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# Analysis of proper ground slot capacity for receiving-Delivery operation in Indonesia Kendaraan terminal

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# ANALYSIS OF PROPER GROUND SLOT CAPACITY FOR RECEIVING-DELIVERY OPERATION AT INDONESIA KENDARAAN TERMINAL

By

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## DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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# ABSTRACT

Title of Dissertation: **Analysis of Proper Ground Slot Capacity For Receiving-Delivery Operation At Indonesia Kendaraan Terminal**

Degree : **Master of Science in International Transport and Logistics**

Indonesia Kendaraan Terminal (IKT) is dedicated terminal to handling vehicle cargo. currently, IKT has one entrance gate and 14 ground slots for trucks. It causes a queue at certain hours because of the trucks coming at the same time. Therefore a study is needed to determine the proper capacity for Receiving and delivery operation by considering the needed the terminal management who desire to optimize the utilization of their facilities and the customer who want to obtain high level of service from terminal management.

The research will focus on the consequence of the utilization an number of facilities to the number of truck served in the terminal and their waiting time by using a queuing theory. To calculate the arrival rate and service rate pattern in the terminal will be using the statistical test. Meanwhile, the total cost model will be calculated total cost between waiting costs from customer and service cost from terminal management side will be analyzed to gain the minimum cost with the highest level of service.

The concluding and recommendation chapter showing the utilization and optimum number of facilities can be consider by the terminal management to provide a proper ground slot capacity in order to minimize Turnaround Time of truck inside the terminal. A number of recommendations are made regarding the result of this research paper and recommendation also for preparation to the terminal management for the challenges in the future.

**KEYWORDS**: Proper Ground Slot Capacity, RoRo terminal, Receiving-delivery operation, gate operation, queuing model.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| CBU | Completely Built Up |
| CEU | Car equivalent Unit |
| FIFO | First In Firs Out |
| Gaikindo | Gabungan Industri Kendaraan Bermotor Indonesia |
| IKT | Indonesia Kendaraan Terminal |
| IPC | Indonesia Port Corporation |
| IDR | Indonesia Rupiah |
| K-S Test | Kolmogorov Smirnov Goodness of Fit Test |
| PCC | Pure Car Carrier |
| PCTC | Proper Container Terminal Capacity |
| PDF | The probability density function |
| PDI | Pre Delivery Inspection |
| RoRo | Roll On Roll Off |
| RoPax | RoRo Passanger |

# Chapter 1 INTRODUCTION

## 1.1 Background

Indonesia is an archipelago nation of which two per three area is oceans and is located in a strategic location because it was at the intersection of trade routes of the world and location between two oceans and two continents. Therefore, Indonesia's seaway transportation has very important role in transporting goods both for domestic and also for international routes. In Indonesia ports also support of economic growth and social mobility and trade in the region is enormous. Thus, port become a key factor for the Indonesia government to create a fair logistics fee structure in order to support national economic growth.

It is important role of location factors in the port system are supported by Le et al. (2006) said that commercial port competitiveness is determined by the geographical location, physical characteristics, and its relationship with transport and urban centers, to date these factors remain important, the port is now also had to integrate and balance the number of dynamic market processes including globalization, packing, and modern logistics, the port is now required to determine their competitive position. Dynamic processes that require improve the port operational efficiency, managerial and overall productivity. One of factors that can decrease the airport productivity is a delay truck that because by the dense trucks queuing on the ground slot, so that the feasibility of the ground slot capacity on a truck visit that be important to be noted by port management.

In Indonesia the growth of domestic vehicle cargo or completely built up (CBU) cargo is increase significantly in recent years. as shown in figure 1.1.


Source : Gaikindo (2012)

Figure 1.1 Indonesia Car (Completely Built Up) Market within 2005 - 2012

Moreover, Indonesia is one of the automobile manufacturer basis for South East Asia and Persian Gulf Market which is the big market for automobile in the world.

This research focuses on the state owned Indonesia Kendaraan Terminal (IKT) in Indonesia, located in the Tanjung Priok Port, Jakarta and is part of the Indonesia Port Corporation II. Tanjung Priok port is the largest and busiest port in Indonesia with various loaded/unloaded commodity There are several dedicated terminals in Tanjung Priok Port. Indonesia Port Corporation II on November 28th, 2007 has declared Indonesia Kendaraan Terminal as one of the subsidiaries company. IKT itself is planned to be focus to handle the increased flow CBU Vehicle. IKT is the first and the only one dedicated car terminal in Indonesia which is strategically located not far from vehicle manufacturers. IKT mostly handle export and import CBU Cargo. the big manufacturer such as Toyota, Daihatsu, Honda and etc trust to IKT to handle their cargo within the terminal include the loading and unloading of vehicles services (stevedoring). Storage and the loading and un loading vehicle to and from car carrier or truck (receiving / delivery operation). With this important role, IKT is required to perform an effective and efficient operation by minimizing not only the waiting time of ship but the other consider is minimizing the waiting time truck round around time for he receiving and delivery operation in order to give fastest delivery service to customer and keep truck to achieve high frequency round trip per day. an adequate capacity of facilities in the terminal is an essential factor to achieve it. Therefore, a thorough analysis should be performed to determine the optimal facilities for receiving and delivery service, by considering the number of ground slot for truck to handle loading and unloading activities in receiving delivery area, to help terminal operators manage receiving delivery area capacity become better and apply with the safety operation rule.

## 1.2 The Research Problem

The objective of the car terminals management is to provide a sufficient terminal capacity where loading and discharging of vehicle both in quay and yard side and can be handled with a safety operation because cargo is high value and customer need high quality. Fleet car carrier commonly is a truck that operation from the manufacturing premises to the terminal for export vehicle and from terminal to the consignee warehouse for the import vehicle. Fleet car carrier has a length and width that is quite large able to carry six vehicles at a time. The tight schedule of truck from the consignee make the truck company facing with the delay even backlog because of the traffic jam during voyage or cause of the congestion in the receiving/delivery area in the car terminal.  The capacity is limited by the number and utilization of ground slot in the car terminal. Thus, facilities in the car terminal should be comprehensively analyzed to achieve proper ground slot capacity. Inadequate facilities will give an impact for car terminal management and trucking companies. For car terminal, an excess in number of ground slot and low utilization of facilities will cause uneconomic use of terminal resources which decrease the yard storage capacity. Therefore, the car terminal management prefers to using high utilization of facilities. However, a high utilization is leading to the truck waiting time and long truck round time in the terminal. Thus, make an impact lowering the service level of the terminal. The other side, high utilization of facilities will cause unexpected truck waiting time and as consequence can be reduce the round trip from the terminal and to the consignee premises and vice versa  which is undesired by trucking companies. For the trucking companies mind prefer to have a lower utilization in order to get high service level from the car terminal. The turnaround time of trucks within the receiving and delivery operations is an important measure of the performance of car terminal terminals beside the turnaround time of vessels. We can defined The turnaround time of trucks is the duration from the moment of gate entrance to the moment of gate exit. Beside quay and yard side facilities, the other important for the car terminal management is to provide a sufficient receiving and delivery area or truck / car carrier ground slot in order to loading and unloading from the truck to the buffer storage yard and vice versa.

To achieve a proper capacity of truck ground slot for receiving / delivery operation and also reducing the turnaround time of truck by providing an adequate number of ground slot with a proper utilization, the two parties from car terminal views regarding the service facilities related limited area inside the terminal and trucking company views regarding no congestion or zero waiting time related next trip should be considered in balance.

### 1.3 The Expected Contribution

The purpose of the study is to determine the proper car carrier or truck ground slot capacity for receiving and delivery operation at Indonesia Kendaraan Terminal by providing an adequate number of Ground slot with an optimal utilization. It is important because this study might assist PT. Indonesia Kendaraan Terminal to achieve an expected balance between limited yard Storage capacity and adequate number of ground slot on receiving/ delivery area.  Furthermore, The study can be used by Indonesia Kendaraan Terminal management as reference for a proper capacity planning and development in order to reduce the turnaround time of truck and leverage the level of customer service. This study also will help for adding literature for whom to concern the RoRo terminal study because literature about RoRo terminal very rare especially study for receiving and delivery operation.

## 1.4 Research Structure

This thesis will be written with the following chapter:

**Chapter 1 INTRODUCTION**

This chapter explains the background of the study, research problem, the expected contribution, and structure of thesis.

**Chapter 2 LITERATURE REVIEW**

This chapter discusses several literatures and findings related to this research.

**Chapter 3ANALYSIS OF RECEIVING AND DELIVERY OPERATION SYSTEM AT INDONESIA KENDARAAN TERMINAL**

This chapter presents a overview the company including traffic flow and receiving delivery operation system

**Chapter 4 DATA COLLECTION AND ANALYSIS**

This chapter presents collection of data from the Indonesia Kendaraan Terminal specific data required   for this research.

**Chapter 5BUILD OPTIMATION MODEL AND SOLUTION**

This chapter will be presents the measurement and application of the model

**Chapter 6 SUMMARY AND CONCLUSIONS**

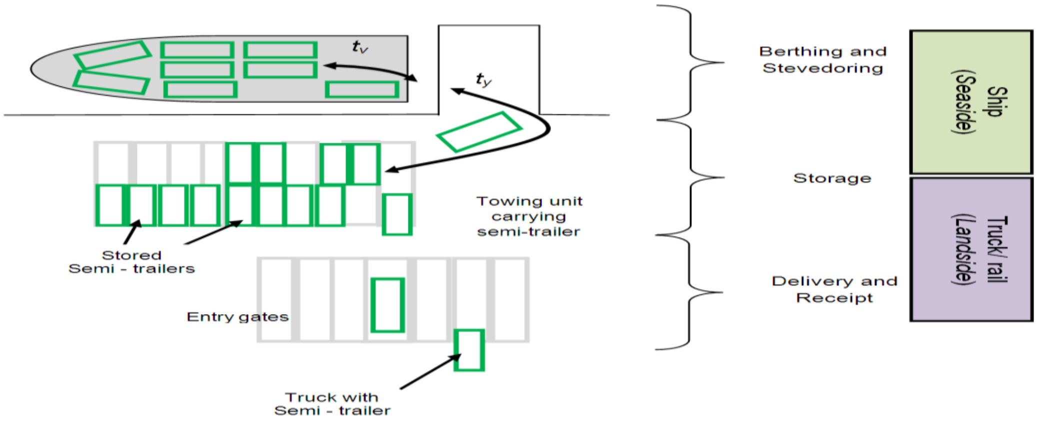
This chapter presents summary and some conclusions which can be drawn from this research and some recommendation for Indonesia Kendaraan Terminal Management

# Chapter 2 LITERATURE REVIEW

This chapter will presented some academic literatures related to the research of RoRo Terminal operation include receiving-delivery operation and ground slot capacity also application of queuing theory in RoRo terminal activities will be discussed as reference. However, research on RoRo terminal is not as much as container terminal, we can benchmark container terminal activity in RoRo terminal for adding the references.

## 2.1 Roro Terminal Operation

From some types of existing terminals, RoRo terminal is a terminal that has a major role in automobile transportation services. Fusco (2010) defines a RoRo terminal as 'pure' when the ships only carry trucks, semi-trailer or platform, and other rolled cargo but excludes those terminals specializing in ferries (where rolled cargo is combined with passengers) or automobiles (when the good to be transported moves by its own means). Meanwhile, Henesey et al. (2003) explained that the operation of the terminal can be divided into four major subsystems, which are largely dependent on different physical areas in the terminal: loading/unloading from/to ship to/from shore; transfer (from berth to storage area); storage; and delivery and receipt. All depending on the kind of traffic/ terminal being dealt with. However, since this Research paper only concerns ground slot capacity of RoRo terminals, so this study only will focus on delivery and receipt area. Furthermore, Henesey et al. (2003) said that RoRo terminals are characterized by, among other aspects, the shorter stay of the platforms in the terminal’s premises as well as the unique feature that the cargo can move by its own means. In short, the three subsystems considered will be: berthing and stevedoring; storage; and delivery and receipt (Fusco et al, 2010) as shown in Figure below.




*Source: Fusco, Sauri, and Spuch. (2010). Quality indicators and capacity calculation for RoRo terminals.* Transportation Planning and Technology, *33 (8).*

Figure 2.1 Pure RoRo divided into three subsystems

The principle of operation system in RoRo terminal and container terminal basically is quite similar. The activity of ship-shore operation is loading / discharging operation, The one of objectives of ship-shore operation is increase the productivity in order the reduce the turnaround time of ship in the port. (Sauri et.al, 2012)describe the stevedoring process in the RoPax terminal as follow,

- Unloading Process (from sea to land) ;When the ship is berthed and customs gives its approval, the unloading process starts. The typical unloading process begins with the vehicles driven by their own drivers: passenger automobiles, trucks, buses, and so on. The trucks and vehicles unloaded at this stage go directly to the exit gates of the terminal or parking in the storage yard. After that, the unloading process starts for all the vehicles/freight driven by the stevedoring team (i.e hands): platforms/semitrailers and whole vehicles (i.e. cars, vans, etc.).
- Loading Process (from land to sea)

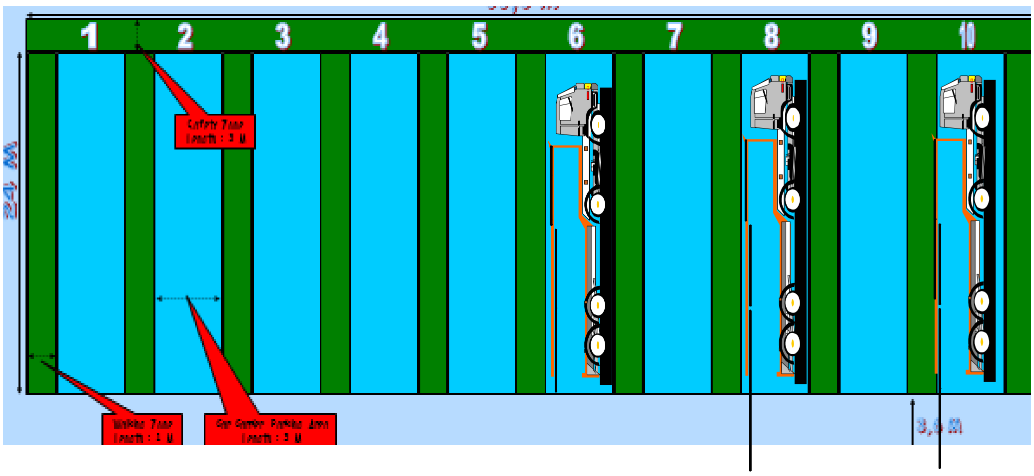
  The cargo to be loaded on vessel arrives at the terminal either by road or by railroad. Once the cargo arrives at the terminal, it is parked in the yard, waiting to be loaded on board. The passengers on board may access through fingers or by means of the stern access gate.

Meanwhile, Guan (2009) notes the yard operation it serves as a buffer to supporting both the quay side and receiving-delivery operation. It also provides the critical interface function between water transport and land transport. The yard operation involves as follow: Space allocation for import-export. Sorting, Stacking and un stacking of cargo. The objectives of the yard operation are two-fold: minimizing truck turnaround time and providing adequate support for vessel operation (high productivity). In the RoRo Terminal offer Pre Delivery Inspection (PDI) to the cargo owner to ensure quality each of cargo before export as value adding activity for the customer. The other differences is how to handle cargo between container terminal and RoRo Terminal is operating system, mostly cargo move by driver or self drive the cargo not necessary using special equipment to transfer cargo only particular cargo using equipment such as vehicle spare parts or break bulk cargo which using RoRo ship/PCC for the transportation. For the quality of service purpose the cargo in the RoRo terminal very valuable, all RoRo terminal stakeholder should involve to avoid the damage cargo during activity in the terminal by following the rules and guidance from Terminal Authority. According to D.C. Mattfeld and H. Kopfer (2002). Terminal operations in vehicle transshipment differ significantly from container transshipment, that is typically supported by rule-based control systems. Firstly, container flows are strongly fragmented, whereas vehicle flows have much in common with bulk cargos. Secondly, containers may be relocated several times during their stay in a hub. Due to the danger of damage resulting to vehicles, the practice of relocation is avoided at vehicle hubs. Third, containers can be stacked upon one another, increasing storage space, whereas vehicles cannot that’s why RoRo terminal require larger storage area than container terminal.

