huo (n.d.) identified that the main factor evaluation is the service time but the construction cost should be minimized. Simulation models were set up to evaluate the efficiency of container traffic at the terminal gate in different numbers of truck lanes. Fleming (2012) also applied the simulation model to decrease the truck queue at the terminal gate. This case uses a pool queue system by pooling the multiple truck queues into one queue.

Huynh (2005) proposed statistics and a simulation model for reducing truck turnaround time and inland transportation costs. The simulation model is built up for explaining the relationship between the number of cranes and trucks turnaround time.

The solution method is increasing yard cranes and applying a truck appointment system.

Moini (2010) demonstrated the simulation model to investigate the operations on the landside and seaside. The objective is to improve traffic congestion in the terminal and increase efficiency of resource allocation. This study uses tactical strategies by extending gate hours and a applying gate appointment system.

Valencia (2006) created a simulation model for studying the relationship between total inbound and outbound ships by each transport mode and the container flow through the terminal. The solutions are to extend gate working hours and use a time window appointment system to reduce the congestion problem.

All of the strategy details can be summarized as per table 2.2.

Table 2.2: Summary of Related Literature

Authors	Objective	Result/ Outcome	Method
Karafa (2012)	To measure traffic problems and emission levels in the container terminal.	Extending gate operation hours is the most effective method to reduce traffic congestion and emission levels.	- Appointment system - Extended gate operation hours.
Fleming (2012)	To evaluate the performance of queuing strategies.	Using a pooled queue strategy is more beneficial in terms of lower and more predictable waiting times.	Pooled queue system and separate queue system.
Moini (2010)	To study the relationship of containers moving between a wharf and truck gates in a container terminal.	- Container dwell time influences truck traffic at gates and the terminal yard capacity. - A truck appointment system causes performance factor improvement.	- Explore truck volume at the gate, terminal and container dwell time - Appointment system
Guan and Liu (2009)	To reduce truck waiting cost and improve efficiency of the gate system.	- Appointment systems are useful for controlling truck arrival but require flexibility. - Increasing the number of gate is a limitation and underutilization of resources in off peak periods.	- Truck appointment system - Increase number of gate and capacity
Valencia (2006)	To reduce queue and waiting time of trucks and vessels.	- Appointment system can reduce congestion at the gate if the truck arrival rate is constant. - Extending operation hours leads to an increase of throughput.	- Time window appointment system - Extended operation hours.
Huynh (2005)	To reduce truck turnaround time.	Having more cranes can minimize truck turnaround time.	- Identify number of crane for terminal efficiency - Truck appointment system
Yu et al. (n.d.)	To reduce investment costs of gates and improve operational efficiency.	The number of truck lanes and service efficiency effects to average waiting time. Increasing truck lanes leads to waiting time being decreased.	Determine the number and service efficiency of entrance lanes and exit lanes

As studying from the related literature, truck traffic problems need to be considered because operation time is the most important issue to improve the performance of the container terminal. In addition, efficiency of operations depends on the number of truck arrivals and available resources such as gate, equipment, operator and operational area. It is also related to costs and utilization.

For the solution formulation, the first thing that should be realized is the factors that influence the delay of operations. After that is to find the proper solutions to analyze the simulation model.

2.6 Summary

This chapter explains the meaning of the main key words and in depth information from the literature review that is necessary for the research. The important key word for container and gate operations consist of operational management, efficiency and simulation. Container operation is a service operation so the one important indicator to improve efficiency is service quality. Simulation is the research tool for analyzing problems in the container operations and finding the best solution. It is useful for making a decision before being applied in the real system. Arena simulation software is selected in this research in order to reduce the waiting time at the bottleneck.

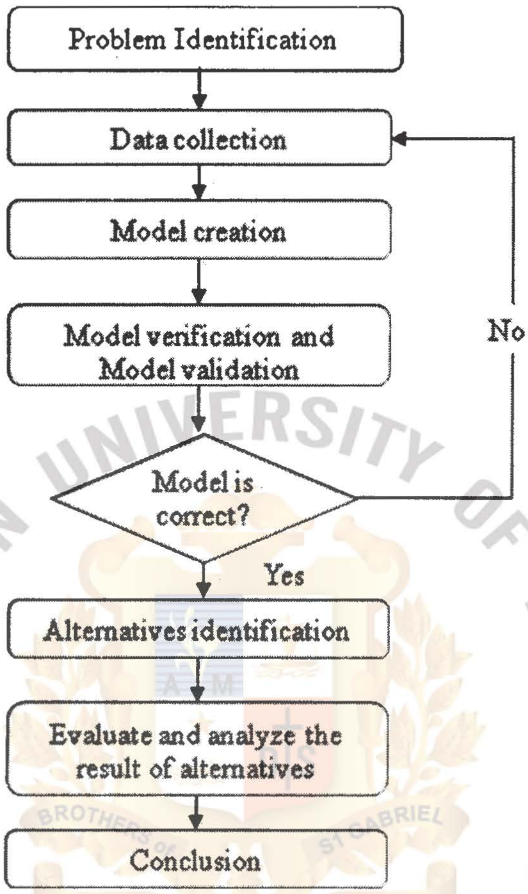
CHAPTER III

RESEARCH METHODOLOGY

This chapter explains the research methodology to analyze gate operations in ABC Company. The research methodology is starting from the current process analysis. Problem identification is the first step that requires specifying the scope of studying the problem. The next step is the data collection that will explain the method and process duration, before summarizing the overall process flow. After gathering the required information, the simulation model is created. The data structure, the input parameters and the model specifications are defined. All data is input in the Arena program to illustrate the operation process. After that is running the model and evaluating the results. Model verification and validation are the next steps to test the correction and reliability of the model. Each step will be repeated if the data is changed and until the results are acceptable.

After the current process analysis is completed, the potential alternatives will be proposed in various scenarios. The simulation model of alternatives is created to evaluate the results and the best alternative will be selected. The steps of the research methodology are illustrated in the below diagram.

Figure 3.1: Research Methodology Framework Diagram



3.1 Problem Identification

This research focuses on studying the full container gate-in process in Ladkrabang area of ABC Company. In order to study the problem, coordination with staff who are concerned with gate-in operation is needed together with the random interview with them for information sharing related to the working system and activities in operations. The concerned people in this operation consist of one supervisor who controls overall operations, and twenty staff such as the inspector, gate staff, survey staff, yard man and controller staff. In this case, the researcher interviewed the yard supervisor, controller staff and also got information from customers' complaints. The related problems and cause of the problems can be classified as per the below table.

Table 3.1: Summary of Problem and Details of Gate-in operation

Type of Problems	Details of Problems
Process time	- Long process time. - Complexity of process.
Equipment and yard operation	- Inadequate of heavy equipment because they need to use for rail operation in the same time as the truck gate-in arrival. - Space for placing containers is limited.
Layout	- Limitation of inspection and gate location - Limitation of truck lanes - Only one entrance way
Resource	Inadequate staff at the gate in peak hours.

In addition, the operations problem can be learned from observations such as the traffic of the trucks at the gate, sometimes the operations time takes longer when the truck driver does not prepare the documents. This affects the flow of following trucks and the trucks cannot move to other gates because they are used for different operations. Also, there is only one entrance and no alternative way in.

For the activities in the container yard such as dropping off containers by using a top loader, actually it takes a very short time if the equipment is enough and ready. Additional information from the controller staff, sometimes the top loader for lift on – lift off the container is needed for rail operations when the train arrives. So, sometimes the equipment level is not enough to support full container gate-in operations. However, this is an unexpected situation.

3.2 Data Collection

There are various methods to collect both quantitative and qualitative data. In this research, the data is collected by informal interviewing staff who are involved with gate-in operations, observation and reviewing the company data. These methods also helped to make a decision to find the solution of the problem.

3.2.1 Informal Interview

Informal interviewing of the operations staff is a suitable method to understand their function in each process, the problems in their operations, the number of staff, the number of equipment in the operation and the working schedules of staff.

Table 3.2: The Example Questions for Interviewing the Supervisor and the Staff

Questions for interviewing the supervisor	Questions for interviewing the staff
1. What is the main factor of traffic problem in your opinion?	1. What is your job?
2. What do you think about this problem?	2. What is the problem in your job?
3. What is your suggestion to improve the traffic problem?	3. How many staff and equipment are there in the operation?
4. Is it possible to change the gate location?	4. How will you reduce the operations time in your opinion?
5. Is it possible to open more gates for this operation?	
6. Is it possible to remove some activities?	
7. Is there any policy or measure existing to solve the problem?	