In order to provide a detail and more accurate analysis, some researchers are focusing their research in the container terminal but it can be applied in the RoRo terminal such as transfer operation in the terminal Kozan (2000), Cheng et al. (2005), Lee et al. (2007), Vis et al. (2005). Meanwhile, Yang and Kim (2006), Kim and Kim (1999), Kim and Kim (2002) Kim et al. (2003), Ng and Mak (2005), Kim and Hong (2006) and Kim and Lee (2006), their research focused in yard operations.

## 2.2 Ground Slot Capacity

Lumsden (2012) describe the slot can have different characteristics depending on any possible resource limitation. A site intended for a container aboard a container vessel sailing between two harbors as well as an in time well defined (for example 07.30-07.33) landing permission on an airport are called slots. To reserve slots on a vehicle, ship or load carrier of course involves costs. At the same time the price of a special slot, for example an attractive landing permission can be high more details of the workflow of a truck at a port. Ground slot not only knew for space cargo stack but in the RoRo Terminal Ground slot can use to describe for truck parking space in the Receiving-Delivery area that used in order to receiving-delivery operation and particular area for safety activity for loading/unloading onto truck. According To Indonesia Kendaraan terminal (2011), for the standardization taking the ground slots area of one truck as 3,5 Meters x 30 Meters suitable for truck with large capacity that able transport 6 (six) car cargo for one time with safely loading / unloading activity. We can see the illustration of ground slot from figure 2,2 below




Source: Indonesia kendaraan Terminal, Guide book for planner (2011)

Figure 2.2 Illustration of ground slot

Inadequate facilities will give an impact for terminal management and trucking companies.  An excess in number of ground slot and low utilization of facilities will cause uneconomic use of terminal resources which decrease the yard storage capacity. Therefore, the RoRo terminal management prefers to using high utilization of facilities. However, a high utilization is leading to the truck waiting time and long truck round time in the terminal

Dwipoyono, B. (2011) defines container terminal capacity as the maximum theoretical throughput, which is limited by the capacities of the berths, equipment, stacks and transportation. Due to Literature addressing Ground Slot Capacity for the Receiving Delivery Operation especially RoRo terminal is rare. Therefore, we can quote from the statement that The Ground Slot Capacity as the maximum theoretical throughput, which is limited by the capacities of the ground slot on the Receiving-delivery area and transportation.

Ground Slot Capacity is important should be comprehensively analyzed to achieve proper ground slot capacity. We can little bit benchmark with the theory from container terminal,  Dwipoyono,  B. (2011) describes The Proper Container Terminal Capacity (PCTC) is a combine capacity of the berth capacity, transfer capacity, yard (storage) capacity, and gate (receiving/delivery) capacity. Whichever capacity is lower which commonly known as bottleneck is considered as PCTC. When the storage capacity and the gate capacity is sufficient enough, the PCTC will mainly be determined by the berths capacity and transfer equipments. The objective of PCTC defined  by Moon (2012) as a handling capacity to cope with incoming containers with no congestion which leads to the port with competitive edge. The PCTC principle can be applied in RoRo terminal as well but In this research the author will be focused only in the ground slot capacity on the receiving-delivery area.

Related to the ground slot capacity, we can use formula for calculating proper Receiving-delivery throughput, Dally (1983) as cited in Dwipoyono, B. (2011) propose a formula to calculate the throughput capacity of a container yard as follow,

$$\mathbf{CC = ( Tgs \times H \times U \times K ) \;/\; ( DT \times PF )} \tag{1}$$

Meanwhile, Moon (2012) propose formula to calculate required Total Ground Slot as follow,

$$\mathbf{Required\ TGS = ( CC \times DT \times PF ) / ( H \times U \times K)} \tag{2}$$

Where CC is Yard throughput in a year; TGS is total ground slot; H is a average stacking height; U is land utilization ratio; K is service days of the yard, usually 365 days; DT is dwell time of container; PF is peaking factor.

From those formula above we can converted to be applied in the RoRo Terminal to calculate the ground slot capacity as follow, CC is Yard throughput in a year(TEUs/year) but in the RoRo terminal, it can be changed as throughput arrived truck in a year (unit/year); TGS is total ground slot; H is a stacking of truck; U is land utilization ratio; K is service minute of the yard; DT is dwell time of Truck stay On the Ground Slot (in minute)t; PF is peaking factor.

## 2.3 Receipt and Delivery Operation

The receiving-delivery operation is the last sequence of the three subsystems operation in the terminal. Guan (2009) said The receiving-delivery operation take the interface function between land and sea transport. The objectives are ensure completion process documents and other procedures, ensure makes no idle time in berth operation and last objective is ensure the activities running fast, efficient, safety and avoid delay transportation movement to port. Indonesia Port Corporation II Training Center (2004) divided The land transport into three modes: as follow: inland waterways, rail and truck. Inland waterways and Rail loading and unloading operations are similar to the quayside vessel operations usually common in container terminal but uncommon for RoRo terminal. On the other hand, transportation for receipt-delivery operation in RoRo terminal commonly by using trucks. The movement of truck inside port or from port to the cargo owner premises is important, cargo owner wish to operate the truck as often as possible without delay in traffic or port. And port also wish the turnaround time truck for receiving delivery operation as soon as possible in order to serve next customer. We can analysis the working process of a truck in order to evaluate the waste activity in the terminal to make receiving delivery operation more fast and efficient. Truck arrivals are random events; the pickup and delivery are subject to a wide variety of factors, such as shippers' own logistics requirements, the availability of truckers, vessel schedules, and warehouse operations (Guan, 2009).Xiaoming Chen, et al. (2010) describes the working process of a trucks in port as follows.. The truck arrives at a terminal gate during its preferred or assigned appointment time window, and if entry gate more than one they randomly chooses an entry gate. After finishing its entry paperwork, it proceeds to a designated yard zone to join a queue, if any, to wait for an available ground slot to load/unload also ensure the equipment of truck such as lashing belt, ramp door and hydraulic running well. Finally, it departs at an exit gate.

Further, Kim et al. (2003) explained that the turnaround time of trucks during the receiving and delivery operations is of the important indicators of customer service level for a terminal and an important measure of the performance of terminals. The turnaround time of trucks is defined here as the duration from the moment of gate entrance to the moment of gate exit. Terminal operators devote various efforts for reducing the turnaround time of trucks. Examples of these efforts are automating the gate operation, adding new facilities and improving operation methods. In order to reduce the turnaround time, the waiting time of trucks at a yard, which occupies the largest portion of the turnaround time, must be minimized. In this study, an attempt is made to reduce complaints of truck drivers by optimal sequencing of trucks for transfer operation in yards.

The Receiving-Delivery operation activity in the RoRo terminal as follow, from storage yard the cargo will be moved by terminal driver or self drive to the truck side in the receiving-delivery area after the truck parking on the ground slot in the receiving-delivery area after that the truck driver take over the handling cargo from terminal driver for loading/unloading activity from the truck side onto truck. So the terminal management have to ensure the adequate number of ground slot and terminal driver in order to reduce the turnaround time truck. The responsibility about who is the most responsible for transfer operation, we can divide by the responsibility of terminal for receiving-delivery operation is from the storage area until truck side on the ground slot (vice versa). While the trucking companies responsibility is from truck side and onto truck until the cargo owner premises (vice versa).

Aiming to provide a detail and more accurate analysis, some researchers are focusing their research principle in the Receiving-delivery container terminal but it can be adopted in the RoRo terminal such as Receiving-delivery operation and terminal layout (Rizzoli, et al. 2002), Henesey (2004)and (Kim et al, 2003). Furthermore, Ballis and Abacoumkin (1996), and Kim et al. (2003) investigate the receipt-delivery in the yard.

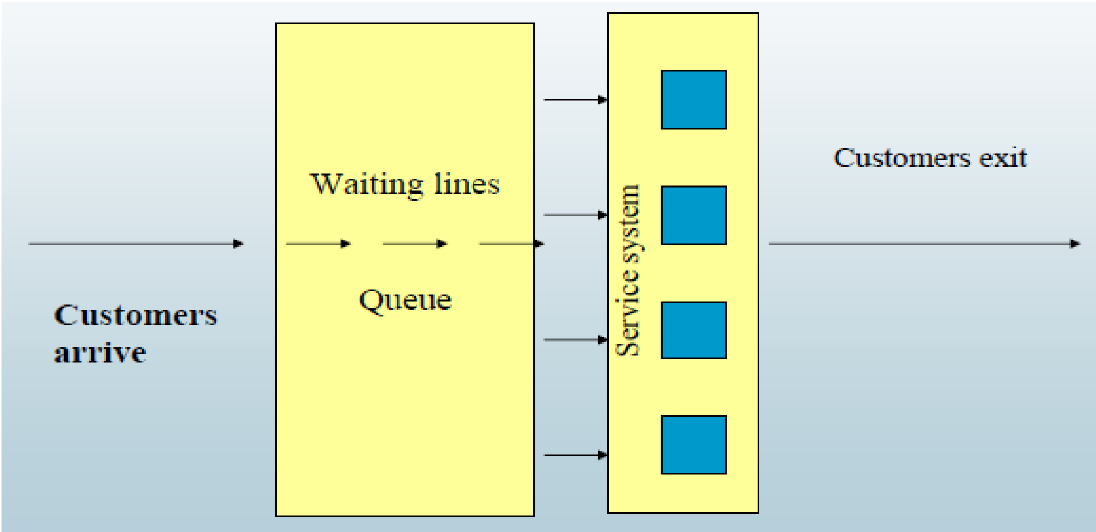
## 2.4 Gate Operation

Gate is the first activities when truck entering the terminal, The gate operation activities started from Trucks arriving at the gate and have to undertake documentation processing and safety inspection. Therefore, trucks in most cases form a queue at the gate complex entrance waiting to be processed. Then instructions are given to pickup or deliver in the receiving-delivery area. Using information processed that the gate complex, the yard operations in this case is driver from the terminal take place to serve those truckers (Guan, 2009). For the established RoRo terminal commonly number of gate line not so important like container terminal because the information about cargoes already inform to the terminal management before the truck departed by information system and do not take time for long during checked process in the gate. Further, James Tsai (2010) said that a truck joins the lane and gradually move toward a waiting line. The truck will stop in the waiting line and moving towards to the station until ready to serve trucks. Therefore, the service time can be measured as the difference in time between two consecutive truck departures at the waiting line in the same lane, given that the travel time between the waiting line and the station is short. A truck departure is defined as the earliest movement that a truck leaving from the waiting line and moving toward the station. A truck stops at the waiting line or continues moving toward the station after leaving the waiting line is not considered as a truck departure. The service time includes the idle time (i.e. no truck at the waiting line) when there is no queue in the lane.

Guan (2009) said that Literature addressing receiving-delivery operations, especially truck processing at the gate, is rare there are only a few studies. Nevertheless, in order to provide more detail and accurate analysis, there are some researchers are focusing their research principle in the gate processing such as the impact from gate congestion Wantanabe (2003), Taniguchi et al. (1999) and (Chang Qian Guan, 2009),

## 2.5 Queuing Theory

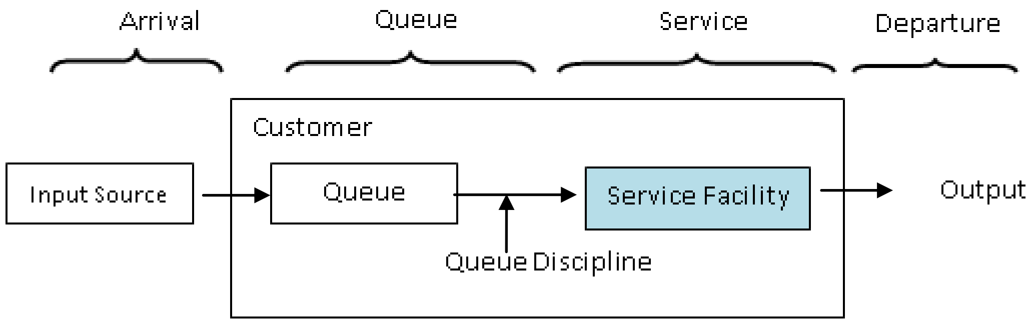
Experience of queue in our day to day lives such as queue for our dinner at the restaurants, queue at the doctor or queue when we enter the highway etc. Queuing theory is a branch of applied probability theory and also mathematics that studies the model waiting act in the queue line system. After we study queuing theory we can applied to analyzed the queue problem in the daily live in order to problem solving. AK Erlang who is the person was first introduced this theory in 1909 in a paper assessing the probability of the phone (Berry, 1992). We can see figure 2.3 below to drawing basic queuing system by AK Erlang. This picture easy to understand.




*Source: Vorácová, (2012). Queuing Theory.*

Figure 2.3 Queuing system

Further more about the queue discipline is explained by Valverde and Succar (2010) said that systems may not only differ in their distributions of the inter arrival and service times, but also in the number of servers, the size of the waiting line (infinite or finite), the service discipline and so forth. Some common service disciplines are: FIFO: (First in, First out): a customer that finds the service center busy goes to the end of the queue. LIFO: (Last in, First out): a customer that finds the service center busy proceeds immediately to the head of the queue. She will be served next, given that no further customers arrive. Random Service: the customers in the queue are served in random order. Round Robin: every customer gets a time slice. If her service is not completed, she will reenter the queue. Priority Disciplines: every customer has a (static or dynamic) priority, the server selects always the customers with the highest priority. This scheme can use preemption or not. Meanwhile, Moon (2012) explained general structure of queuing system consists of several stages namely arrival, queue, service, and departure. Elements of the queuing process have several components likes input source, queue, service facility, and output as shown by the figure 2.4 below




Source: Moon, S. H. (2012). Port Logistics, *Unpublished LECTURE HANDOUT, WMU, Malmo, Sweden*

Figure 2.4 General structure of queuing system

The arrival and service time distribution can be notated with one of the following, M (Markov) for exponential distribution, D (Deterministic) when all customers have the same value, G (General) for general distribution, Ek (Erlang–k) for erlangian distribution or Hk (Hyper-k) for hyper-exponential distribution. James Tsai (2010) said that some research has been done on the gate system using queuing theory. Queuing theory is calculated based on several measurements of performance, such as the average wait time, so the queuing behavior can be analyzed mathematically. The accuracy of the queuing model relies on the essential inputs, such as truck arrival and service times. When empirical data is not available, assumptions are made based on the type of distribution assumed. The proposed vision-based sensing system can effectively collect data for studying the characteristics of truck arrivals and service times. Collecting this data is crucial to validate and refine different distributions used in the simulation models and to improve the reliability of modeling results. According to Moon (2012) Other characteristic of queuing system is a queuing model of M/M/k. It can be implemented to analyze the truck behaviour in terminal. The M/M/k model has the charateristic consist of :

- Customers arrive according to a Poisson arrival;
- Infinite population and possibly infinite line.
- Exponential Service times;
- There are k servers, each of who works at a rate of μ customers (with kμ> l);

According to above statement, the operating characteristics can be described further, as follows:

$$P_0 = \frac{1}{\sum_{n=0}^{k-1}\frac{1}{n!}(\frac{\lambda}{\mu})^n + \frac{1}{k!}\left(\frac{\lambda}{\mu}\right)^k(\frac{k\mu}{k\mu-\lambda})} \quad (1)$$

$$W_q = \frac{(\frac{\lambda}{\mu})^k \mu}{(k-1)!(k\mu-\lambda)^2} P_0 + \frac{1}{\mu} \quad (2)$$

$$L_q = P_0 \frac{(\frac{\lambda}{\mu})^k \rho}{k!(1-\rho)^2} \quad (3)$$

$$\rho = \frac{\lambda}{k\mu} \quad (4)$$

$$W = W_q + \frac{1}{\mu} \quad (5)$$

$$L = \lambda(W_q + \frac{1}{\mu}) = L_q + \frac{\lambda}{\mu} \quad (6)$$

Where :

$\rho_0$ : Probability that there are no customers in the system

$W_q$ : Average time a customer spends in the queue

$L_q$ : Average number of customers in the queue

$\rho$ : Utilization rate for each server

$\lambda$ : Average rate of arrival (number of customers per unit time)

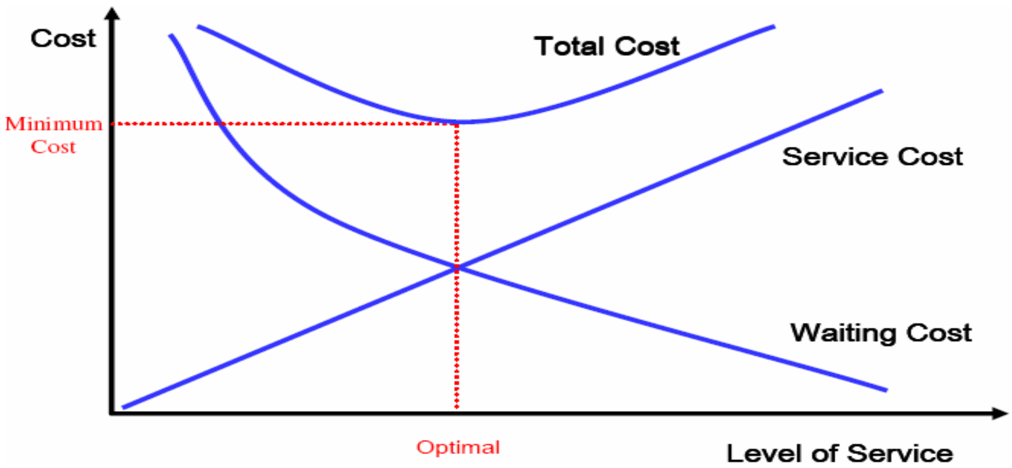
W : Average time a customer spends in the system

L : Average number of customers in the system

$\mu$ : Average rate of service (number of customers per unit time)

k : Number of server

For the cost matter, according to Park et al. (2009) calculation of cost optimization can be calculated using a queuing theory based on the distribution of inter arrival time of truck and the truck service distribution. The coordinate between improvement of service facilities and truck's waiting costs. The optimal service level should be considered by the operating costs of terminal system and truck's waiting costs. This leads to optimal throughput calculation. Further to optimal throughput calculation, study conducted by Park et al. (2009) has focused on improving the necessity of port development through an economic analysis based on the direct and indirect costs based on truck and cargo waiting. We can see in figure 7 the minimum total cost will be achieved when service cost and cost of ship's time reach a breakeven point




Source: Moon, S. H. (2012). Port Logistics, *Unpublished LECTURE HANDOUT, WMU, Malmo, Sweden*

Figure 2.5 Port Queuing System-related Costs

**Costs of queuing system:** In order to apply a queuing theory, it give an approach to minimize the following objective function of operating costs. Hence, $Z = C\text{q} + C\text{w}$ where:

$Z$ = total costs (total costs of the system)

$C$q = service cost

$C$w = waiting cost.