As concluded from table 3.2, the factor of traffic problem is the amount of time for container inspection and registration at the gate. The possible way to solve the problem is to increase the number of staff, open more gates and reduce the process time by inspecting containers and registration at the same time.

3.2.2 Observation

Observation is looking through the real work process to understand the current situation and activities from the terminal gate to the terminal yard. Moreover, observation is useful to collect the time process for each truck in order to input data in the simulation model.

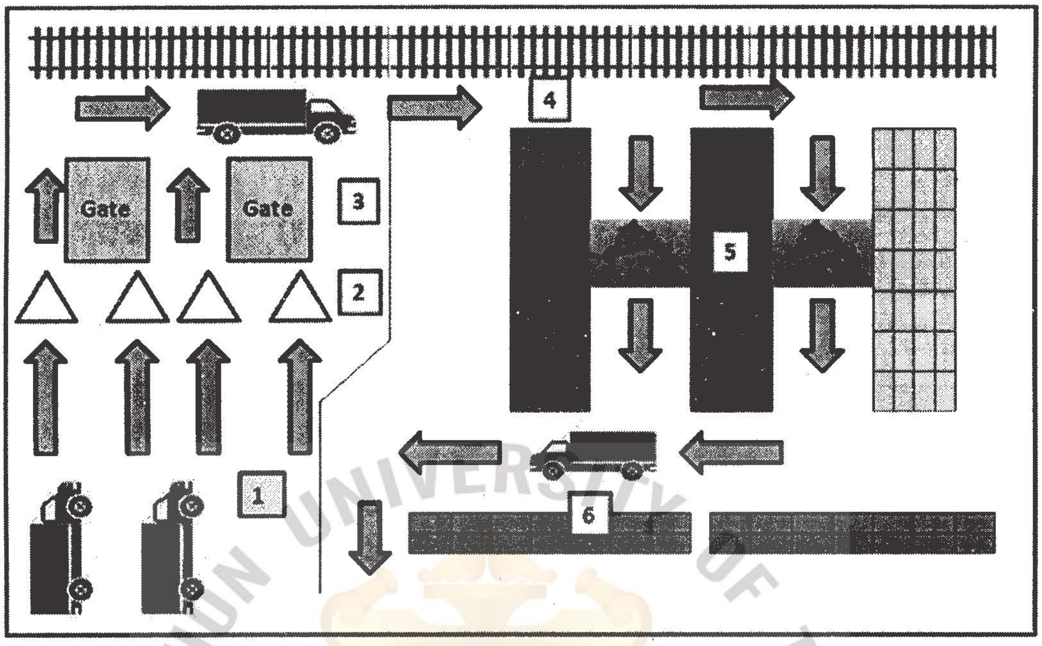
3.2.3 Review from document and historical data

The data is also collected from document and historical data to study the background, the policy of the company, the quantity of container gate-in moves I01, E02 and service time of gate operations. In addition, the information is gathered from the company layout to learn the traffic routes of the trucks from the entrance to the exit of the terminal, the location of gates and the container yard.

The related data is collected randomly from 30 trucks. The duration time to collect all data is in the peak period from Tuesday to Thursday. Process time is recorded starting when the trucks arrive at the gate, time intervals at each service point until the truck moves out from the container yard. The total number of daily trucks that gate-in is obtained from the company's monthly data (see appendix A). However, the truck arrival time is difficult to forecast because it depends on the shipping operations of customers. Therefore, the truck arrival time is collected from the historical data by selecting the peak date in three months from December 2013 to February 2014. The reason is to get the maximum number of trucks at gate-in to measure the efficiency and productivity of gate operations.

In this research, Arena simulation is the research tool used to build up the queuing model because it is convenient and easy to understand the flow of data and bottlenecks in process in the form of a diagram. A simulation is also simple to calculate the data and decrease the risk since the data in the actual system is plentiful and complicated. Before setting up the model, the work process flow is designed to figure the conceptual model. The simulation model creation and analysis will be explained in the section 3.3 to 3.5.

Figure 3.2: Process Flow of Full Container Gate-in operation



From the figure 3.2, the work process is described as following.

Step 1: Truck arrives at the terminal.

Step 2: Truck moves to the terminal gate for inspection. There are 2 gates and they can accommodate a maximum of 4 trucks at one time. Staff will write container number, seal number and condition of container on EIR form (see sample in figure 3.3) and submit it to the driver. If the container condition is damaged, the truck will move out from the yard.

Step 3: Truck driver submits EIR form and customs documents to the gate staff and pays the gate charge. The staff will check the documents. If the documents are correct, they will update the data in the system and give an approval sticker to the driver. If document is incomplete or have an error, the truck will move out from the gate to revise the documents. After the documents are revised, the driver gets back to gate staff to recheck the documents for approval again.

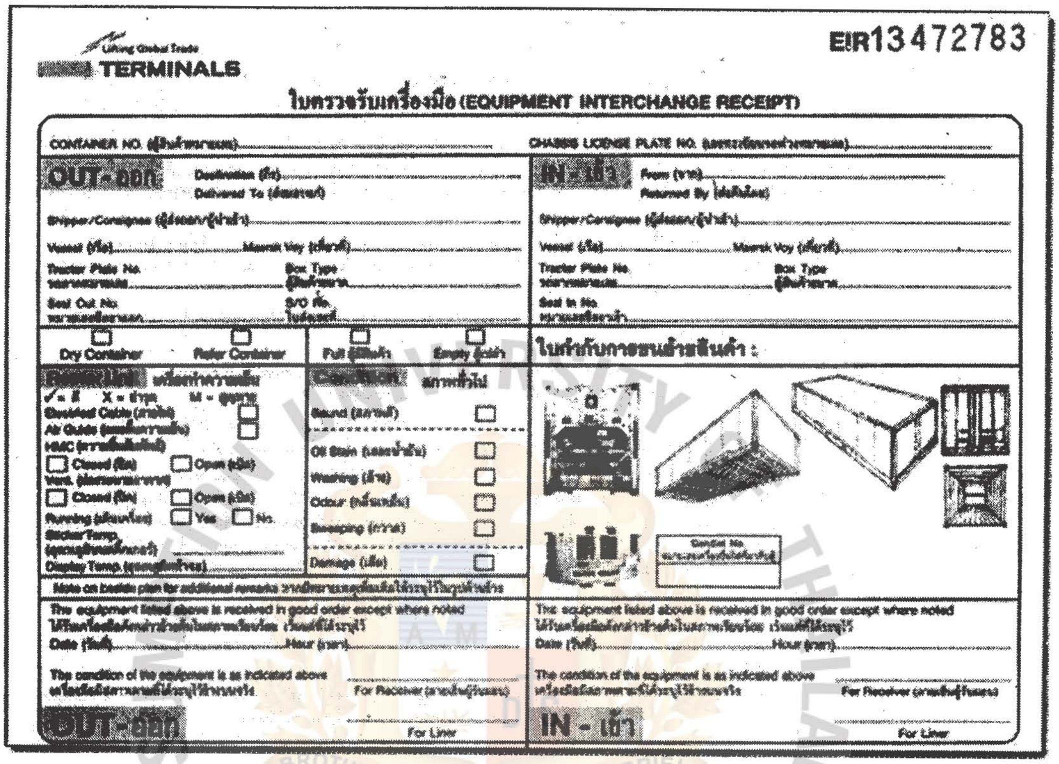
Step 4: Truck moves to contact with CY staff for planning container drop position.

Step 5: Truck moves to the yard for dropping off the container.

Step 6: Truck moves out from the yard. It is the end of the process.

The company's service operations are 24 hours every day.

Figure 3.3: EIR Form


TERMINALS

EIR13472783

ใบตรวจรับเครื่องมือ (EQUIPMENT INTERCHANGE RECEIPT)

CONTAINER NO.

CHASSIS LICENSE PLATE NO.

OUT - ออก

Destination

Delivered To

Shipper/Consignee

Vessel

Voy

Tractor Plate No.

Box Type

Seal Out No.

IN - เข้า

From

Returned By

Shipper/Consignee

Vessel

Voy

Tractor Plate No.