**Waiting cost:** The higher the service level, the less the waiting time and waiting cost, but the waiting costs depend on the inter arrival time of trucks arrival and trucks service time. Consequently, waiting costs include: truck's waiting cost, cargo backlog cost.

**Total system cost (total service cost):** Decision making problem based on a queuing system represents how to balance between the waiting cost and the service level. It can be calculated on the basis of the following formula:

Minimize: $TC(S) = I \cdot C1 + W \cdot C2$

where:

| | |
|---|---|
| $TC(S)$ | = total system cost based on the service level |
| $(S)$, $I$ | = service provider's total hours during a specific period, |
| $C1$ | = cost per unit hour in the hours, |
| $W$ | = total waiting hours during a specific period and |
| $C2$ | = cost per unit hour in the waiting hours. |

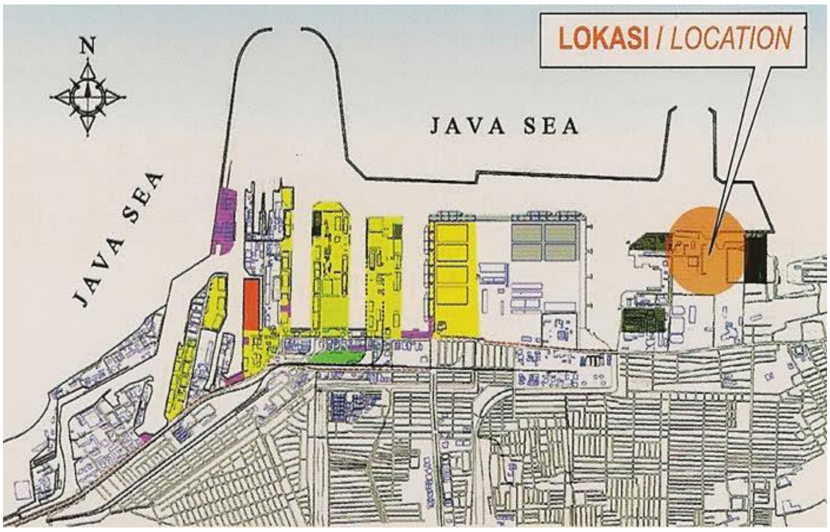
# Chapter 3 ANALYSIS OF RECEIVING AND DELIVERY OPERATION SYSTEM AT INDONESIA KENDARAAN TERMINAL

This chapter will present an overview and evaluation of the existing condition of Indonesia Kendaraan Terminal (IKT) based on the car terminal facilities and equipment, receiving and delivery area, and car carrier queue. The evaluation will be limited to cover only at ground slot of Indonesia Kendaraan Terminal (IKT).

## 3.1 Indonesia Kendaraan Terminal (IKT) Overview

Tanjung Priok Port as one of the major port in Indonesia not only break bulk or container comodity as major cargo in Tanjung Priok Port but also RoRo cargo such as truck, passenger car or the other vehicle. The amount of export and import Roro cargo passing through Tanjung Priok Port has increased significantly over the years.
In order to give satisfy to the customer especially for Automobile customer, Indonesia Port Corporation II (Pelindo II) on Nov. 28th, 2007 formalized the establishment the first dedicated car terminal in Indonesia namely the Indonesia Kendaraan Terminal (IKT) as Special Business Unit and directly responsible to board of director Indonesia Port Corporation II, the location at the east side of Tanjung Priok Port its suitable for Pure Car Carrier (PCC) or RoRo Ship to berthed because the draft relatively deep with the huge back up area. The new car terminal expected to make handling more safety and increase productivity.

Indonesia Kendaraan Terminal (IKT) also trusted from 8th biggest shipping line around the world to serve their ship’s also cargo, the achievement from customer is for the best stevedoring company in southeast asia in year 2011. The Achievement considering the performance, safety and skill of labor. Indonesia Kendaraan Terminal (IKT) also has certificate ISO 9001: 2008. Now IKT also have agreement with shipping line in order to give supervise the safety both inside the vessel and also in the yard side. Because the safety operation is very important in the RoRo terminal due to high value of cargo.




*Source:* http://www.indonesiaport.co.id/read/terminal-mobil-tanjung-priok.html

Figure 3.1 location of Indonesia Kendaraan Terminal (IKT)

To comply with requirement under the ISPS Code regulations, Indonesia Kendaraan Terminal using CCTV system and security guard 24 hours per days. For give transpiration information and make convenience for the special customer the berthing management using berth-window system and all customer can see the real time activities in the berth also yard from the internet. All activitiess are controlled by the sophisticated information technology such as handheld devices for barcodes and RFID cargo identification.

Indonesia Kendaraan Terminal have plan to expand the storage capacity one of them is increasing the parking building capacity from three storey become to five storey, and the expectation is can adding 800 slot CEU (Car Equivalent Unit) by adding 2 level storey. Recently the management have plan and now still on progress is expand the land side around 22-hectare to the west side terminal. The management hope they can serve the domestic cargoes and also the transshipment to Australia continent destination. The management still looking to the shipping line that have plan to use the new storage yard as the hub transshipment. The terminal management also have mission become the biggest logistic center for automobile in Indonesia because the opportunity is very big. From the performance matter, Indonesia Kendaraan Terminal have same performance with two car terminals in the southeast Asia there are Thailand and also Singapore The terminal performance for loading passenger car cargo onto vessel with performance indicator at a rate around 220 units car per hour, and unloading quiet fast with rate of 280 units car per hour.

Table 3.1 Equipment & Facilities of IKT

| DESCRIPTION | DETAIL | CAPACITY |
|---|---|---|
| **A. BERTH FACILITIES** | | |
| | 1. CHANNEL : | - 14 M LWS |
| | 2. BERTH I, | LENGTH : 88 M', DEPTH : -6 M LWS |
| | 3. BERTH II, | LENGTH : 220 M', DEPTH : -12 M LWS |
| **B. STORAGE FACILITIES** | | |
| | 1. LAND AREA : | + 14,5 Ha |
| | 2. OPEN STORAGE PARKING SLOT | |
| | > YARD A (Temporary Landing) : | 1,8 HA, Capacity = 1.000 units |
| | > YARD B : | 0,5 HA, Capacity = 180 units |
| | > YARD C : | 1,7 HA, Capacity = 740 units |
| | > YARD E : | 5,0 HA, Capacity = 2.500 units |
| | > YARD F : | 2,5 HA, Capacity = 1.100 units |
| | > TEMPORARY YARD : | 1 HA, Capacity = 516 units |
| | > PARKING BUILDING 5 FLOOR : | 5,0 HA, Capacity = 2.583 units |
| | | Total Capacity = 8.619 units |
| **C. OTHER FACILITIES** | | |
| | ACCESS ROAD : | 500 m |
| | WAREHOUSE : | 3.000 m2 |
| | CAR WASH : | 3 Lines |
| | OFFICE AND WORKSHOP : | 1 Units |
| | GATE IN/OUT : | 6 ways |
| | SERVICE POINT : | 2 Units |
| | YARD SWEEPER : | 2 Units |
| | TUG MASTER : | 1 Units |
| | TAXI CAR : | 6 Units |

Source : IKT

There are several operational main activities and also value added activities in Indonesia Kendaraan Terminal (IKT) as follow:

STEVEDORING = Loading / unloading cargo Activities from the ship to the dock or they call temporary landing

CARGODORING = moving cargo activities from the docks to the accumulation storage or otherwise

STORAGE = accumulation activities in the accumulation field buildup cargo or warehouse

RECEIVING / DELIVERY = receiving or deliver cargo activities from the carrier company to/or from accumulation storage via gate.

PRE DELIVERY INSPECTION (PDI) = activities to ensure the physical quality of the export cargo before loading to the vessel

CAR WASHING = activities washing cargo before delivery to the customer as the optional service give from terminal.

MINOR REAPAIR = activities to fix the cargo before delivery or export

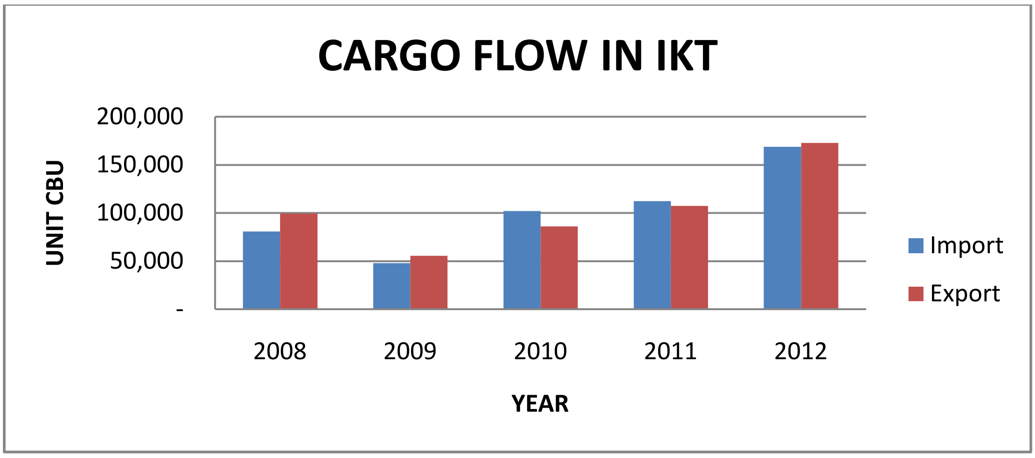
## 3.2 Terminal Flow

Operational data comprises cargo traffic flow and ship call and other supporting data

Table 3.2 Cargo Throughput at IKT

| Year | Cargo | | |
|---|---|---|---|
| | import | export | total |
| 2008 | 80,787 | 99,317 | 180,104 |
| 2009 | 36,054 | 44,542 | 80,596 |
| 2010 | 101,926 | 86,212 | 188,138 |
| 2011 | 112,425 | 107,376 | 219,801 |
| 2012 | 168,694 | 172,715 | 341,409 |

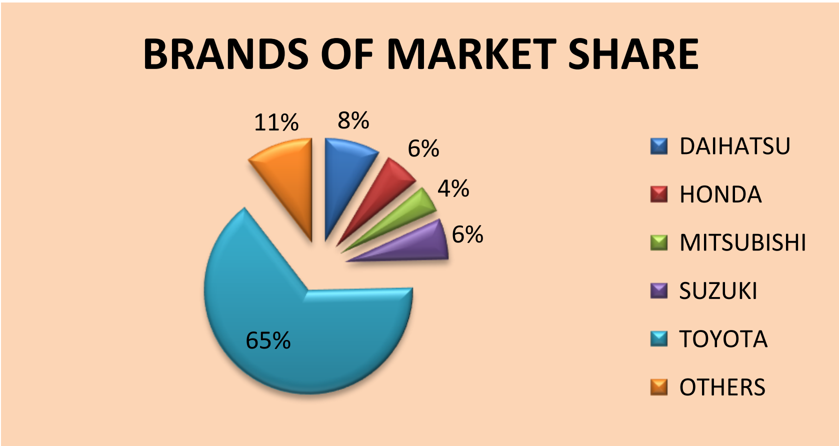
Source : IKT




Source: IKT

Figure 3.2 Cargo Traffic in IKT from 2008 to 2013

The above table illustrates the flow of export and import of cars into Indonesia Kendaraan Terminal (IKT). It is an increasing in both imports and exports from 2008 to 2012, except in 2009. This is due to the world economic crisis in 2008 which impacted the demand and the decline in production in 2009. In the comparison between the amount of imports and exports, imports seen that on average larger than the number of export, except in 2012 in which the exports is greater than imports.

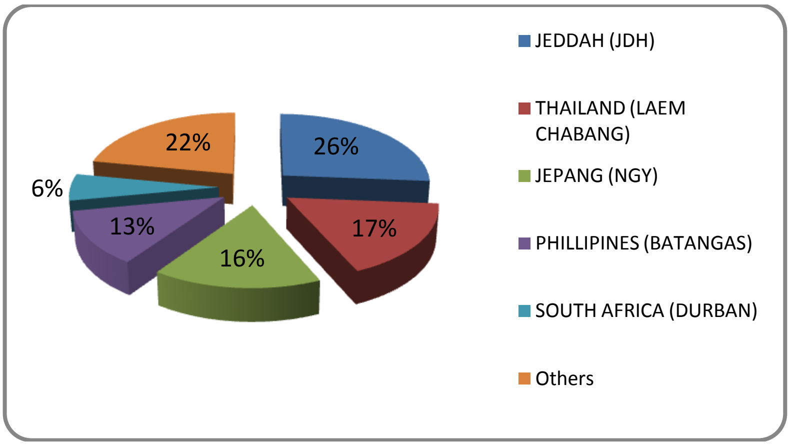



Source: IKT

Figure 3.3 Brands of Market Share In Year 2012

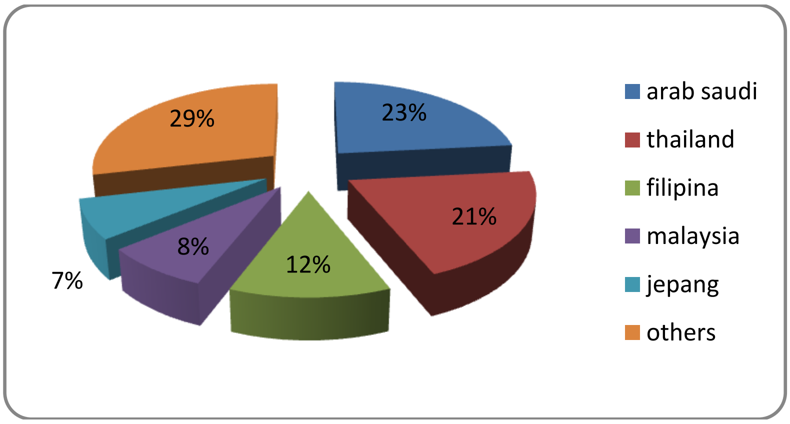
Based on figure 3.3 above, it is clearly that Toyota as dominated brands cargo in IKT with 65% from the total throughput in 2012 followed by Daihatsu with 8%. The growth of Toyota market will be influence to the IKT prospect market in the future that's why The IKT management continue to support Toyota to increase the export and import cargo by give the dedicated storage area for Toyota in the multi storey parking.

IKT also trusted by principal manufacturing such as Toyota, Daihatsu, Honda, Nissan and Suzuki to handle export completely build up cargo to many destination around the world. To view the destination of the exported cars, the figures below will describe it.




Source: IKT

*Figure 3.4* export destination 2011

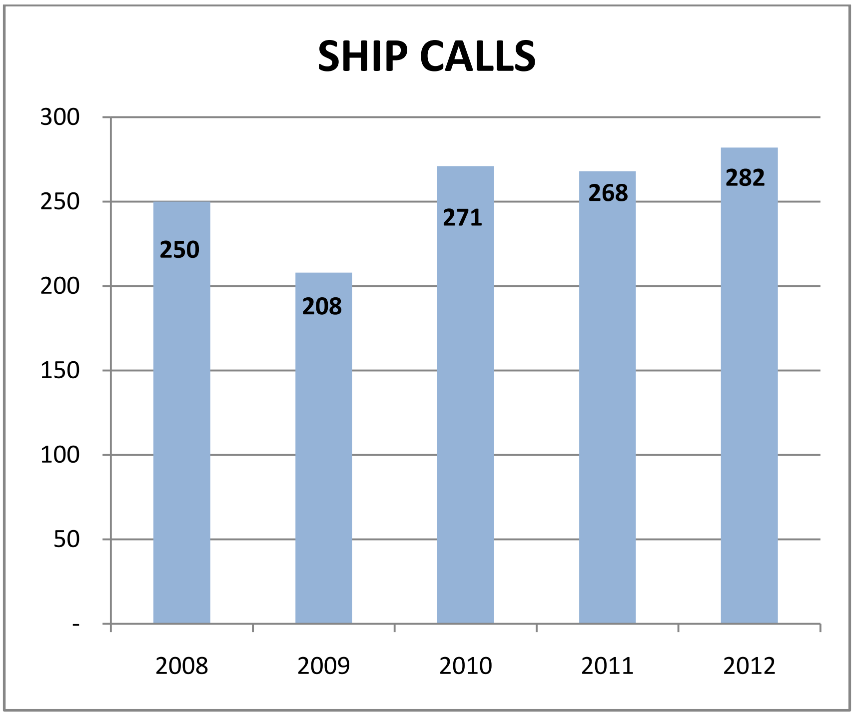



Source: IKT

*Figure 3.5* export destination 2012

Based on figures above It can be seen that the main destination of cars export is Saudi Arabia, Thailand, Philippine, and Japan. In 2011, the number of the exported cars to Saudi Arabian amounted to 26% of the total export while in 2012 decreased to 23% of total export. The cars exported to Thailand have increased from 17%

previously to 23% in 2012. The cars Exported to Philippine increased which previously was ranked fourth after Japan becoming the third in 2012.




Source: IKT

Figure 3.6 Ship Calls in IKT from 2008 to 2012

Based on figure above there was not much fluctuation in ship calls. Year 2012 was recorded as the year with the biggest number of ship calls in IKT. The growth was quiet smaller than cargo traffic growth. This is indicate that shipping line bring the cargo by using larger vessel year by year to achieve economic of scale and also the trend in IKT now the shipping line using the large vessel in order to direct calling to the dominated destination such as to Persian gulf rather than using small vessel and transshipment in Singapore. Ship call in 2009 as presented in figure above, the number of ship calls decrease significantly from 250 ship calls in 2008 to 208 ship calls in 2009, but then it slightly rose in 2010 into 271 ship calls and dropped slightly in 2011 by 268 ship calls and increased significantly again in 2012 with 282 ship calls.

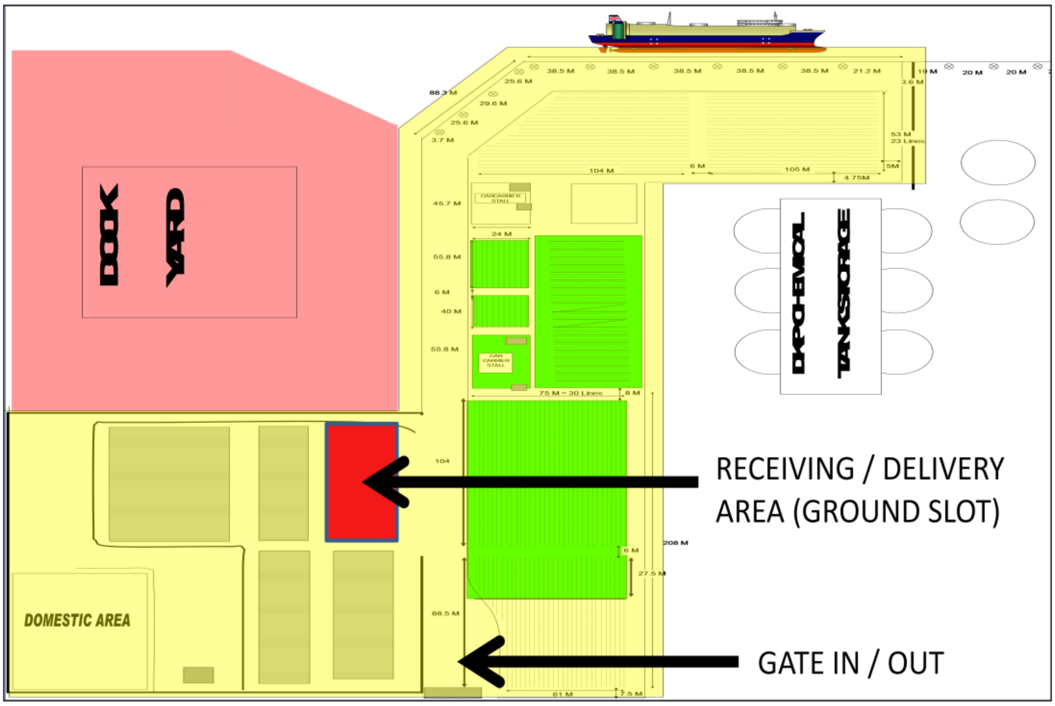
Table 3.3 Daily Cargo Flow on September 2012

| Date | THROUGHTPUT | | | | | |
|---|---|---|---|---|---|---|
| | BEGINNING | ENTER | | EXIT | | THE END |
| | UNIT | IMPORT | RECEIVING | EKSPOR | DELIVERY | UNIT |
| | | | | | | |
| 1 | 10,723 | 0 | 339 | 0 | 138 | 10,924 |
| 2 | 10,924 | 2,116 | 0 | 1,107 | 0 | 11,933 |
| 3 | 11,933 | 159 | 832 | 0 | 531 | 12,393 |
| 4 | 12,393 | 1,518 | 381 | 958 | 860 | 12,474 |
| 5 | 12,474 | 1,522 | 774 | 1,409 | 1,306 | 12,055 |
| 6 | 12,055 | 459 | 474 | 2 | 566 | 12,420 |
| 7 | 12,420 | 234 | 401 | 577 | 540 | 11,938 |
| 8 | 11,938 | 0 | 788 | 0 | 264 | 12,462 |
| 9 | 12,462 | 687 | 246 | 1,499 | 80 | 11,816 |
| 10 | 11,816 | 0 | 583 | 0 | 866 | 11,533 |
| 11 | 11,533 | 505 | 409 | 962 | 606 | 10,879 |
| 12 | 10,879 | 2,752 | 645 | 543 | 1,236 | 12,497 |
| 13 | 12,497 | 292 | 430 | 408 | 332 | 12,479 |
| 14 | 12,479 | 0 | 792 | 0 | 822 | 12,449 |
| 15 | 12,449 | 1,340 | 908 | 1,275 | 275 | 13,147 |
| 16 | 13,147 | 0 | 654 | 0 | 0 | 13,801 |
| 17 | 13,801 | 1,197 | 665 | 1,070 | 1,244 | 13,349 |
| 18 | 13,349 | 904 | 401 | 1,613 | 807 | 12,234 |
| 19 | 12,234 | 0 | 413 | 0 | 807 | 11,840 |
| 20 | 11,840 | 958 | 0 | 717 | 0 | 12,081 |
| 21 | 12,081 | 0 | 659 | 0 | 1,293 | 11,447 |
| 22 | 11,447 | 653 | 826 | 229 | 184 | 12,513 |
| 23 | 12,513 | 773 | 0 | 1,125 | 0 | 12,161 |
| 24 | 12,161 | 277 | 729 | 0 | 1,097 | 12,070 |
| 25 | 12,070 | 1,544 | 729 | 907 | 657 | 12,779 |
| 26 | 12,779 | 949 | 695 | 1,217 | 1,129 | 12,077 |
| 27 | 12,077 | 721 | 892 | 0 | 305 | 13,385 |
| 28 | 13,385 | 0 | 746 | 962 | 420 | 12,749 |
| 29 | 12,749 | 0 | 413 | 0 | 0 | 13,162 |
| 30 | 13,162 | 0 | 0 | 0 | 0 | 13,162 |
| | | | | | | |
| | **TOTAL** | 19,560 | 15,824 | 16,580 | 16,365 | 370,209 |
| | **AVERAGE** | 630.97 | 510.45 | 534.84 | 527.90 | 11,942.23 |

Source : IKT

Based on the example data on Table 3.3 above, it can be seen daily handling of IKT quiet busy both for the export-import operation and receiving-delivery operation. The total handling of export on September 2012 16,580 Unit Cargo and the total handling of import 19,560 Unit Cargo, Meanwhile, total handling of receiving as 15,824 Unit Cargo per month and the total handling of delivery is amount to 16,580 Unit Cargo per month. And average for daily handling of receiving-delivery operation more than 500 unit cargo. The receiving and delivery data is also as the amount of the cargo to passing the ground slot.

### 3.3 Operational System of Receiving and Delivery



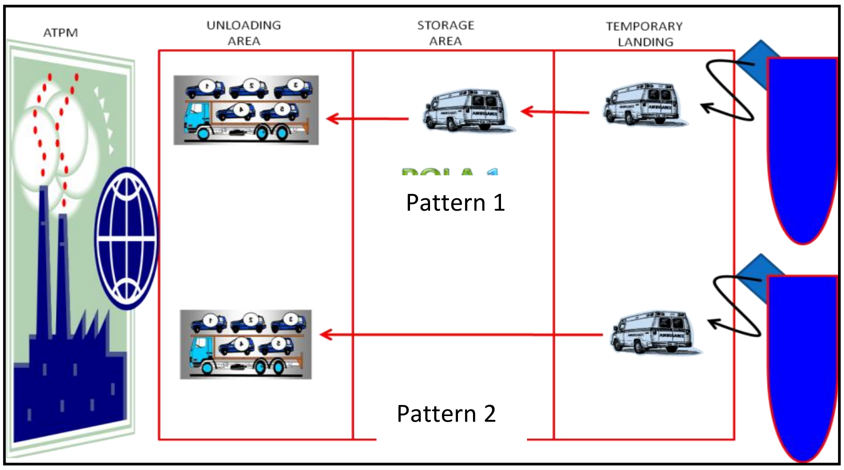

Source: IKT

Figure 3.7 Receiving and Delivery area location in the IKT

The receiving and delivery operation in the Indonesia Kendaraan Terminal (IKT) is one of the important concern for the terminal management, they want to give as fast as possible service to the truck same concern with the loading / unloading of the cargo to the vessel. Previously, the terminal management use receiving-delivery area in the several location even near the wharf the thoughts is if the receiving and delivery area near the storage block the service more faster but its very dangerous car carrier enter to the terminal until beside of storage and disturbing the stevedoring and cargo activities. The other drawback is the car carrier driver transfer cargo directly from onto truck until the slot of storage and otherwise and back to the truck by walking until loading or unloading finish. It's quiet danger walking in the terminal. The Terminal officer only controlling, receive and delivery operation.

Meanwhile, started from the beginning 2011 the terminal management located the receiving and delivery area in the dedicated area as the figure 3.7 above (the red mark) with the 14 ground slots for the car carriers, the location is near from the gate an far from the wharf, It is very safe to transfer cargo to or from the storage. To minimize the risk from the car carrier driver behavior, the terminal management employ the terminal driver or they call pool driver to transfer cargo from the receiving and delivery area to the storage and other wise and use shuttle car for the activities pool driver avoid walking in the terminal and also reduce service time. The terminal management provide for pool driver around 20 person everyday. So with this way also cutting the responsibility, the car carrier driver only until receiving and delivery area.

On the other hand, the important for the satisfaction customer is checking quality of the cargo, usually during the hand over from the car carrier driver to the pool driver, the inspection officer check the quality each cargo. If found the damage can be 2 ways, if the minor damage the cargo transfer to the quarantine area to be repair and if major damage the cargo rejected by terminal and have to back to customer warehouse.



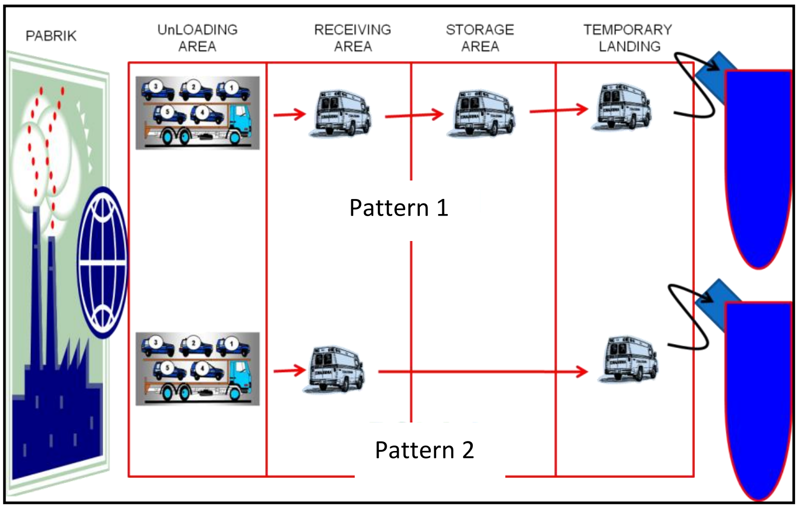

Source: IKT

Figure 3.8 Flow of Import Cargo Movement

The figure 3.8 above describe the flow of operation from the vessel berthed until the cargo delivery via gate until arrived at the customer warehouse and some step of procedure have to exercise for all stake holders. The Delivery procedure at the Indonesia Kendaraan Terminal as follow**:**

1. User or consignee provides the completeness of delivery document (Delivery order and Customs clearance document) to service points in the IKT to apply the Delivery Application.
2. Service point officers verify the completeness of delivery document by SMT On-Line, entering the carrier car number that will transport cargo, issuing a letter of assignment to the Coordinator of pool drivers.
3. Driver of Empty car carrier enter to the gate and gate officer enter vehicle number to conform the readiness of document and issue id gate. Car carrier move to delivery area based on the ground slot which has been determined by gate officer.
4. Based on the documents that have been approved, IKT officers in the delivery area provide information cargo which will be move to the pool driver and conduct the delivery activity of Cargo from storage area to delivery area.

5. If the cargo unloading from the vessel would be directly delivery and administrative requirements have been completed, cargo from the temporary landing could directly to the delivery area without passing the storage area
6. IKT officers check the cargo, fill the cargo damage check list, and vehicle frame number.
7. Car Carrier driver loading the cargo from the delivery area onto the truck
8. Service Point Officers entry the data and issued permit letter.
9. Car carrier exit via the gate




Source: IKT

Figure 3.9 Flow of Export Cargo Movement

The figure 3.9 above describe the flow of operation receiving from the shipper manufacturing until the cargo loading onto the vessel and some step of procedure have to exercise for all stake holders. The receiving procedure at the Indonesia Kendaraan Terminal (IKT) as follow**:**

1. Car carrier drivers give a truck identity to the gate officer.
2. Gate officer enters the number of car carrier as well as the cargo company that publishes Gate Id and give direction to the truck driver to the receiving are which ground slot has been determined.

3. Car carrier drivers give the gate id and permit Letter to the IKT officer in the Ground slot Area.
4. Field officers conduct documents verification and allocate terminal drivers using the Handy Talkie to inform the pool driver located in the driver's waiting room.
5. Car carrier drivers unload the cars into the receiving area.
6. IKT officers check the completeness of cargo and ensure the cargo in good condition by filling out the check list of cargo conditions as well as cargo Tool kit, verifying the physical frame number conformed to the document number, making event letter of cargo Handover signed by forwarder officer, logistics officer and IKT officer.
7. IKT drivers conduct receiving activity of the cargo from the receiving area to storage area
8. If the cargo ready and would be directly to loading onto the vessel and also administrative requirements have been completed, cargo from the receiving area could directly to the temporary landing without passing the storage area
9. Car carrier exit via the gate.