Box Type

Seal In No.

Dry Container

Reefer Container

Full

Empty

Sound

Oil Stain

Washing

Odour

Sweeping

Damage

The equipment listed above is received in good order except where noted

Date

Hour

The condition of the equipment is as indicated above

For Receiver

For Liner

The equipment listed above is received in good order except where noted

Date

Hour

The condition of the equipment is as indicated above

For Receiver

For Liner

3.3 Model Creation

After collecting data and mapping the process flow, the simulation model is built up in the Arena program. The objective of creating the model is to analyze the performance and the queuing system.

Arena is a simulation program with graphical figures that consists of modules and datasheets. The creating process starts from selecting the modules from the template panel and placing them on the screen. After that is defining input parameters to place in the module and datasheet before connecting each module to create the flow path. All steps will be repeated until the model is completed.

Input parameter for setting in the model is as following.

i. The number of the truck arrivals

ii. The service time for each process

iii. The number of staff and equipment in each process

iv. The time schedule of staff

v. The number of the trucks rejected from inspection and documentation: This data is obtained from record documents.

The value of data is from monthly records, operations staff' information and estimates from random observations.

3.3.1 Input Data Analysis

Some observed data such as the process time of the random 30 trucks needs to be analyzed in order to find the based distribution value to set in the model. In this study, Arena Input Analyzer is used for input data analysis. For example, the distribution of the activity at the gate process time is tested as per figure 3.4.

Figure 3.4: Distribution Result in Arena Input Analyzer
(The Example of Gate Process Time)

Distribution:	Triangular
Expression:	TRIA(3, 3.29, 5.96)
Square Error:	0.00988
Chi Square Test	
Number of intervals	4
Degrees of freedom	2
Test Statistic	1.36
Corresponding p-value	0.509
Kolmogorov-Smirnov Test	
Test Statistic	0.0714
Corresponding p-value	0.56

The distribution testing from the input analyzer has two methods: Chi Square Test and Kolmogorov-Smirnov Test (K-S test). The researcher refers to the K-S test in this case because the number of input data is not higher than 50. Statistical Hypothesis Testing for the distribution results of the activity at the gate process time is explained as per below.

Assumption:

H_0: The collected data follows Triangular distribution with parameter a = 3, b = 3.29, c = 5.96

H_1: The collected data does not follow Triangular distribution with parameter a = 3, b = 3.29, c = 5.96

If p-value is higher than 0.05 (p-value > 0.05), the null hypothesis (H_0) will be not rejected. According to figure 3.4, p-value = 0.56 so the hypothesis H_0: The distribution results TRIA (3, 3.29, 5.96) is not rejected. It means that triangular distribution results are acceptable for setting in the simulation model.

Table 3.3: Distribution Data of Time for Each Activity

Activity	Time (minutes)	p-value
Survey and inspect containers	NORM(4.86, 0.531)	0.51
Register, check document and pay gate charge	TRIA(3, 3.29, 5.96)	0.56
Planning drop off container position	TRIA(0.999, 1.5, 2)	0.16
Drop off container	UNIF(2, 3.21)	0.61

All process time data is analyzed and the distribution of each process is indicated in table 3.3. From Hypothesis Testing shown above, the p-value of all process is higher than 0.05. The distribution values of all process are input in the Arena simulation model.

3.3.2 Resource

The one important variable to put in the model is the number of resources such as related staff and equipment. The table 3.4 classifies the work details in each position. Working operations are 24 hours. The working schedule of staff is separated into 2 shifts per day: day shift (08.00 – 20.00) and night shift (20.00 – 08.00). They have a 1 hour break time but it can be changeable (see table 3.5).

Table 3.4: Work Function of Staff

Staff Position	Number of staff	Work function
Inspector	8	Inspect the condition of containers and report inspection result in EIR form.
Survey staff	4	Assist inspection staff to survey containers, write container number and seal number on EIR form.
Gate staff	8	Check container details in system, check documents and collect the gate charge.
CY staff	4	Plan container drop-off position.
Yardman	4	Stand by at the yard to signal and direct the truck driver.
	4	Control heavy equipment to move the containers from the truck to storage area.

Table 3.5: Working Schedule of Inspection and Gate Staff

Staff	Number of staff	Shift	Break time
Inspector	2	Day	11.00 a.m. -12.00 p.m.
	2		12.00 p.m. - 01.00 p.m.
	2	Night	11.00 p.m. -12.00 a.m.
	2		12.00 a.m. - 01.00 a.m.
Gate	2	Day	11.00 a.m. -12.00 p.m.
	2		12.00 p.m. - 01.00 p.m.
	2	Night	11.00 p.m. -12.00 a.m.
	2		12.00 a.m. - 01.00 a.m.

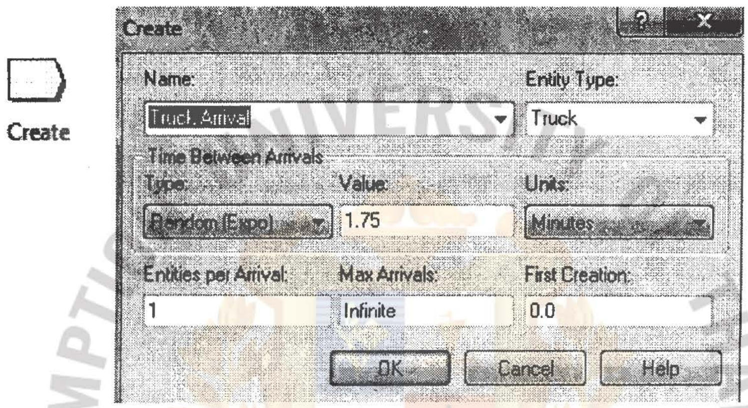
Break time of survey staff, CY staff and yardman is the same as others, but they will standby all the time.

3.3.3 Model building

After gathering all the data, the simulation model is created and details are input in the model. The details in the model will be explained as follows:

Create Module: The first module is applied in the model by inputting data of truck arrivals under exponential distribution average 1.75 minutes as per figure 3.5.

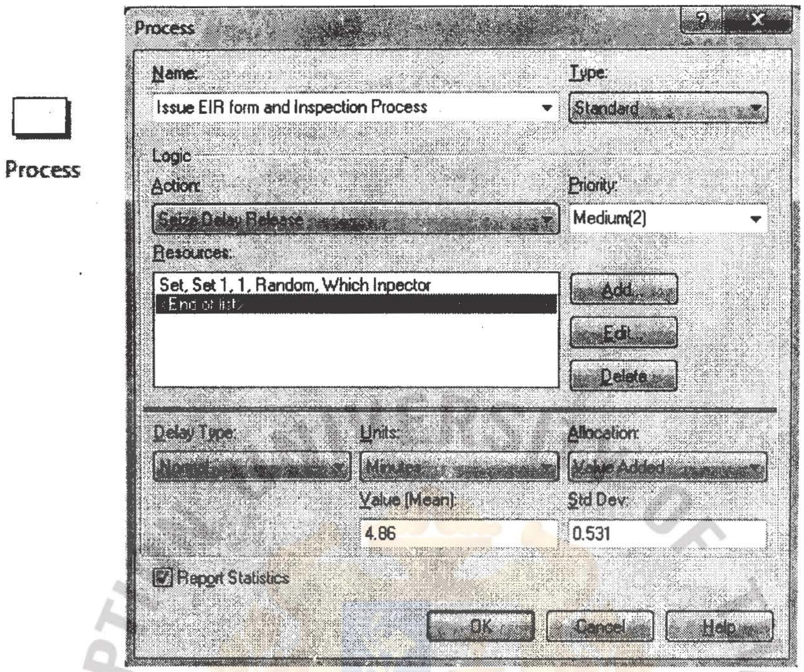
Figure 3.5: Created Module Details



Process Module: This module is used for each activity. For example, issue EIR form and inspection process is input with a normal distribution or NORM (4.86, 0.531). Details are shown as per figure 3.6.

Figure 3.6: Process Module Details

(The example of issue EIR form and inspection process)



This module also has a sub detail of resources as per figure 3.7. There is one group of staff while the type of resource is Set. Details of each staff and working schedule are input in the datasheet (see figure 3.8).

Figure 3.7: Resource Details of Issue EIR Form and Inspection Process

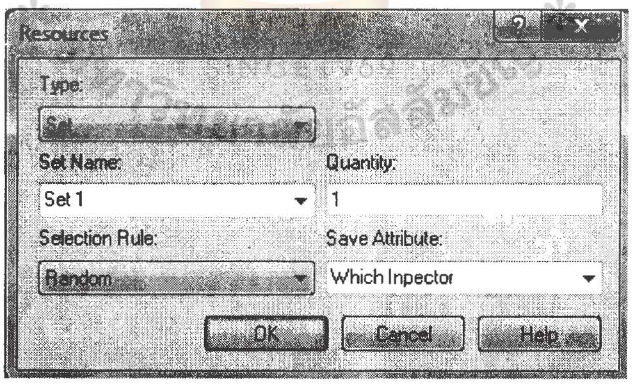


Figure 3.8: Details of Each Staff

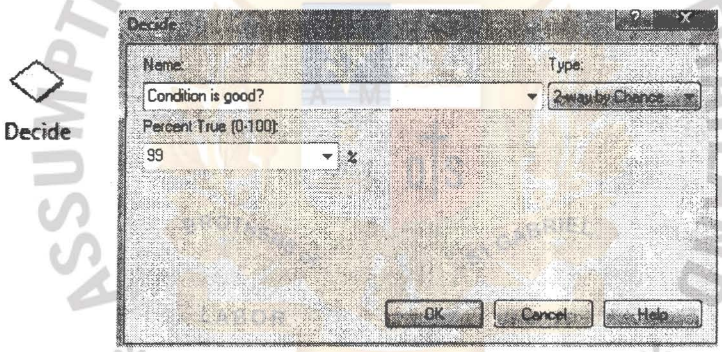
(The Example of Issue EIR Form and Inspection Process)

	Name	Type	Capacity	Schedule Name	Schedule Rule	Busy / Hour	Idle / Hour	Per Use	StateSet Name	Failures	Report Statistics
1	Inspector 1	Based on Schedule	[illegible]	Schedule Inspector 1	Wait	0.0	0.0	0.0		0 rows	☑
2	Inspector 2	Based on Schedule	[illegible]	Schedule Inspector 2	Wait	0.0	0.0	0.0		0 rows	☑
3	Inspector 3	Based on Schedule	[illegible]	Schedule Inspector 3	Wait	0.0	0.0	0.0		0 rows	☑
4	Inspector 4	Based on Schedule	[illegible]	Schedule Inspector 4	Wait	0.0	0.0	0.0		0 rows	☑
5	Inspector 5	Based on Schedule	[illegible]	Schedule Inspector 5	Wait	0.0	0.0	0.0		0 rows	☑
6	Inspector 6	Based on Schedule	[illegible]	Schedule Inspector 6	Wait	0.0	0.0	0.0		0 rows	☑
7	Inspector 7	Based on Schedule	[illegible]	Schedule Inspector 7	Wait	0.0	0.0	0.0		0 rows	☑
8	Inspector 8	Based on Schedule	[illegible]	Schedule Inspector 8	Wait	0.0	0.0	0.0		0 rows	☑

Decide Module: It is used for the decision making process. The figure 3.9 is the example of the container inspection process by setting type as a 2-way by Chance and good condition and container is 99 percent.

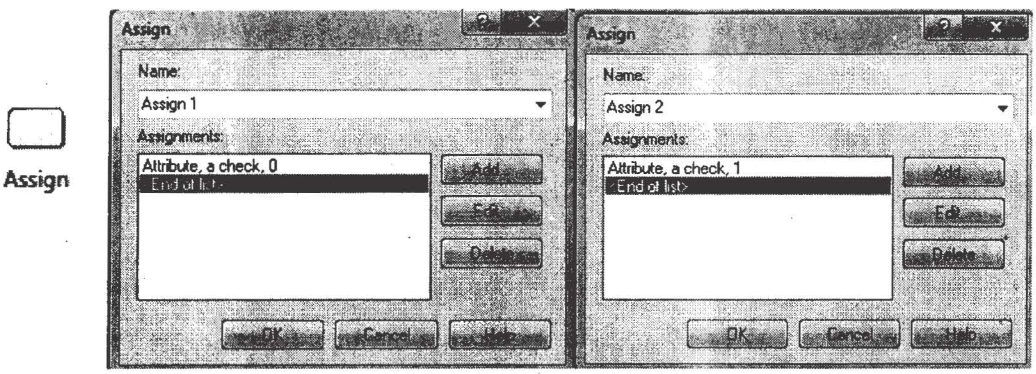
Figure 3.9: Decide Module Details

(The Example of Inspection Process)



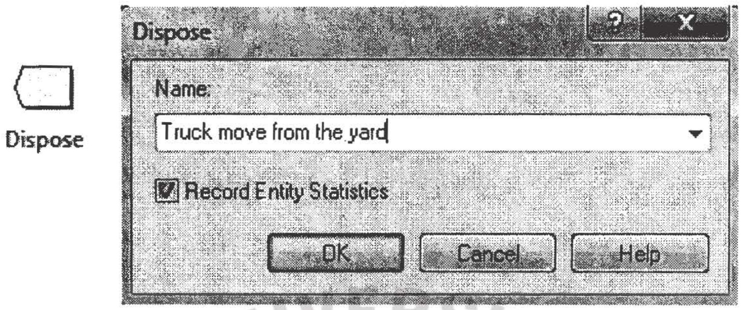
Assign Module: It is used for assigning specific data in the model such as the attribution of the document checking process (see figure 3.10).

Figure 3.10: Assign Module Details



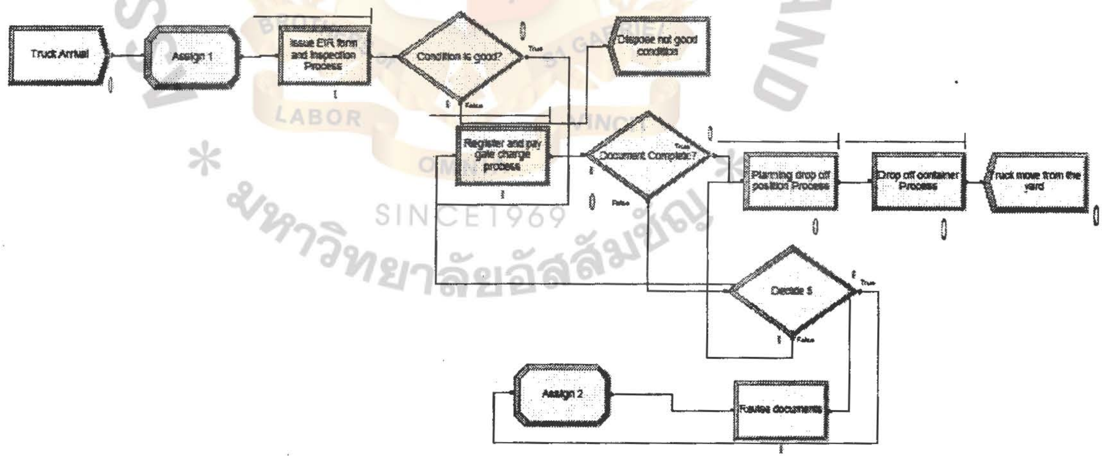
Dispose Module: It is the last module to be put in the model after all building processes are completed.

Figure 3.11: Dispose Module Details



When the model creation is completed, the model will look like the graphic flowchart connecting of all modules. The entity arrival is moving from Create Module and out from Dispose Module. The completed model for full container gate-in process is illustrated as per figure 3.12.

Figure 3.12: The Arena Simulation Model for Full Container Gate-in operation



3.3.4 Model running set up

To obtain the reliable statistical information, model running set up should be designed with the suitable length of time and number of replications. The running duration set up is 24 hours per run. The number of models run is 10 replications. The results of each replication are summarized as per the below table.

Table 3.6: The Simulation Result from Different Running Replication

Replication	Total number of truck out	Truck arrival rate (per hour)	Number of truck in queue
1	812	34	6
2	817	34	5
3	771	32	4
4	808	35	4
5	815	34	4
6	822	35	5
7	741	32	4
8	769	33	4
9	805	35	6
10	821	35	5

3.4 Model Verification and Model Validation

After getting the results from model running, they needs to be tested to prove that the model is applicable and to represent the actual system. Therefore, the model should have verification and validation as explanation in this section.