# Chapter 4 DATA COLLECTION & ANALYSIS

## 4.1 Data requirements

The data collection will be shown in this chapter. Data collected consists of both qualitative and quantitative data. All data collected in the field observation and collecting information and data from Indonesia Kendaraan Terminal to knowing the process of receiving and delivery activities especially car carrier activity, and collect the data of trucks arrival and receiving pattern, service time rate, facilities in the terminal. Meanwhile, to collect data also obtained from the other sources such as trucking company to collect the cost of trucking. The primer data such as data of number of arrived truck, time of arrival are gathered from document of Indonesia Kendaraan Terminal. While, service time rate at ground slot and also gate, queuing time at ground slot and gate are gathered by observation in the field.

### 4.1.1 Time between Arrival of Trucks

Iime between arriving trucks is one of the important data required in this research is data of The closer between the trucks, then the shorter time between arriving trucks. The trucks time between arrivals calculation as follow:

a. Firstly by using the Sturgess Rules we able to determine the number of bins k which calculated = 1 + 3,3log N. Base on data, the number of trucks calls in the year 2012 about 29,667 trip, so we got the number of bins

$$k = 1 + 3.3\log(29{,}667) = 15.75$$

b. After that we should determine the bin width h, we can divide the maximum and minimum value by number of bins. We can see the data that the minimum trucks time between arrival is 0 minute and the maximum truck time between arrival is 30 minutes, so the amount bin width is

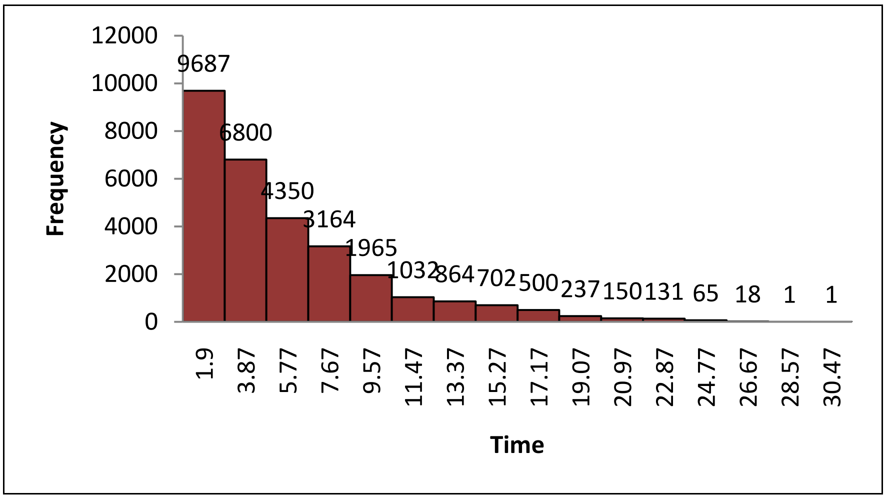
$$h = \frac{30-0}{15.75} = 1{,}9$$

c. After we got the number of the bin k and bins width h and we can tabulate the frequency of data in each bin interval and the calculation as shown in table 4.1.

*Table4.1* Trucks time between arrivals Distribution

| Bin | Interval (minutes) | | | Frequency |
|---|---|---|---|---|
| 1 | 0 | - | 1.9 | 9687 |
| 2 | 1.9 | - | 3.87 | 6800 |
| 3 | 3.87 | - | 5.77 | 4350 |
| 4 | 5.77 | - | 7.67 | 3164 |
| 5 | 7.67 | - | 9.57 | 1965 |
| 6 | 9.57 | - | 11.47 | 1032 |
| 7 | 11.47 | - | 13.37 | 864 |
| 8 | 13.37 | - | 15.27 | 702 |
| 9 | 15.27 | - | 17.17 | 500 |
| 10 | 17.17 | - | 19.07 | 237 |
| 11 | 19.07 | - | 20.97 | 150 |
| 12 | 20.97 | - | 22.87 | 131 |
| 13 | 22.87 | | 24.77 | 65 |
| 14 | 24.77 | | 26.67 | 18 |
| 15 | 26.67 | | 28.57 | 1 |
| 16 | 28.57 | | 30.47 | 1 |
| Average | 4,7 minutes | | | Σ 29667 |

*Source: Author calculation base on data during the year 2012*




*Source: Author calculation base on data during the year 2012*

*Figure4.1Histogram of Trucks Time between arrivals*

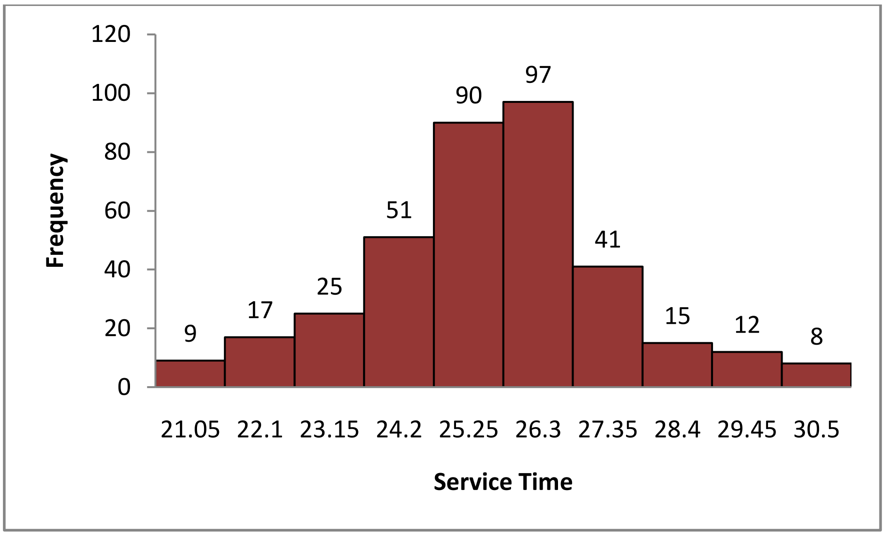
### 4.1.2 Truck Service Time at Ground Slot

Truck service time consists of data of service time operation all of these data is collected from information system technology which able to recorded activities in the terminal such as the service time of time rate , gate service time, ground slot service time it can be shown in table below

*Table4.2* Service time rate at ground slot distribution

| Bin | Interval (minutes) | | | Frequency |
|---|---|---|---|---|
| 1 | 20 | - | 21.05 | 9 |
| 2 | 21.05 | - | 22.1 | 17 |
| 3 | 22.1 | - | 23.15 | 25 |
| 4 | 23.15 | - | 24.2 | 51 |
| 5 | 24.2 | - | 25.25 | 90 |
| 6 | 25.25 | - | 26.3 | 97 |
| 7 | 26.3 | - | 27.35 | 41 |
| 8 | 27.35 | - | 28.4 | 15 |
| 9 | 28.4 | - | 29.45 | 12 |
| 10 | 29.45 | - | 30.5 | 8 |
| | Average | 25 minutes | | Σ 365 |

*Source: Author calculation base on data during the year 2012*




*Source: Author calculation base on data during the year 2012*

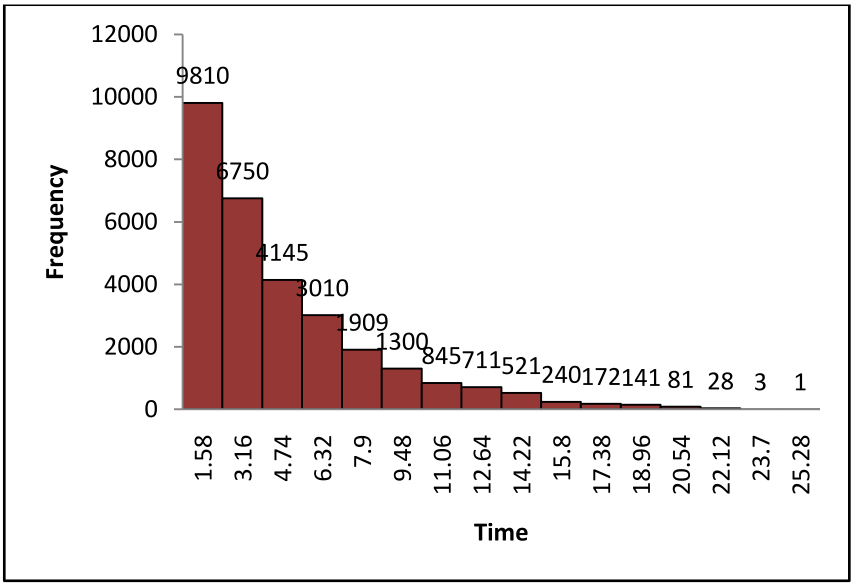
*Figure4.2 Loading/unloading Service Time Histogram*

### 4.1.3 Service Time rate at the gate

*Table4.3* Service of time rate at the gate

| Bin | Interval (minutes) | | | Frequency |
|---|---|---|---|---|
| 1 | 0 | - | 1.58 | 9810 |
| 2 | 1.58 | - | 3.16 | 6750 |
| 3 | 3.16 | - | 4.74 | 4145 |
| 4 | 4.74 | - | 6.32 | 3010 |
| 5 | 6.32 | - | 7.9 | 1909 |
| 6 | 7.9 | - | 9.48 | 1300 |
| 7 | 9.48 | - | 11.06 | 845 |
| 8 | 11.06 | - | 12.64 | 711 |
| 9 | 12.64 | - | 14.22 | 521 |
| 10 | 14.22 | - | 15.8 | 240 |
| 11 | 15.8 | - | 17.38 | 172 |
| 12 | 17.38 | - | 18.96 | 141 |
| 13 | 18.96 | | 20.54 | 81 |
| 14 | 20.54 | | 22.12 | 28 |
| 15 | 22.12 | | 23.7 | 3 |
| 16 | 23.7 | | 25.28 | 1 |
| Average | 3,94 minutes | | | Σ 29667 |

*Source: Author calculation base on data during the year 2012*




*Source: Author calculation base on data during the year 2012*

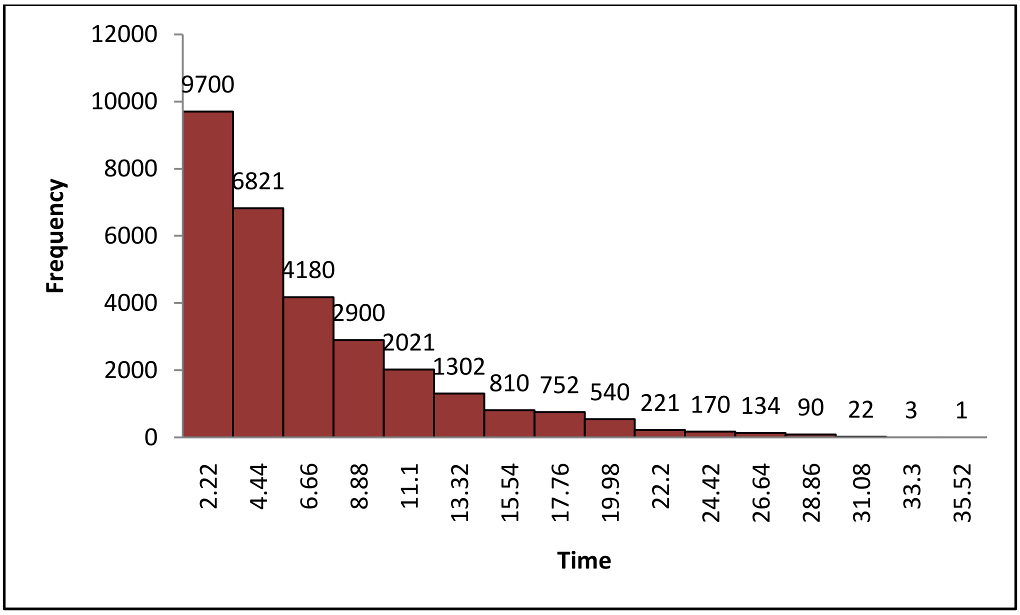
*Figure 4.3* of Gate Service of time rate Histogram

### 4.1.4 Service Time rate at the ground slot

*Table 4.4* Service time rate at the Ground Slot

| Bin | Interval (minutes) | | | Frequency |
|---|---|---|---|---|
| 1 | 0 | - | 2.22 | 9700 |
| 2 | 2.22 | - | 4.44 | 6821 |
| 3 | 4.44 | - | 6.66 | 4180 |
| 4 | 6.66 | - | 8.88 | 2900 |
| 5 | 8.88 | - | 11.1 | 2021 |
| 6 | 11.1 | - | 13.32 | 1302 |
| 7 | 13.32 | - | 15.54 | 810 |
| 8 | 15.54 | - | 17.76 | 752 |
| 9 | 17.76 | - | 19.98 | 540 |
| 10 | 19.98 | - | 22.2 | 221 |
| 11 | 22.2 | - | 24.42 | 170 |
| 12 | 24.42 | - | 26.64 | 134 |
| 13 | 26.64 | | 28.86 | 90 |
| 14 | 28.86 | | 31.08 | 22 |
| 15 | 31.08 | | 33.3 | 3 |
| 16 | 33.3 | | 35.52 | 1 |
| Average | 5,5 minutes | | | Σ 29667 |

*Source : Author calculation base on data during the year 2012*




*Source : Authorcalculation* base on data during the year 2012

*Figure4.4* of Ground Slot serive time rate Histogram

### 4.2 Several Costs in the Terminal

Many kind of costs arise in the terminal such as costs by terminal management like the expenses for providing terminal facilities called service costs and costs by the customer like storage cost, berthing cost but in here we are discuss about trucking companies like cost arise due to congestion or waiting cost.

#### 4.2.1 Service costs

Costs of facilities consist of costs required for investment and maintenance of terminal receiving and delivery facilities consist of ground slot and gate . In term of investment cost the data collected is the unit price of facilities. Whereas maintenance cost is assumed as the proportion of investment cost. In detail the costs of facilities is presented in the table 4.5 and 4.6.

*Table4.5* Cost of ground slot

| Type | Economic Usage | Investment /unit price | Maintenance /year |
|---|---|---|---|
| Material | | | |
| *Paint | 5 Years | IDR. 48,000/kg | 2.50% |
| *Thinner | 5 Years | IDR.35,750/ltr | 4% |
| *Brush | 5 Years | IDR.16,500/piece | 3.50% |
| Pay | | | |
| *Foreman | 30 Years | IDR.108,296/day/person | 5% |
| *Employee | 30 Years | IDR.70,587/day/person | 3.50% |
| *Workman | 30 Years | IDR. 83,145/day/person | 2.50% |
| *The Tool | 30 Years | IDR. 4,000/equipment | 2.50% |
| Construction | 30 Years | IDR.500,000/ground slot/m2 | 5.00% |
| Electricity | 30 Years | IDR. 45,000,000 | 3.00% |

*Source: Indonesia kendaraan Terminal*

*Table4.6* Cost of gate

| Type | Economic Usage | Investment /unit price | Maintenance /year |
|---|---|---|---|
| Gate | 25 Years | IDR. 1,401,926,776 | 7.00% |
| Employee/gate | | IDR. 5,900,000/day/3person | 2.00% |
| Employee/ground slot | | IDR.192,000/day/car | 3.00% |

*Source: Indonesia Kendaraan Terminal*

### 4.2.2 Waiting Costs

Waiting cost is the cost that arise due to wait for the service in the terminal. Waiting costs can be suffered by trucks at the ground slot and also gate.

a. Truck revenue

Truck revenue is revenue got by trucking companies in order to give service to the their customer. If we discuss about opportunity cost of the trucks is the revenue that would be obtained if the trucks operation. In other word, when the trucks can't operation due to wait at the gate or ground slot, the trucks owner loss the opportunity to get more revenue. Data required is collected at 10 trucks company that their trucks operations. The revenue and number of operation days in the year 2012 with all the member of trucking companies in Indonesia Kendaraan Terminal are shown in table 4.7.