3.4.1 Model Verification

Model verification is done to test the model behavior whether it is as per the intention while the verification method is to check the logic of the model structure such as the number of entities, queuing systems and statistic results.

The number of entities in and out of the process is important because it verifies that the model is for regular running. Verification analysis begins with the comparison of the truck volume: the number of entities out from the simulation and the actual volume from data collection. From the model running 10 replications in table 3.6, the average number of entities out is 798 trucks per day. The actual volume of the truck is 832 trucks per day. The different values between the results from simulation and the number of the trucks from the actual data is 4.09%. If the different value is not more than 10%, the model is acceptable.

Another key concern in this study for model verification is the number of rejected jobs in the operation. There are rejected jobs in 2 activities as per table 3.7 and 3.8.

Table 3.7: The Number of Rejected Truck from Inspecting Containers Process

Number of Replication	Number of good condition container	Number of damage condition container
1	804	11
2	810	14
3	767	6
4	800	10
5	808	12
6	819	6
7	733	10
8	763	8
9	800	8
10	811	12
Percentage result	98.79%	1.21%
Actual data percentage	99.00%	1.00%

According to table 3.7, the number of rejected trucks from the inspection process is 1.21%. It is different from the actual data of 0.21%. As per the agreement with the operations department, the results will be acceptable if the different values are not more than 10%. Thus the data from the simulation is acceptable.

Table 3.8: The Number of Rejected Truck from Checking Document Process

Number of Replication	Number of correct document	Number of incorrect document
1	820	25
2	817	14
3	786	21
4	814	16
5	824	21
6	831	18
7	743	12
8	774	13
9	813	19
10	809	12
Percentage result	97.92%	2.08%
Actual data percentage	98.01%	1.99%

From table 3.8, the number of rejected trucks from the checking documents process is 2.08% compared with the actual data of 1.99%. Its discrepancy is 0.09% so the simulation results are acceptable.

3.4.2 Model Validation

Model validation is done to test the accuracy of the model in order to represent the actual system. Validation will be possible by comparing the model results to the actual data. Statistical Hypothesis Testing is the standard method to test the sample data as follows.

Statistical Hypothesis Testing for average waiting time of the truck at the bottleneck point

Table 3.9: Validation of Average Waiting Time at the Bottleneck from Model Running 10 Replications

Number of replication	Average waiting time (minutes)
1	10.75
2	9.12
3	7.98
4	7.13
5	6.84
6	8.22
7	7.92
8	6.32
9	10.89
10	8.81

From the table 3.9, the average waiting time of the simulation results ($\bar{X}$) = 8.40 Minutes

The average waiting time from actual data (μ) = 8.94 Minutes

Assumption:

H_0: Average waiting time of the truck is 8.94 minutes ($\mu = 8.94$)

H_1: Average waiting time of the truck is not 8.94 minutes ($\mu \neq 8.94$)

Statistical Hypothesis Testing is the rule of decision making to accept or reject the null hypothesis (H_0) by defining the Critical Value and Level of Significance.

Level of Significance (α) = 0.05 and the number of data (n) $= 10$

Statistical testing in this research is T-Test because the number of data is less than 30.

The critical value of $t_{\frac{\alpha}{2},n-1} = t_{0.25,9} = 2.2622$

Thus the hypothesis H_0 is rejected when $t > 2.2622$ or $t < -2.2622$

For the statistic testing, $t = \frac{(\bar{X} - \mu)}{\sigma / \sqrt{n}}$

$\bar{X}$ = 8.4, Standard Deviation (σ) = 1.54, μ = 8.94, n =10

$t = \frac{(8.4-8.94)}{1.54/\sqrt{10}}$ = -1.11

According to t = -1.11, the hypothesis H_0 is not rejected. It means that the simulation results are accepted and this model can be used for analyzing the average truck waiting time.

3.5 Summary

This chapter aids in understanding the working process of full container gate-in operations in the current situation. The research is conducted by analyzing the problems and collecting data through the interviews, observations and referencing the company's historical data records. The research tool is the simulation method to analyze gathered information, and evaluate the results to choose the solution of traffic problems at the gate.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

The purpose of this chapter is to summarize the analysis from as-is simulation and identify the alternative to improve the traffic problem of full container gate-in operations. The study of the current operations focuses on the queuing time at the bottleneck. After that, the alternatives will be proposed in various scenarios in order to reduce the trucks' waiting time based on the research objectives. The simulation model of each scenario will be built up by adjusting the as-is simulation model. The results of each scenario will be compared and the best solution will be selected.

4.1 The Analysis of Current Full Container Gate-in Process

The analysis in this research focuses on improving the full container gate-in process. The quantity of resource and facility in the current process is the first important variable to find the solution. Information is explained in table 4.1.

Table 4.1: Resource and Facility of Current Operation

Resource and facility	Quantity
Gate	2
Gate lane	4
Inspector	8
Gate staff	8

From chapter 3, the average truck waiting time at the bottleneck from model running is validated. Additionally, the average of cycle time and the number of truck outs is summarized as per table 4.2

Table 4.2: Simulation Result of Current Operation

Data Type	Simulation result
Average waiting time at the bottleneck	8.4 minutes
Cycle time	13.6 minutes
The number of truck out	798 trucks

4.2 The Alternative Scenarios of Full Container Gate-in Process

The alternative to solve the traffic problem is identified in the table 4.3. Each has different criteria improvements based on the current operations. All alternatives will focus on reducing the waiting time for inspection and the registration process. Details of each alternative will be explained in the next section.

Table 4.3: Alternative for Improving Full Container Gate-in Operation

Alternati	Improvement criteria	Scenario
1	Add the number of gate lane and staff	- Open one gate - Add inspector and staff at the gate
2	Adjust the staffs' working schedule	Change break time of inspector and gate staff
3	Adjust the process at the gate	- Combine the step of container inspection and registration. - Add survey staff

4.2.1 The Alternative Scenario by Increasing Gate and Staff

The first alternative focuses on the number of gates and operations staff. The objective is to increase the gate service lane for container inspection and registration process. This alternative will open one additional gate while placing two staff at a time, i.e. one is working as inspector while the other one is working as a gate staff. Therefore, the simulation model is adjusted by adding two staff and four staff. After running the model, the waiting time of each scenario is compared as per table 4.4.

Table 4.4: The Waiting Time Result by Increasing Gate and Staff

Scenario	Resource		Simulation result	
	Inspector	Gate staff	Average waiting time (minutes)	Average number of truck in queue
1	8	8	8.40	4.87
2	9	9	6.81	4.13
3	10	10	3.88	2.36

Table 4.4 explains the average waiting time of each scenario with the various quantities of staff and gate lanes. The first scenario is the result of the as-is simulation model. The second scenario is adding one inspector, one gate staff and one additional gate lane. The average waiting time from the second scenario is decreased 1.59 minutes or 18.92%, compared to the first scenario. The average number of trucks in queue of the second scenario is reduced by 0.74 trucks from the first scenario. For the third scenario, two inspectors and gate staff are added with one additional gate lane from the original scenario. The average waiting time from this scenario is 3.88 minutes, that is, decreasing from the second scenario 2.93 minutes or 34.86%. Furthermore, the average number of trucks in the queue is also reduced from the second scenario 1.77 trucks. From the comparison in table 4.4, the third scenario which is adding four staff will be selected because the average truck waiting time is the lowest.

The more additional staff that are placed, the lower the waiting time at the bottleneck will be. In contrast, this method will gradually increase the average waiting time of the process in the container yard by about 0.5 minutes because more trucks will move to the yard but the resource quantity is not changed. Anyhow, it does not impact the customer's satisfaction.

4.2.2 The Alternative Scenario by Changing Staff Schedule

This alternative focuses on the working schedule of the inspector and gate staff. The working schedule is adjusted by changing the break time of each staff. The table 4.5 is the current schedule of the inspector and gate staff. Two staff in each position have the same break hours. This brings the longer waiting time of trucks during these periods. After changing the schedule, each staff will have a different break time (see table 4.6). However, each inspector and gate staff must have the same break time because they work at the same gate lane.

Table 4.5: The Current Working Schedule of Inspector and Gate Staff

Quantity of Staff		Shift	Break time (Original)
Inspector	Gate staff		
2	2	Day	11.00 a.m. -12.00 p.m.
2	2		12.00 p.m. - 01.00 p.m.
2	2	Night	11.00 p.m. -12.00 a.m.
2	2		12.00 a.m. - 01.00 a.m.

Table 4.6: The New Working Schedule of Inspector and Gate Staff

Quantity of Staff		Shift	Break time (New)
Inspector	Gate staff		
1	1	Day	11.00 a.m. -12.00 p.m.
1	1		11.30 a.m. -12.30 p.m.
1	1		12.00 p.m. - 01.00 p.m.
1	1		01.00 p.m. - 02.00 p.m.
1	1	Night	11.00 p.m. -12.00 a.m.
1	1		11.30 p.m. -12.30 a.m.
1	1		12.00 a.m. - 01.00 a.m.
1	1		01.00 a.m. - 02.00 a.m.

The simulation result of the average waiting time and average number of trucks in the queue for each scenario is compared as per table 4.7.

Table 4.7: The Result from Adjusting the Working Schedule

Scenario	Simulation result	
	Average waiting time (minutes)	Average number of truck in queue
Current schedule	8.40	4.87
New schedule	6.86	3.97

After adjusting the working schedule, the average waiting time is slightly lower than the current schedule similar to the number of trucks in queue. The result of average waiting time between the current and new schedule is different by 1.54 minutes. The result of the average number of trucks in queue of the new schedule is lower than the current schedule by 0.9 trucks.

This method is useful when many trucks are on a break time period but this is not always the best alternative because the actual truck arrival time is unstable. In addition, the actual break time cannot be firmly designated as the timetable because the operations time is also unstable.

4.2.3 The Alternative Scenario by Adjusting Process at the Bottleneck

The third alternative is adjusting the process at the bottleneck in order to reduce the processing time of the activities at the gate and reduce the cycle time. The original as well as the new process flows are illustrated in figure 4.1 and figure 4.2. In the new process flow, the activity of the container inspection, checking of documents and paying gate fees will be done concurrently. The processing time of these activities will be saved as the truck drivers do not need to wait for container inspection before submitting the documents and paying fees at the gate. The truck drivers will go to the gate right after receiving the EIR form. Therefore, this method needs to issue EIR form in the first step.

Figure 4.1: Full Container Gate-in Operation (Current Process Flow)

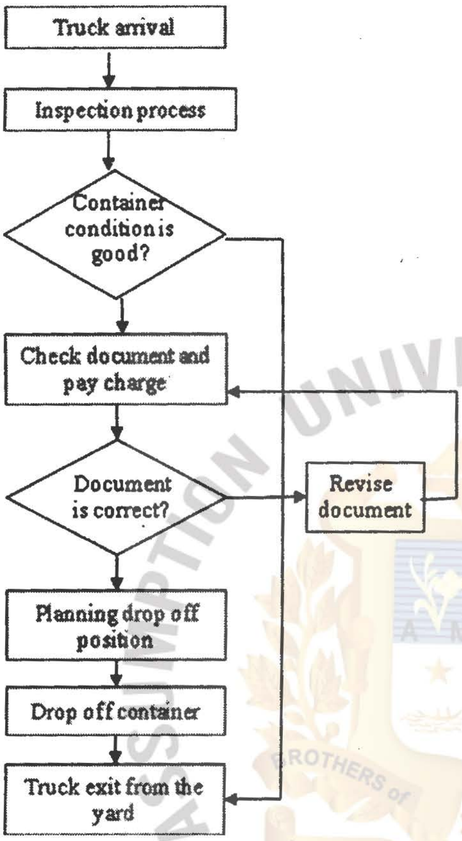
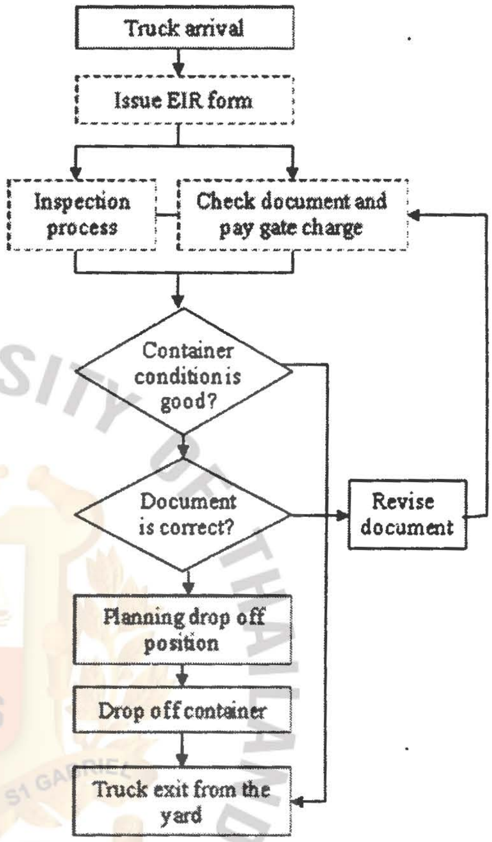


Figure 4.2: Full Container Gate-in Operation (New Process Flow)



From figure 4.2, the process flow is changed in the way that the truck driver needs to contact with staff to obtain the EIR form at the terminal entranceway. Next, the truck driver moves to the gate for container inspection and submits the documents for checking and paying fees simultaneously. After that, the further steps still remain the same.

In terms of the resources, the new operations flow needs additional staff for issuing EIR forms. Therefore, four staff will be added in this process for the new operational flow.

Table 4.8: The Simulation Result by Changing the Process

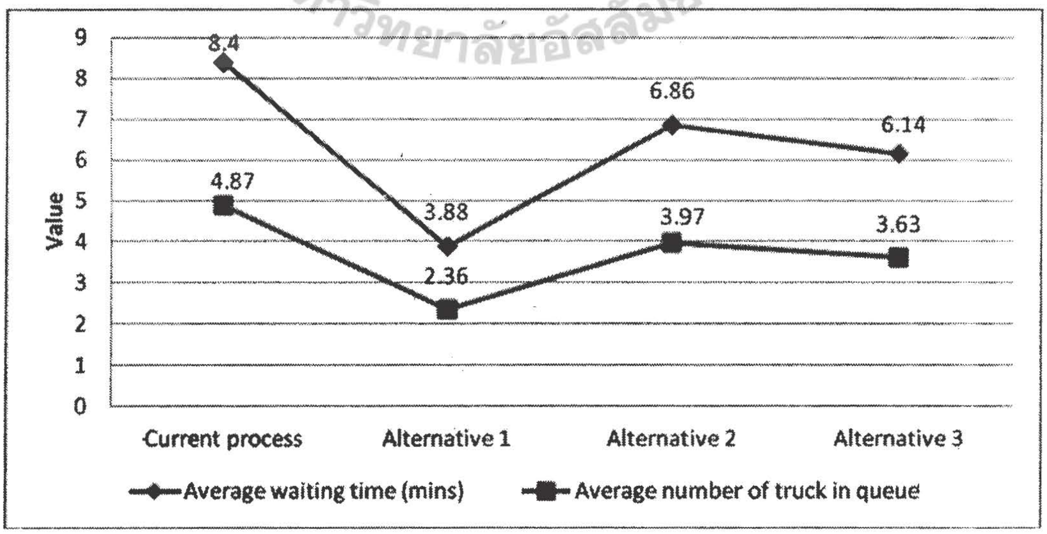
Scenario	Simulation result		
	Average waiting time (minutes)	Average number of truck in queue	Average cycle Time (minutes)
Current process	8.40	4.87	13.60
New process	6.14	3.63	9.76

From table 4.8, the average waiting time results of the new process flow is decreased, compared to the original, 2.26 minutes or 26.92%. For the average number of trucks in the queue, it decreased by 1.24 trucks. The additional compared data, average cycle time, the simulation results of the new process flow is 9.76 minutes. It can help shorten from the current process by 3.84 minutes or 28.24%. Cycle time reduction also increases the capacity of truck service in process.