*Table4.7* Truck Revenue in the year 2012

| **No** | **Truck Name** | **Revenue truck/day (IDR)** | **Cost /day** |
|---|---|---|---|
| 1 | PT. Anugerah Abadi | 4,000,000 | 2,369,596 |
| 2 | PT. Delima Mas | 6,000,000 | 3,554,394 |
| 3 | PT. ECL / MOL auto Carrier | 4,000,000 | 2,369,596 |
| 4 | PT. Dunia Express | 10,000,000 | 5,923,990 |
| 5 | PT. K Line Mobaru Diamond Indonesia (KMDI) | 6,000,000 | 3,554,394 |

| | | | |
|---|---|---|---|
| 6 | PT. Parani Artha Mandiri | 4,000,000 | 2,369,596 |
| 7 | PT. Puninar Jaya | 4,000,000 | 2,369,596 |
| 8 | PT. Tristar Transindo | 10,000,000 | 5,923,990 |
| 9 | PT. PJPT Senopati | 4,000,000 | 2,369,596 |
| 10 | PT. Karya Putra Lokatirta | 6,000,000 | 3,554,394 |
| | **Average** | | 3,435,914 |

*Source: Author calculation base on the data from 10 Truck companies*

b. Waiting cost of Truck

To calculate truck waiting cost which is represented by fuel and overtime driver costs, we have to know the data of structure waiting cost of truck that will arise due to waiting of service in every single hour and presented in table below.

*Table4.8* Waiting Cost Of Truck

| | **Time (hours)** | **Price (IDR)** |
|---|---|---|
| Fuel | 1 | 9,000 |
| Driver | 1 | 50,000 |
| Total | 2 | 59,000 |

*Source: Trucking Company PT. Puninar Jaya*

## 4.3 Research Methodology

This research will be analyzed by using quantitative method, more details the above research problem will be solved by using Queue Model. This research uses secondary data that sourced from Indonesian PortCorporation II and business unit of Indonesian Port Corporation II namely Indonesia Kendaraan terminal. To analyze the problem in this research several data and methods will be required.

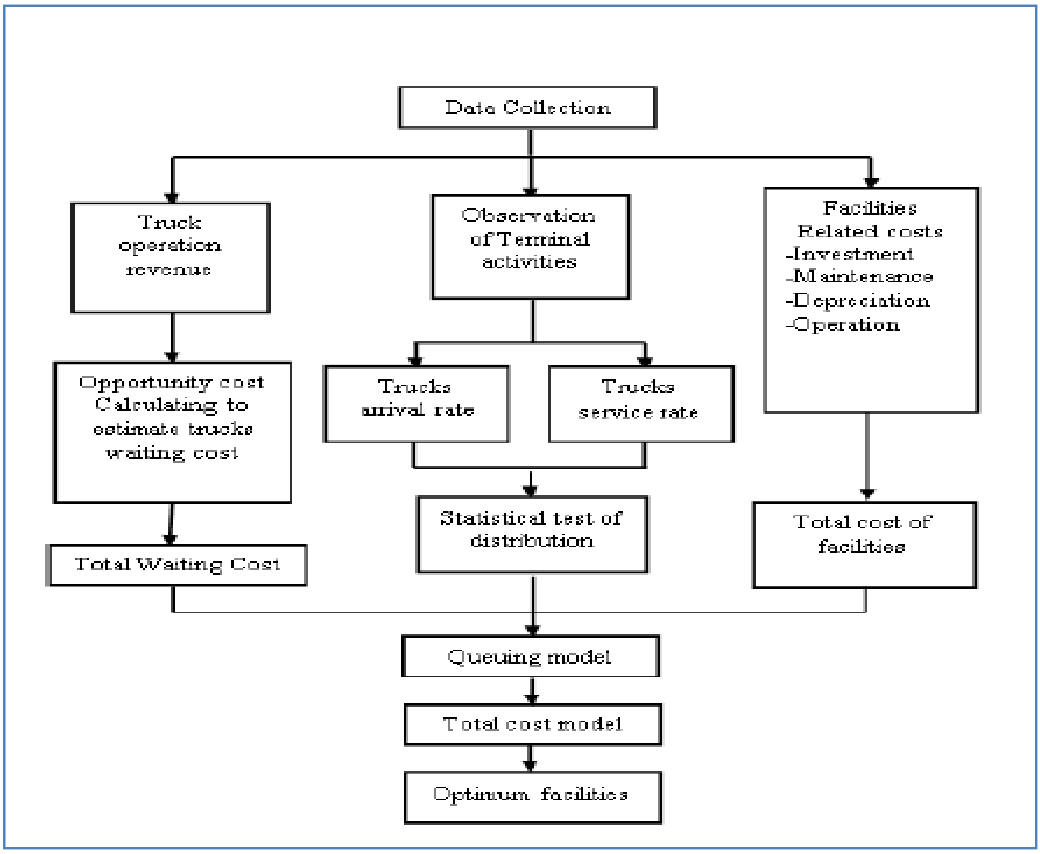
### 4.3.1 Research method

The research methodology consists of three major objectives:

1) Analyze the pattern of truck arrival in the terminal and service rate for truck also
2) Develop hypotheses regarding their pattern to determine a suitable queuing model or analysis arrival of the truck and service in the distribution patterns.
3) Determine the adequate number of facilities or number of ground slot for truck on the receiving delivery area which will minimize the truck around time in the terminal.
4) Determine the most optimal cost of ground slot by applying minimum cost model.

Aiming to study on those three research objectives, will be applied methods such as:

1) A statistical examination, Kolmogorov Smirnov goodness of fit test is used to examine the distribution of truck arrival rate and service rate.
2) The best mathematical model in queuing theory is used in order to estimate the performance parameters in the queuing system.
3) The most minimum cost model is used to analyze the adequate number of facilities or number of ground slot for truck on the receiving delivery area.




*Source : author*

*Figure 4.5* Research Methodology

### 4.3.2 Data analysis method

#### 4.3.2.1 Histogram

The meaning theory of histogram in a simple word is the distribution data which illustrated by graphical or bar chart. Following steps are involved in the construction of a frequency distribution as follow (Sturges, 1926) :

(1) Find the range of the data: The range is the difference between the largest and the smallest values.

(2) Decide the approximate number of classes: Which the data are to be grouped. There are no hard and first rules for number of classes.. H.A. Sturges (1926) has given a formula for determining the number of classes.

$K = 1 + 3.322 \log N$ (4.1)

Where, k = Number of Classes

Log N = Logarithm of the total number of observations

(3) Determine the approximate class interval size: The size of class interval is obtained by dividing the range of data by number of classes and denoted by h

class interval size $h = \frac{Range}{NumberofClasses}$ (4.2)

(4) Decide the starting point: The lower class limits or class boundary should cover the smallest value in the raw data. It is a multiple of class interval. For Example:0, 5, 10, 15 etc… are commonly used.

(5)Determine the remaining class limits (boundary): When the lowest class boundary of the lowest class has been decided, then by adding the class interval size to the lower class boundary, compute the upper class boundary. The remaining lower and upper class limits may be determined by adding the class interval size repeatedly till the largest value of the data is observed in the class.

(6) Distribute the data into respective classes: All the observations are marked into respective classes by using Tally Bars methods which is suitable for tabulating the observations into respective classes. The number of tally bars is counted to get the frequency against each class. The frequency of all the classes is noted to get grouped data or frequency distribution of the data. The total of the frequency columns must be equal to the number of observations.

#### 4.3.2.2 K-S test (Kolmogorov Smirnov Goodness of Fit Test)

Kolmogorov Smirnov is used to specify the sample data which follow the population distribution. The sample population being fit with the population distribution is expected. The appropriate queue model depends on service time and pattern of arrival.

Considering theory from Rajagopalan, 2006 (as cited in Dwipoyono, B. 2011) noted that Kolmogorov Smirnov Goodness of fit test (K-S test) can be use for the purpose test of frequency distribution which can be explained as follow:

a. Aim

Based on a random sample, test the population distribution F(x) be regarded as $F_0(x)$,.

b. Source

Let $X_i$, (i = 1,2,3,4…,n) a random sample of n observations be drawn from a population. assumed $F_0(x)$ be the cumulative distribution function (CDF) of a specified (given) population.

c. Hypothesis

$H_0$: the population distribution F(x) is $F_0(x)$, $F(x) = F_0(x)$

$H_1$: the population distribution F(x) is not $F_0(x)$, $F(x) \neq F_0(x)$

d. Critical value ($D_\alpha$) and Level of significance (α)

The sample size n more than 35 and The critical value $D_\alpha$ for the level of significance is gained as follow the table 4.9 below.

*Table4.9* the K-S Test Statistic Critical values

| Sample Size (n) | Level of Significance $\alpha$ for D = max$\mid F_0(X) - F_n(X) \mid$ | | | | |
|---|---|---|---|---|---|
| | .20 | .15 | .10 | .05 | .01 |
| Over 35 | $\frac{1.07}{\sqrt{n}}$ | $\frac{1.14}{\sqrt{n}}$ | $\frac{1.22}{\sqrt{n}}$ | $\frac{1.36}{\sqrt{n}}$ | $\frac{1.63}{\sqrt{n}}$ |

*Source : Dwipoyono, B (2011)*

e. Method calculation

1) Count the cumulative distribution $F_0(x)$ according to the specified population distribution and the sample observations.

2) Gain the cumulative distribution of the sample, $F_n(x)$ be the empirical distribution function, $F_n(x)$ = (Amount of observations $X_i \leq x$)/n.
3) Find the absolute difference $| F_0(x) - F_n(x)|$

f. Test Statistic

$$D = \text{maximum } | F_0(x) - F_n(x)| \tag{4.3}$$

g. Conclusion

If $D \leq D_\alpha$, accept $H_0$ and If $D > D_\alpha$, reject $H_0$ or accept $H_1$

#### 4.3.2.3. Frequency Distribution

To look the distribution of data we can used Frequency distribution of data. Which distribution pattern is fit of the data. If the random variable is discrete then it has the probability mass function. otherwise, it has the probability density function. Poisson has a probability mass function since it is a discrete probability distribution that expresses the probability of a given number of events occurring in a fixed interval of time and/or space. Poisson distribution is likely to be derived from binomial distribution. (Richard J. Larsen, 2012). Following is the probably density function of poison distribution by Moon (2012):

$$P_t(X = n) = \frac{(\lambda t)^n}{n!} e^{-\lambda t}, \tag{4.4}$$

Where,

P (X) = Probability distribution

$\boldsymbol{\lambda}$ = the average rate of arrival

t = the length of interval

e = 2.7182818 (the base of the natural logarithm)

n = 0, 1, 2, ….. (number of customer)

While Dwipoyono (2010) noted for exponential distribution is gained by using the formula:

$$f(t < x \leq T) = \left| e^{-\left(\frac{t}{m}\right)} - e^{-\left(\frac{T}{m}\right)} \right| \quad (4.5)$$

Where,

f(t<x≤T) : probability density function for service time or time between arrival from t to T.

m : average service time or time between arrival

#### 4.3.2.4 Queuing Model

There are two queuing systems will be analyzed in this research. Firstly, trucks service at the gate. Second, trucks service at the ground slot. The several kind queuing model will be applied, such as :

a. M/M/1 model with the assumption as follow : Services are discipline with First in First out (FIFO), the arrival pattern follows exponential distribution, the service pattern follows exponential distribution, single server system.

b. M/M/1(∞) model with the assumption as follow : queue length discipline is infinite, Services are discipline with First in First out (FIFO), the arrival pattern follows random distribution, the service pattern follows random distribution, with the single server system, infinite population.

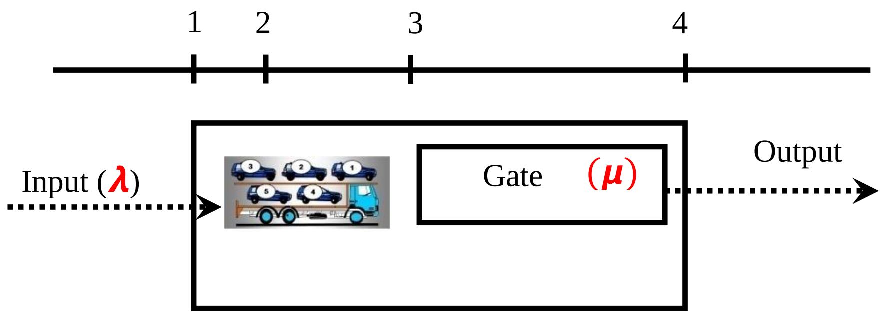
c. M/M/k model with the assumption as follow Services are discipline with FIFO, the arrival pattern follows exponential distribution, the service pattern follows exponential distribution, server system more than one.

d. G/G/1model with the assumption as follow : Services are discipline with FIFO, time between entering and leaving the system in steady state, with the single server system.

We can drawing the queuing system in the receiving and delivery operation in the Indonesia Kendaraan Terminal in order to choose which one queuing model accordance with this case, it consist of :

a. Trucks service at the gate

To explain queuing system of trucks service at the gate we can see as shown in figure 4.6below




*Source: author*

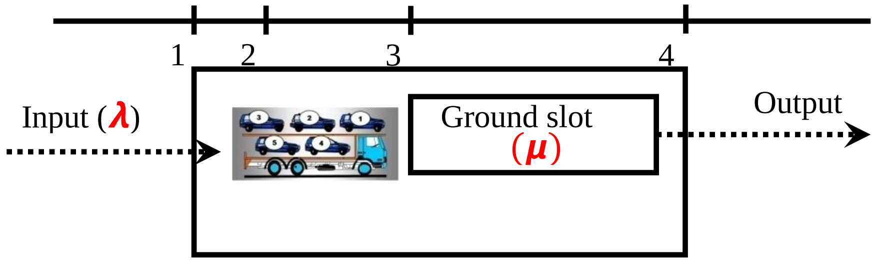
*Figure4.6Queuing system of trucks service at a gate*

The stages of trucks arrival queuing system at the gate as follow:

1) The activities in the Point 1 is the trucks has arrived at the gate.
2) Mark $\lambda$ or Arrival rate of trucks is input number of trucks arrive at the gate per unit time.
3) In the Point 2, the trucks are queuing to be served at a gate.
4) For their arrival rate, we assumed trucks time between arrivals to follow Poisson distribution or an exponential distribution .
5) In the Point 3 is the starting point of gate service which is counted when the truck has been completely stay at gate.
6) The several activities service time of trucks at the gate between point 3 and 4 are time for checking document cargo and identify the truck number.
7) While, Point 4 is the output when trucks service at a gate has been finish which counted when the trucks has been moved to the ground slot buffer zone.
8) Service time of trucks at a gate is hypothesized to base on an exponential distribution.

b. Trucks service at the ground slot

To explain queuing system of trucks service at the ground slot we can see as shown in figure 4.7.




*Source: author*

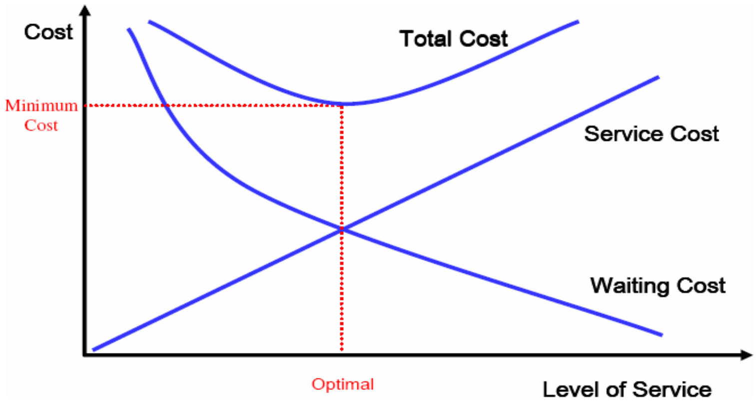
*Figure 4.7 Queuing system of trucks service at a ground slot*

The stages of trucks arrival queuing system is explained as follow:

1) The first activities happen in point 1, the trucks has arrived at the buffer Zone.
2) Mark $\lambda$ or Arrival rate of trucks is input number of trucks arrive at the buffer zone before entering ground slot per unit time.
3) In the Point 2, the trucks are queuing at the buffer zone to be served at ground slot
4) For their arrival rate, we assumed Trucks time between arrivals to follow Poisson distribution or an exponential distribution .
5) In the Point 3 is the starting point of ground slot service which is counted when the trucks has been served at the ground slot.
6) The several activities service time of trucks at a ground slot or between point 3 and 4 are preparation time for loading/unloading operation, haulage (storage to/from ground slot) and documentation.
7) While, point 4 when trucks service at a ground slot has been finish which counted when the trucks has been move out from ground slot is the output.
8) Service time of trucks at a ground slot is hypothesized to base on an exponential distribution.