4.3 Comparison of Alternative Scenarios

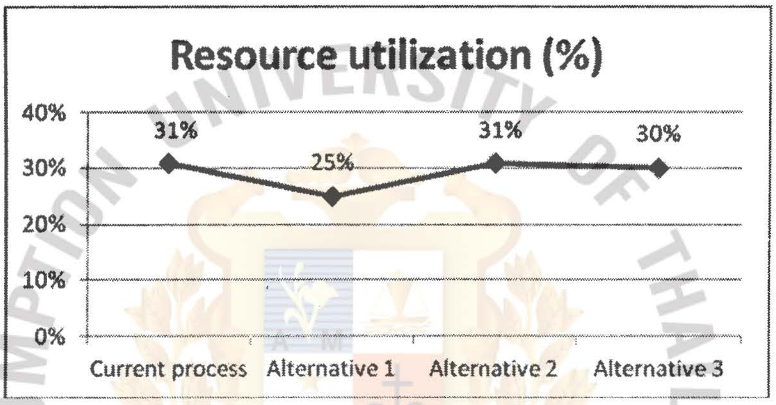
In this study, all alternative scenarios will be compared with the results of waiting time, the number of trucks in the queue, cost and resource utilization to select the best solution. The first priority to consider is the waiting time and the number of trucks in the queue. The second priority to consider is the resource utilization of staff and costs.

Figure 4.3: Average Waiting Time and Average Truck in Queue of Each Scenario



According to figure 4.3, the average waiting time and the average number of trucks in the queue from the first alternative is the lowest. The value of waiting time is 3.88 minutes that decreases from the current process of 4.52 minutes or 53.77%. Similarly, the number of trucks in the queue of this alternative is reduced from 4.87 trucks to 2.36 trucks. Therefore, this method is the most effective for saving non-value added time at the bottleneck.

Figure 4.4: Average Resource Utilization of Each Scenario



In figure 4.4, the average resource utilization of staff from the first alternative is the lowest percentage because the quantity of staff is increased. The resource utilization is decreased from current process from 31% to 25%. It is different from the original 6%. The resource utilization of the second and third alternative is not different from the current situation.

Table 4.9: Estimated Cost for Each Alternative

Alternative	Additional Cost	Estimated cost (Baht)	Total cost (Baht)
1	- Facility	135,000	168,000
	- Add 2 staffs (inspector and gate staff)	33,000	
	- Facility	135,000	201,000
	- Add 4 staffs (inspector and gate staff)	66,000	
2	No additional cost	-	-
3	Add 4 survey staffs	36,000	36,000

One important factor to selecting the alternative is the cost. From table 4.9, the first alternative which adds 4 staff requires the highest cost. The total cost is from increased staff, facility and gate office supplies. For the third alternative, there is the additional cost of increased survey staff only. There is no additional cost for the second alternative because the resources did not change.

Table 4.10: Comparison All Criteria from All Alternatives

Criteria	Alternative 1 (add 4 staff)	Alternative 2	Alternative 3
Average waiting time (minutes)	3.88	6.86	6.14
Average resource utilization	25%	31%	30%
Cost (Baht)	201,000	-	36,000
Average cycle time (minutes)	13.60	13.60	9.76

Table 4.10 summarized the simulation results of each criterion from each alternative. The results from the first alternative have the lowest waiting time but its resource utilization is reduced and it requires the highest investment. For the second alternative, the results do not change except the waiting time which is slightly decreased from the current process but higher than the others. In the third alternative the results of the waiting time are higher than the first one while the cycle time is reduced. In addition, the cost of the third alternative is lower than the first alternative.

From the comparison in table 4.10, the first alternative and the third alternative are useful for improving the full container gate-in process. The first alternative is useful for reducing the truck waiting time at the bottleneck. The third alternative does not reduce as much waiting time as the first one but it does reduce more cycle time.

After proposed the alternative results and discussed with the manager of operation team, the first alternative is not the best way to reduce the waiting time due to the limitation of the budget. Besides, they do not have the policy to open additional gate. It needs to consider the traffic management if using this alternative. Thus, the third alternative is the recommend method to implement for solving the traffic problem of full container gate-in operations. It can be applied with the less cost than the first alternative. The third alternative will have additional costs by adding the survey staff only. The improved process is also applied in practice the right away. Moreover, it can reduce cycle time and this also increases the capacity of truck service in process.

4.4 Summary

The queuing truck traffic in full container gate-in operations has improved by using the Arena simulation program in this chapter. The three alternatives are proposed by changing the different factors in the simulation model of the current operations to reduce the truck waiting time at the bottleneck. The factors which are applied in the simulation model are various such as the number of staff, the number of resources, working schedule and the process flow rearrangement. The simulation results of current operations and each solution is compared to identify the changed results. Also, the simulation of all alternatives is compared with the different criteria such as the average waiting time, average resource utilization, additional costs for improvement and average cycle time. The comparison of the advantages of each alternative are needed to select the appropriate solution for improving the operations.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

In this chapter, the summary of the findings, conclusions and recommendations including the future studying for improving the traffic flow in container operations will be explained.

5.1 Summary of the Findings

This research emphasizes improving the service time of the full container gate-in process in ABC company. The study specifies on process of receiving full containers starting from when a truck arrives at the gate until the truck moves away from the container yard. The simulation represents the actual operations to analyze the problem whilst the different solutions will be applied to reduce the waiting time at the bottleneck.

The current operation is simulated and three alternatives are applied to the current simulation model with different scenarios. The first scenario focuses on increasing the number of staff and gate lanes. The second one focuses on adjusting staff's break hours while the third one focuses on adjusting the work process flow. The results of the current process and all scenarios are analyzed through critical factors such as the trucks' waiting time, resource utilization, additional cost and cycle time.

The results from the current simulation model pointed out that the longest waiting time occurs during the process of container inspection and registration. Its value is 8.4 minutes. The simulation results from the first alternative showed that the average waiting time dropped to 3.88 minutes. The waiting time of the second alternative is 6.86 minutes. For the third alternative, the waiting time is reduced to 6.14 minutes.

From the comparison of all results, the second alternative shows the highest waiting time.

In the current operation, the resource utilization is 31%. After applying the first alternative in the simulation, the resource utilization is 25% which is the lowest value because many resources such as inspectors and gate staff are more in use. For the third alternative, the resource utilization is 30% which is only a 1% difference from the current operations.

The additional cost for utilizing the first alternative is 201,000 Baht, which is mainly for increasing gate facility and four staff. For the third alternative, the additional cost is 36,000 Baht which is lower than the first one. This additional cost comes from hiring four new survey staff for issuing EIR forms.

Moreover, the third alternative is the only method to reduce the cycle time because the operational flow is improved by operating two activities, i.e. container inspection and registration process, at the same time. The cycle time is reduced from 13.6 minutes to 9.76 minutes. That means it can save time 28.23%.

5.2 Conclusions

The traffic congestion at the gate affects a long queue and a long waiting time for the container returning process. In addition, based on the company's data, the container traffic volume trend in 2014 is continuing to grow as the company has planned to acquire more customers. The most workable alternative is needed not only to improve the service performance, but also to increase customer satisfaction.

After the results from all alternatives are evaluated, the first one promoting the number of the gate lanes and staff can reduce the waiting time the most. However, the cost for this improvement is the highest if compared with the other alternatives. Besides, opening additional gates and increasing staff will create the uncontrollable costs such as costs for equipment repairing and electricity while the third alternative only requires staff employment.

Moreover, adding more gate lanes will reduce the trucks' waiting time only at the gate. Nonetheless, it will increase the waiting time of process in the container yard because there will be more trucks moving out from the gate to the yard. In other words, it is still considered an inefficient improvement to reduce the truck waiting time in overall operations.

From the research objective, the most appropriate alternative to reduce the trucks' time of full container gate-in operation is the third alternative which aims to adjust the process of inspection and complete the registration process at the same time. From the simulation results, the average waiting time is as low as 6.14 minutes. It is not the best result but the cycle time is lowered to help the company enhance their service capacity for the growing demand in the future.

5.3 Theoretical Implications

This research is concentrated on queuing time reduction because it is vital to improve the container operations. Processing time management, resource utilization and cost management are the main factors to measure the productivity which is one of the indicators of gate operational efficiency (Le-Griffin & Murphy, 2006). The company has to control these factors appropriately to boost the company's productivity.

The third alternative is selected as a proper solution to reduce the waiting time and cycle time. Also, good time management will increase the productivity. This solution will be useful for the company to enhance the performance.

5.4 Managerial Implications

Operational service time is the most important for measuring the service performance of the company. The third alternative is the appropriate one to apply to reduce the waiting time and reduce the cycle time in the container operations because it is easier to manage by adjusting the process and increasing survey staff. This solution also saves cost for the company. In addition, cycle time reduction will help the company enhance service capacity. Therefore, the company would get more customer satisfaction and profitability from the gate processing time improvement.

To apply this alternative, it will be more effective if the company can manage the operations time well enough because processing time can change depending on the real situation. Moreover, container operations are considered unpredictable and uncontrollable situations. This should a concern accordingly.

5.5 Limitations and Recommendations for Future Research

From the result of the new alternative, it could fulfill the objective of reducing the waiting time for full container gate-in operations in the ABC Company. However, this study is limited to improving the full container gate-in operations only. Therefore, when applying this alternative with the other operations such as container gate-out, the company needs to be aware of the concerns in operations because process and factors of the problem are different.

For further research studying, the process improvement would be adapted by utilizing more than one alternative such as combining the first one and the third one. The process flow will be adjusted to reduce the cycle time meanwhile opening more gates and increasing more staff will reduce the waiting time. It would increase the efficiency of service performance of the company. Additionally, the limitations of this research were that is focused on reducing the waiting time at the gate only. Therefore, the further study would focus on the scope to improve the process service time in the container yard for the upmost efficiency in overall operation.

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APPENDICES

APPENDIX A

Data Collection from Historical Record

Data from historical record

1. The total number of full container gate-in trucks in 3 months periods (from December 2013 to February 2014)

Table 1: The volume of trucks in December 2013

Date	Volume of trucks (E02)	Volume of trucks (I01)	Total volume of trucks
1-Dec-13	46	284	330
2-Dec-13	168	189	357
3-Dec-13	320	224	544
4-Dec-13	398	77	475
5-Dec-13	192	113	305
6-Dec-13	198	82	280
7-Dec-13	143	101	244
8-Dec-13	58	209	267
9-Dec-13	250	143	393
10-Dec-13	348	118	466
11-Dec-13	375	61	436
12-Dec-13	408	76	484
13-Dec-13	245	76	321
14-Dec-13	250	49	299
15-Dec-13	73	208	281
16-Dec-13	325	113	438
17-Dec-13	465	73	538
18-Dec-13	565	45	610
19-Dec-13	367	112	479
20-Dec-13	239	118	357
21-Dec-13	171	96	267
22-Dec-13	123	147	270
23-Dec-13	310	78	388
24-Dec-13	425	98	523
25-Dec-13	503	30	533
26-Dec-13	477	25	502
27-Dec-13	283	43	326
28-Dec-13	197	142	339
29-Dec-13	21	171	192
30-Dec-13	10	155	165
31-Dec-13	1	2	3

Table 2: The volume of trucks in January 2014

Date	Volume of trucks (E02)	Volume of trucks (I01)	Total volume of trucks
1-Jan-14	4	77	81
2-Jan-14	52	67	119
3-Jan-14	87	70	157
4-Jan-14	70	95	165
5-Jan-14	3	124	127
6-Jan-14	129	79	208
7-Jan-14	345	127	472
8-Jan-14	329	182	511
9-Jan-14	293	211	504
10-Jan-14	190	34	224
11-Jan-14	139	82	221
12-Jan-14	29	154	183
13-Jan-14	207	104	311
14-Jan-14	439	139	578
15-Jan-14	465	59	524
16-Jan-14	360	84	444
17-Jan-14	221	123	344
18-Jan-14	224	63	287
19-Jan-14	56	139	195
20-Jan-14	211	184	395
21-Jan-14	439	155	594
22-Jan-14	575	24	599
23-Jan-14	313	94	407
24-Jan-14	229	129	358
25-Jan-14	241	118	359
26-Jan-14	68	192	260
27-Jan-14	274	150	424
28-Jan-14	624	203	827
29-Jan-14	573	45	618
30-Jan-14	375	113	488
31-Jan-14	211	64	275

Table 3: The volume of trucks in February 2014

Date	Volume of trucks (E02)	Volume of trucks (I01)	Total volume of trucks
1-Feb-14	159	93	252
2-Feb-14	32	104	136
3-Feb-14	287	92	379
4-Feb-14	451	61	512
5-Feb-14	446	75	521
6-Feb-14	408	173	581
7-Feb-14	230	131	361
8-Feb-14	267	73	340
9-Feb-14	85	137	222
10-Feb-14	442	145	587
11-Feb-14	584	110	694
12-Feb-14	511	86	597
13-Feb-14	410	50	460
14-Feb-14	187	108	295
15-Feb-14	201	140	341
16-Feb-14	47	157	204
17-Feb-14	308	108	416
18-Feb-14	695	137	832
19-Feb-14	602	36	638
20-Feb-14	464	76	540
21-Feb-14	283	123	406
22-Feb-14	214	46	260
23-Feb-14	72	131	203
24-Feb-14	279	122	401
25-Feb-14	468	66	534
26-Feb-14	579	33	612
27-Feb-14	584	76	660
28-Feb-14	306	174	480

2. The total number of good condition containers and damage condition containers collected in 30 days from February to March 2014.

Date	Good condition container	Damage condition container
1	252	3
2	136	0
3	379	4
4	512	5
5	521	5
6	581	6
7	361	4
8	340	3
9	222	2
10	587	5
11	694	7
12	597	6
13	460	6
14	295	3
15	341	3
16	204	2
17	416	4
18	832	8
19	638	7
20	540	5
21	406	3
22	260	3
23	203	2
24	401	4
25	534	6
26	612	6
27	660	7
28	480	5
29	380	5
30	275	3

3. The total number of trucks with correct document and error document collected in 30 days from February to March 2014.

Date	Correct document	Error document
1	247	5
2	133	3
3	372	7
4	502	10
5	510	11
6	569	12
7	354	7
8	333	7
9	218	4
10	576	11
11	680	14
12	584	13
13	451	9
14	289	6
15	335	6
16	200	4
17	408	8
18	815	17
19	625	13
20	529	11
21	398	8
22	255	5
23	199	4
24	393	8
25	524	10
26	600	12
27	647	13
28	470	10
29	478	10
30	269	6

APPENDIX B

Data Collection of Process Time

Data collection of process time from randomly 30 trucks

Table 1: Process time of truck number 1 - 10

Activity	Truck 1	Truck 2	Truck 3	Truck 4	Truck 5	Truck 6	Truck 7	Truck 8	Truck 9	Truck 10
Survey and inspect containers	5	5.1	4	4.5	5	4.7	4.9	6	5.9	5.1
Register, check document and pay gate charge	4.7	4.2	4.5	4	4.9	3.2	4.3	5.7	5.5	3.7
Revise document error	0	0	0	0	0	20	0	0	0	0
Planning drop off container position	1.4	1.5	1.5	1.7	1.2	1.5	1.3	1.5	1.4	1.5
Drop off container	2.7	2.4	2.5	2.2	2.6	2	3	2.2	3	2.8

Table 2: Process time of truck number 11 - 20

Activity	Truck 11	Truck 12	Truck 13	Truck 14	Truck 15	Truck 16	Truck 17	Truck 18	Truck 19	Truck 20
Survey and inspect containers	4.1	4	4.8	5	4.7	4.9	4.3	5	4.5	5.2
Register, check document and pay gate charge	3.3	3.3	3.5	4	5	4.3	3.8	5	3.5	3.1
Revise document error	0	0	0	0	0	0	0	0	0	0
Planning drop off container position	1.3	1.5	1.4	1.1	1.5	1.3	1.5	1.4	1.5	1.1
Drop off container	2.8	3	2.6	2.7	2.8	2	2.5	3.1	2.1	2.6

Table 3: Process time of truck number 21 - 30

Activity	Truck 21	Truck 22	Truck 23	Truck 24	Truck 25	Truck 26	Truck 27	Truck 28	Truck 29	Truck 30
Survey and inspect containers	6.1	5	5.3	4	5.2	4.9	4.8	4.5	4.3	5
Register, check document and pay gate charge	4.8	3.5	3.2	4	3.8	3.6	3.4	4.2	3.5	5
Revise document error	0	0	50	0	0	0	0	0	0	0
Planning drop off container position	1.7	1.5	1.5	1.8	1	1.5	1.7	1.5	1.5	1.3
Drop off container	2.9	2	2.9	2.2	2	2.1	2.5	3	2.4	3