### 4.3.3 Total Cost Model

One of the objectives of this research is to determine the number of ground slot also gate which the cost is minimum with high level of service. To determine the minimum cost, it requires calculating the total cost at the ground slot and gate. Total cost is  the service costs by Indonesia Kendaraan Terminal due to providing facilities, labour etc. the waiting cost is  cost arise due to waiting for service and customer have to pay it. The optimum level of service be attained in situations where the total cost is gained at a minimal point. Total cost of service as a function is shown in Figure 4.8.




Source: Moon, S. H. (2012). Port Logistics, *Unpublished LECTURE HANDOUT, WMU, Malmo, Sweden*

*Figure 4.8* Total Cost Model

### 4.3.4. Cost of waiting

The cost of waiting is cost suffered by the trucks companies. Their cost is increasing due to the fuel and over time cost of driver. Beside that, they have to lose the opportunity to operate the trucks for transporting cargo. Such cost is call opportunity cost.

### 4.3.5 Cost of Service

Cost of service is cost to provide facilities, employee and investment. It is incurred by the Indonesia Kendaraan Terminal. The amount of service costs depend on the number of facilities and employee provided. Indonesia Kendaraan Terminal has to add the gate and ground slot, so the cost of service will increase according to the increasing facilities of gates and ground slots.

### 4.3.6 Facilities Required

a) Ground slot

We already discuss at the previous chapter to calculate capacity of ground slot for truck which is represented by the total number of truck that can be stack in the ground (Total Ground Slot) is calculated by Moon (2012) formula and we can converted to calculated required ground slot for receipt and delivery cargo, as follow:

$$\text{Required } TGS = \frac{CC.DT.PF}{H.U.K} \quad (4.6)$$

Where:

TGS : total ground slot

CC : throughput arrived truck in a year

DT : dwell time of truck (in a minutes)

PF : peaking factor

H : stacking of truck

U : land utilization ratio

K : service of the yard (in a minutes)

b) Gate

Number of gate required is determined by the queuing model of trucks arrival in the terminal which considers the number of trucks waiting.

# Chapter 5 BUILD OPTIMATION MODEL AND SOLUTION

This chapter will be presents the measurement and application of the model. The explained calculation and analysis that will be shown in this chapter consists of the following subject:

a. The distribution test of truck service time pattern and truck arrival pattern.
b. Analysis and calculation facilities of receiving and delivery composition required in the Indonesia Kendaraan Terminal.
c. Analysis and calculation of queuing model for ground slot and gate.
d. Analysis and calculation of total cost model for determining the optimal number of facilities required.
e. Proper ground slot capacity for receiving and delivery analysis and calculation.

## 5.1 Distribution Test

The exponential distribution assumed for the truck arrival pattern and service time pattern. We using K-S test (Kolmogorov Smirnov Goodness of fit test) for test frequency distribution. The test trucks time between arrivals distribution conducted with these steps. As follow:

a. The step number one is formulating statistical hypotheses.

   $H_0$: Null hypothesis that mean no effect among variable and no relations between variables.

   $H_1$: Alternative hypothesis for example the population distribution of trucks time between arrivals F(x) is not the same as $F_0(x)$ which follows the exponential distribution.

b. The second steps selections the critical value $D_\alpha$ with the significance level 95% and number of sample is 29,667 data.

$$D_{0.95} = \frac{1.36}{\sqrt{29,667}} = 0,008$$

c. The next steps calculate $F_n(x)$, the cumulative distribution of the sample we have to calculate each time interval of the cumulative frequency probability. Below is the calculation

interval between 0 and 1.97:F(0<x≤1.9) = 9687 / 29667 = 0.3265

interval between 1, 9 and 3, 87: F(1.9<x≤3.87) = (9687+6800)/29667 = 0.5557

then calculated the other intervals. The cumulative distribution of the sample

d. We already discuss in the previous chapter about the frequency distribution and probability density function (pdf). Now we can assumed in order to follow exponential distribution with the formula as follow:

$$f(t < x \le T) = \left| e^{-(\frac{t}{m})} - e^{-(\frac{T}{m})} \right|$$

4.7 hours is data the average trucks time between arrivals, the pdf for each interval is calculate as follow:

$$f(0 < x < 1,9) = \left| e^{-(\frac{0}{4,7})} - e^{-(\frac{1,9}{4,7})} \right| == 0,\ 3325$$

$$f(1,9 < x < 3,87) = \left| e^{-(\frac{1,9}{4,7})} - e^{-(\frac{3,87}{4,7})} \right| == 0,\ 2285$$

For other intervals we can use this formula to calculate the probability density function.

e. And then we calculate the cumulative of pdf and also should determine the absolute difference the calculating for all bins, will be shown in table 5.1 below.

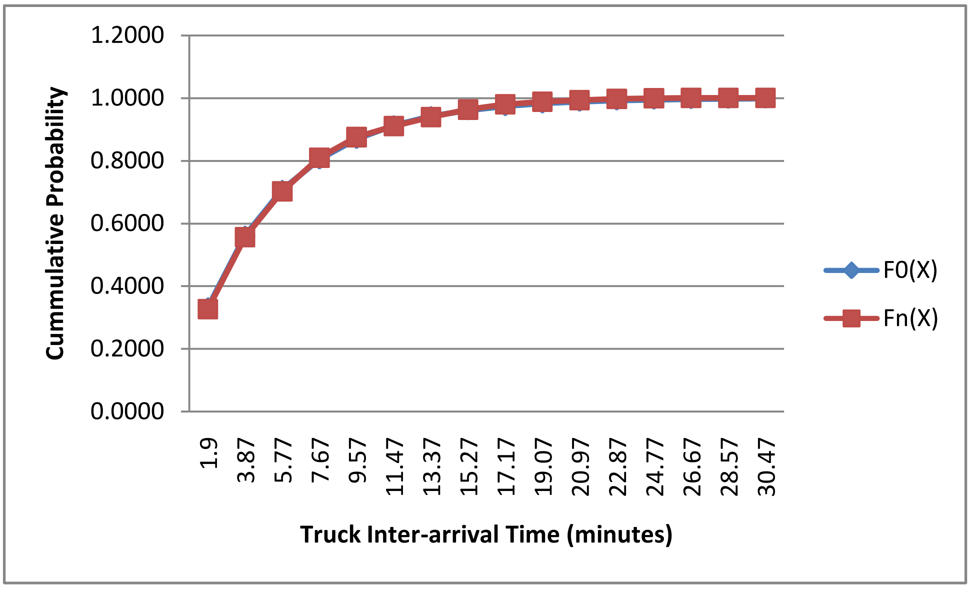
Table5.1 Cumulative distribution function of truck time between arrivals

| *Interval* | | | *Empirical Distribution* | | | Specified Distribution | | Different |
|---|---|---|---|---|---|---|---|---|
| | | | *Frequency* | *Probability* | Cum Prob. $F_n(X)$ | *Probability* | Cum Prob. $F_0(X)$ | D |
| 0 | - | 1.9 | 9687 | 0.3265 | 0.3265 | 0.3325 | 0.3325 | 0.006 |
| 1.9 | - | 3.87 | 6800 | 0.2292 | 0.5557 | 0.2285 | 0.5611 | 0.005 |
| 3.87 | - | 5.77 | 4350 | 0.1466 | 0.7024 | 0.1460 | 0.7070 | 0.005 |
| 5.77 | - | 7.67 | 3164 | 0.1067 | 0.8090 | 0.0974 | 0.8044 | 0.005 |
| 7.67 | - | 9.57 | 1965 | 0.0662 | 0.8752 | 0.0650 | 0.8695 | 0.006 |
| 9.57 | - | 11.47 | 1032 | 0.0348 | 0.9100 | 0.0434 | 0.9129 | 0.003 |
| 11.47 | - | 13.37 | 864 | 0.0291 | 0.9392 | 0.0290 | 0.9418 | 0.003 |
| 13.37 | - | 15.27 | 702 | 0.0237 | 0.9628 | 0.0193 | 0.9612 | 0.002 |
| 15.27 | - | 17.17 | 500 | 0.0169 | 0.9797 | 0.0129 | 0.9741 | 0.006 |
| 17.17 | - | 19.07 | 237 | 0.0080 | 0.9877 | 0.0086 | 0.9827 | 0.005 |
| 19.07 | - | 20.97 | 150 | 0.0051 | 0.9927 | 0.0058 | 0.9885 | 0.004 |
| 20.97 | - | 22.87 | 131 | 0.0044 | 0.9971 | 0.0038 | 0.9923 | 0.005 |
| 22.87 | | 24.77 | 65 | 0.0022 | 0.9993 | 0.0026 | 0.9949 | 0.004 |
| 24.77 | | 26.67 | 18 | 0.0006 | 0.9999 | 0.0017 | 0.9966 | 0.003 |
| 26.67 | | 28.57 | 1 | 0.0000 | 1.0000 | 0.0011 | 0.9977 | 0.002 |
| 28.57 | | 30.47 | 1 | 0.0000 | 1.0000 | 0.0008 | 0.9985 | 0.002 |
| | | | 29667 | 1.0000 | | | | |

Source: Author calculation

f. Determine again for the max value of absolute difference, which is 0.006.

g. The last step is to draw a summary with the criteria if the value of Dα is higher than or the same as D then the hypothesis $H_0$ regarding the distributional form is accepted. Base on the calculation D = 0.006 and $D_{0.95}$ = 0,008, we got $D \leq D_\alpha$, and $H_0$ is accepted. Therefore, calculate from statistic the trucks time between arrivals follow an exponential distribution. the cumulative distribution function of trucks time between arrivals is relatively same with exponential distribution as presented at Figure 5.1 below




Source: Author calculation

Figure5.1 Cumulative distribution function of trucks time between arrivals

To conduct the distribution of time between arrival of trucks we can using the method test of frequency distribution by using K-S test. The test of distribution is shown in table 5.2 below.

Table5.2 K-S Test on Distribution of Truck Time between Arrivals and Truck Service Time

| Description | Unit | Sample | Average | D | $D_{0.95}$ | Distribution |
|---|---|---|---|---|---|---|
| Truck arrival | Minute | 29,667 | 4.7 | 0.006 | 0.008 | Exponential |
| Gate Service time | Minute | 29,667 | 3.9 | 0.005 | 0.008 | Exponential |
| Ground Slot Service time | Minute | 29,667 | 5.5 | 0.006 | 0.008 | Exponential |

Source: Author calculation

It is clear from presented in table 5.2 above that all of distributions test follow the exponential distribution it also means that arrival distribution of trucks is Poisson from calculation distribution of time between arrivals

## 5.2 Facilities required in the Indonesia Kendaraan Terminal analysis.

Facilities required for receiving and delivery operations in the Indonesia Kendaraan Terminal that will be analyzed are gate and ground slot.

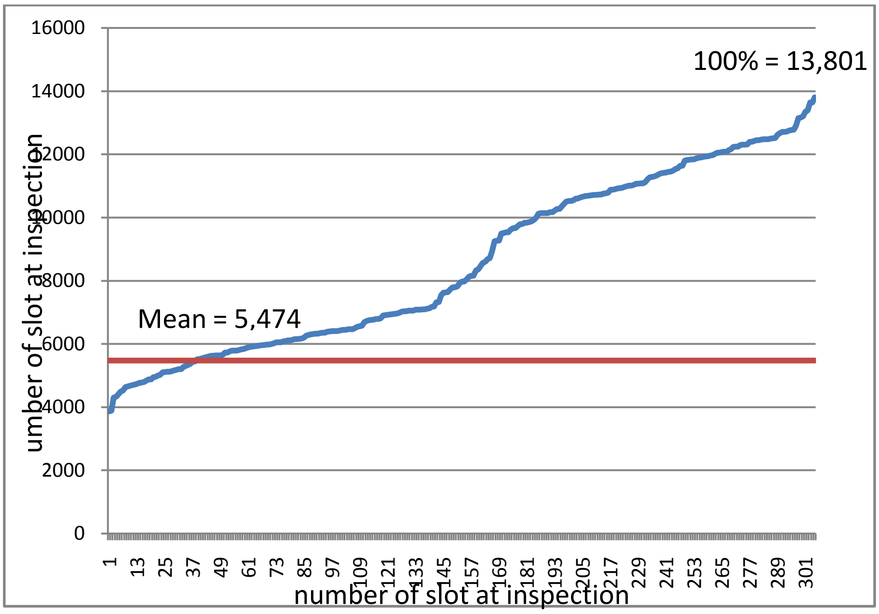
### 5.2.1 Gate

Currently there is 1 gate that serves all the trucks that come and 1 gate that serve truck coming out. There is one officer in a shift where there are 3 ship in one day. Service time at the gate is average of 5 minutes for a truck. Queue at the arrival gate caused more trucks at the same time

### 5.2.2 Ground Slot

Currently there are 14 units of a ground slots, the average service time in the ground slot is 30 minutes, while the number of officers on the ground slot is 15 officers. Queue at the ground slots caused by the arrival of the truck at the same time.

### 5.2.3 Peaking Factor




Source : Author

Figure5.2 Peaking Factor

$$PF = \frac{Max}{Mean} = \frac{13{,}801}{5{,}474} = 2{,}5$$

Required TGS is calculated using formula as follow,

$$\text{Required } TGS = \frac{Capacity.DT.PF}{H.U.K} = \frac{29667.20.2{,}5}{1.0{,}33.219000} = 20 \text{ Ground slot}$$

Thus, for this calculation the terminal required 20 ground slot to handled truck for receiving and delivery activities at peak time.

### 5.3 Service costs and waiting costs calculation

To analyze and knowing the total costs in the Indronesia Kendaraan Terminal we have to calculation of service costs and waiting costs. According on data presented in previous chapter all costs also revenue will be converted and use the same currency that is IDR per day.

#### 5.3.1 Service costs

Service costs is the costs from terminal management to provide facilities for receiving and delivery operation which consist of gate and ground slot

##### 5.3.1.1 Facilities costs

Service costs are calculated and analysis of area gate and ground slot. Calculation of this cost costs consist of the cost for maintenance and investment.

a. Facilities cost at gate

1 unit gate of investment by terminal = IDR. 1,401,926,776 , The management assumed economic usage of gate is 30 years and interest (r) 9%. The formula to calculate the investment cost is

$$\text{AnnualCost} = \text{Investment}\frac{r(1+r)^{25}}{(1+r)^{25} - 1} = \text{IDR}.1{,}401{,}926{,}776\frac{0{,}09(1+0{,}09)^{25}}{(1+0{,}09)^{25} - 1}$$

= IDR 142,724,908/year

Maintenance cost = 5% x IDR 142,724,908/year = IDR 7,136,245/year

Total cost =IDR 149,861,153/year = IDR 410,578/day

b. Facilities cost at ground slot

1 unit ground slot of investment = 30 m x 3,5 m x IDR.500,000 /$m^2$ = IDR 52,500,000 /year

The management assumed economic usage of ground slot is 30 years and interest (r) 9 % the formulato calculate the investment cost is

$$\text{AnnualCost} = \text{Investment}\frac{r(1+r)^{30}}{(1+r)^{30}-1} = \text{IDR}.52,520,000\frac{0,09(1+0,09)^{30}}{(1+0,09)^{30}-1}$$

= IDR 5,110,158

Maintenance cost = 5% x IDR 5,110,158 /year = IDR 255,507 /year

Total cost = IDR 5,365,666 /year = IDR14,700 /day

### 5.3.1.2 Labor costs

Calculation of the labor costs consist of the labor cost at gate and ground slot. The following are labor cost at gate and ground slot:

a. Labor cost at gate

   Currently, there is one gate in Indonesia car terminal with one officer in one shift. Salary for one employee is IDR 1.9 million per month. Since the amount of shift in a day is 3 shifts the cost of labor at gate is IDR 1,9 million x 3 officers/ 30days = IDR 190,000 per day.

b. Labor cost at ground slot

   Labor cost at ground slot depends on the number of car loaded/unloaded from the trucks. The higher number of car, the bigger cost of labor in ground slot. Cargo firms spend IDR 192,000 per car loaded/unloaded from the trucks. Since average capacity of truck can load 5 cars then cost of loading/unloading for a truck is IDR 192,000 x 5 cars = IDR 960,000 per truck.

### 5.3.2 Truck waiting costs

We already discuss the meaning of truck waiting cost previously The average revenue each truck per trip is IDR 2,000,000. Thus, the trucks opportunity cost is IDR 2,000,000 per trip. The trucks cost of queue includes fuel cost of gasoline and the employee cost of overtime. The cost of refueling is IDR 9,000 per hour while the cost of overtime is IDR50,000 per hour.

## 5.4 Queuing model Analysis

The kind of queuing theory that will be applied and analyzed are queuing model of truck service at a gate and queuing model for ground slot. We can consider to the frequency distribution test and also the inter-arrival time of truck an exponential distribution pattern. After we having know kind of queuing model, we have the characteristics inter arrivals time is exponentially distributed and server more than one, a queuing model of M/M/k can be choosed to calculate and analyze the queuing for the receiving and delivery activities inside terminal.

### 5.4.1 The Trucks service queuing model

#### 5.4.1.1 Ground slot Queuing model

Several data required to analyze and calculate the queuing model are describes as follow.

a. $\lambda$ or Truck arrival rate calculation according to the average trucks time between arrivals. The average trucks time between arrivals 4,7 minutes so the trucks arrival rate is 29,667 trucks per year in the terminal.
b. The activities Truck service time at ground slot are time required for truck handling which is assumed 30 minutes, time for loading/unloading of car which depends on the number of ground slot. The cycle time of service is 30 minutes per 1 truck.

c. Because truck service rate (μ) 7300 trucks per year is < λ= 29,667 trucks per year it should be have more than one server or ground slot. By using the minimum number of server k = 5 the requirement of the queuing model there is k. λ > μ have been met.

With using model M/M/5 , the average number of trucks in the Indonesia Kendaraan terminal we can obtained by calculate several characteristics in the queuing model, there are:

a. Utilization rate for each ground slot

$$\rho = \frac{\lambda}{k\mu} = \frac{29667}{5(7300)} = 0,8127$$

b. Average time a truck spends in the queue

$$W_q = \frac{\left(\frac{\lambda}{\mu}\right)^k \mu}{(k-1)!(k\mu-\lambda)^2} P_0 + \frac{1}{\mu}$$

$$W_q = \frac{(\frac{29667}{7300})^5 7300}{(5-1)!(5(7300-29667)^2}(0,0105) + \frac{1}{7300}$$

$$W_q = 0,00021$$

c. Probability that there is no truck in the system

$$P_0 = \frac{1}{\sum_{n=0}^{k=5} \frac{1}{n!}(\frac{\lambda}{\mu})^n + \frac{1}{k!}(\frac{\lambda}{\mu})^k (\frac{k\mu}{k\mu-\lambda})}$$

$$P_0 = \frac{1}{\frac{(\frac{29667}{7300})^0}{0!} + \frac{(\frac{29667}{7300})^1}{1!} + \frac{(\frac{29667}{7300})^2}{2!} + \ldots\ldots + \frac{(\frac{29667}{7300})^5}{5!} + \frac{(\frac{29667}{7300})^5}{5!}(\frac{5(7300)}{5(7300)-(29667)})}$$

$P_0$=0, 0105

d. Average number of trucks in the queue

$$L_q = P_0 \frac{\left(\frac{\lambda}{\mu}\right)^k}{k!} \frac{\rho}{(1-\rho)^2}$$

$$L_q = 0.0105 \frac{(\frac{29667}{7300})^5 0,8127}{5!(1-0,8127)^2}$$

$$L_q = 2,268$$

e. Average time a truck spends in the Indonesia Kendaraan Terminal

$$W = W_q + \frac{1}{\mu} = 0.00021 + \frac{1}{7300} = 3,078 \text{ hours}$$

f. The average number of trucks in the Indonesia Kendaraan Terminal

$$L = L_q + \frac{\lambda}{\mu} = 2,268 + \frac{29667}{7300} = \quad 6,33$$

After we calculate at the following above, we also able to analyzes for the number of server k = 5 gates to k = 9. The calculation summary is presented in table 5.3 below.

Table 5.3 characteristics of queuing model

| Characteristic | Unit | Number of Ground slot (k) | | | | |
|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 |
| Λ | Trucks/year | 29667 | 29667 | 29667 | 29667 | 29667 |
| µ | Trucks/year | 7300 | 7300 | 7300 | 7300 | 7300 |
| P | % | 81,27% | 67,73% | 58.05% | 50,79% | 45,15% |
| Po | | 0,0105 | 0.0141 | 0.0157 | 0.0165 | 0.0168 |
| W | Years | 0.00035 | 0.00029 | 0.00028 | 0.00027 | 0.00027 |
| | Hours | 3,078 | 2,57 | 2,46 | 2,42 | 2,41 |
| Wq | Years | 0,00021 | 0.00015 | 0.00014 | 0.00013 | 0.00013 |
| | Hours | 1,87 | 1,37 | 1.25 | 1,22 | 1,20 |
| L | Trucks | 6,3321 | 4,6392 | 4,2522 | 4,1278 | 4,0851 |
| Lq | Trucks | 2,2681 | 0,5752 | 0.1883 | 0.0639 | 0.0211 |

Source: Author calculation

The above table shows that using the more ground slot make the lower utilization and make more less trucks has to wait for ground slot services.

#### 5.4.1.2 Gate Queuing model

We can use the same way as the calculation in queuing model above and gained data input as explained as follow:

a. $\mu$ or Truck service rate is 43,800 trucks/ year.
b. $\lambda$ or Truck arrival rate is 74,167(29,667x2,5) trucks / year.
c. Due to $\mu$ 43,800 trucks per year is less than $\lambda$ 74,167 trucks / year it should be have more than one server. The requirement of the queuing model k. $\lambda >$ $\mu$ By using the minimum number of server k = 1 have been met.

The below table will be shows the number of server k = 1 gate to k = 2 gate after we know data input

Table 5.4 l characteristics of gate queuing model

| Characteristic | Unit | Number of Gate (k) | |
|---|---|---|---|
| | | 1 | 2 |
| $\lambda$ | Trucks/year | 74,167 | 74,167 |
| $\mu$ | Trucks/year | 43800 | 43800 |
| $\rho$ | % | 169,33% | 84,66% |
| Po | | 3,9847 | 0,0742 |
| W | Years | 0,00036 | 0,00009 |
| | Hours | 3,2162 | 0,8547 |
| Wq | Years | 0,00034 | 0,00007 |
| | Hours | 3,015 | 0,65 |
| L | Trucks/year | 25,46 | 5,52 |
| Lq | Trucks/year | 23,76 | 3,83 |

Source: Author calculation

## 5.5 The Total cost model Analysis

The total cost analysis is used to determine the optimal number of facilities required in order to make customer satisfy with no congestion and terminal management spent less cost to provide facilities. It can be calculated on the basis of the following formula: $TC(S) = I \cdot C1 + W \cdot C2$ the explanation as follow,

a. The queuing model of trucks service at gate which analyzes the truck handling operation in the gate and ,$C2$ is the number of gate and $C1$ is the average number of trucks at the Indonesia Kendaraan Terminal which is gained from the queuing model analysis. $I$ is waiting cost of trucks per trucks per day. $W$ is total cost of service which consists of cost for provide the gate.
b. The queuing model of trucks service which analyzes the truck handling operation in the ground slot and , $C2$ is the number of gate and $C1$ is the average number of trucks at the Indonesia Kendaraan Terminal which is gained from the queuing model analysis. $I$ is waiting cost of trucks per trucks per day. $W$ is total cost of service which consists of cost for provide the ground slot.

### 5.5.1. Truck and gate service at ground slot total cost

The Total cost for trucks service at ground slot is analyzed to determine the requirement number of ground slot in the Indonesia Kendaraan Terminal with the objective is minimum total cost. The total cost calculation result as shown in the below figure.

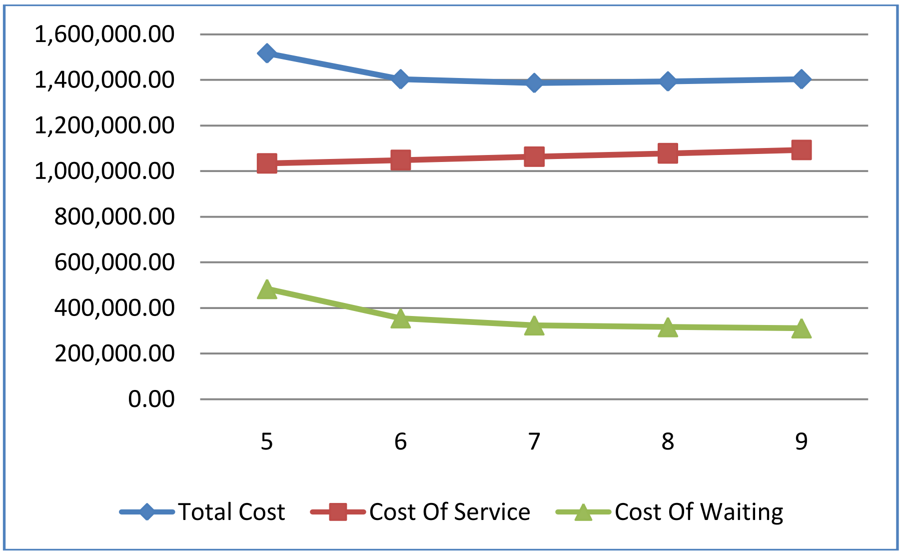
Table 5.5 Trucks Total Cost (in IDR /day)

| Number of ground slot (k) | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|
| Costs of Service | 1,033,500 | 1,048,200 | 1,062,900 | 1,077,600 | 1,092,300 |
| a. Ground Slot | 73,500 | 88,200 | 102,900 | 117,600 | 132,300 |
| b. Employee | 960,000 | 960,000 | 960,000 | 960,000 | 960,000 |
| Average number of trucks (L) | 6,33 | 4,64 | 4,25 | 4,13 | 4,08 |
| Wq (hour) | 1.87 | 1.37 | 1.25 | 1.22 | 1.20 |
| Costs of waiting | 483,330 | 354,830 | 323,750 | 315,980 | 310,800 |
| a. Refueling Cost | 16,830 | 12,330 | 11,250 | 10,980 | 10,800 |
| b. Over time cost | 93,500 | 68,500 | 62,500 | 61,000 | 60,000 |
| c. Opportunity cost | 374,000 | 274,000 | 250,000 | 244,000 | 240,000 |
| Total cost (TC) | 1,516,830 | 1,403,030 | 1,386,650 | 1,393,580 | 1,403,100 |

Source: Author calculation

The above table describes the total cost of facilities for each number of ground slot. Based on the figure above it can be seen that the total cost of 5 ground slots are IDR

1,516,830 which consist of cost of service is IDR 1,033,500 and cost of waiting is IDR 483,330. When the number of ground slot increase to become 6 ground slot, then the cost of service increase to be IDR 1,048,200, while cost of waiting decrease to be IDR 354,830. So that the total cost in 6 ground slots is IDR 1,403,030. The minimum of total cost is at 7 ground slot is IDR 1,386,650



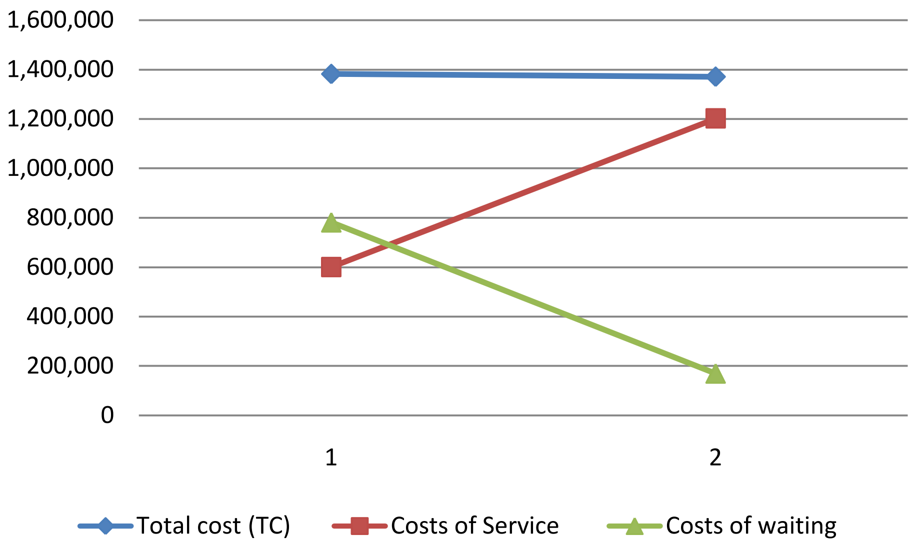

Source: Author calculation

Figure 5.3 Total Cost for Trucks

Table 5.6 Gate Total Cost (in IDR / day)

| Number of gate (k) | 1 | 2 |
|---|---|---|
| Costs of Service | 600,578 | 1,201,156 |
| a. Ground Slot | 410,578 | 821,156 |
| b. Employee | 190,000 | 380,000 |
| Average number of trucks (L) | 25,46 | 5,52 |
| Wq (hour) | 3 | 0.654 |
| Costs of waiting | 780,885 | 169,386 |
| a. Refueling Cost | 27,135 | 5,886 |
| b. Over time cost | 150,750 | 32,700 |
| c. Opportunity cost | 603,000 | 130,800 |
| Total cost (TC) | 1,381,463 | 1,370,542 |

Source: Author calculation




Source: Author calculation

Figure 5.4 Graphic of Gate Total Cost

As seen in table 5.6 and figure 5.4 Total cost is achieved by using 2 units gate with the total cost IDR 1,370,542 per day.

## 5.6 Analysis of Proper ground slot Capacity

In the terminal, proper ground slot capacity is obtained when the truck can be handled with a minimum or even zero waiting time in other word is no congestion with the optimum utilization of facilities provide by terminal. To calculate proper capacity in receiving and delivery operation need several items that will be consider as follow:

a. Terminal working hour is 365 days and each day operation is 10 hours for safety reason.
b. The number of facilities receiving and delivery operation. Previously we have been analysis the optimum number of ground slot in the terminal is 7 units and the optimum number of gate is 2 gates.

c. Utilization of which is gained from queuing analysis. Based on queuing analysis the optimum utilization of ground slot by using 7 units is 58.05%. The optimum utilization for gate operation is 84.66%.

The below table will be shows proper capacity for receiving and delivery operation by consider the terminal working hour and utilization.

Table 5.7 Proper Receiving and delivery facilities capacity calculation

| Type of Service | Queuing Time (minutes) | Utilization (%) | Proper Capacity |
|---|---|---|---|
| | | | Truck |
| Gate Service | 3,94 | 84.66% | 14,600 |
| Ground slot service | 5,5 | 58,05% | 51,100 |

Source: Author calculation

From table 5.7 above we calculate that ground slot capacity are more and less the same of about 51,100 truck and the gate capacity of receiving/delivery operation is around 14,600 trucks.

Table 5.8 Evaluation of Receiving and Delivery Facilities

| Types | Existing | Required | Shortage/Surplus |
|---|---|---|---|
| Ground Slot | 14 Slots | 7 Slots | 7 Slots |
| Gate | 1 line | 2 lines | -1 line |

Source: Author calculation

The Table 5.8above shows the evaluation of overall facilities and also presented the ideal facilities for the terminal management with the highest utilization and lowest cost.

# Chapter 6 CONCLUSION AND RECOMMENDATION

Based on this study we have been analysis and we able to conclude and recommendation for Indonesia Kendaraan Terminal (IKT) management to achieve excellent service to the customer with several consideration, as follow :

1. The analysis shows that the optimum number of ground slot is 7 units ground slot with the average utilization 58.05% By using this optimum number of ground slot would be achieved the minimum total cost of IDR 1.386650 per day with the proper capacity of around 7 units ground slot.

2. The optimum number of gate is 2 units gate with the average utilization 84,66% By using this optimum number of ground slot would be achieved the minimum total cost of IDR 1.370.542 per day with the proper capacity of around 2 units gate.

3. Based on this research we recommend that the usage of 7 ground slots instead of the existing 14 ground slots in the IKT is more efficient regarding the cost of service and avoid the waste facilities. While for the usage of 2 gates instead of the existing 1 gate in the IKT is more efficient regarding the level of service also cost of service, in additional in the customer point of views it is more than satisfying them due to almost no waiting time suffered.

4. Due to the optimalisation facilities, IKT management should be extend the working hours by have coordination with customs an also announced to shipper/consigne to extend their working hour in the warehouse because working hour for receiving and delivery operation in the terminal depends on working hour customs and shipper or consigne but still considering the safety rule for night working.

5. The last recommendation is the terminal management have to preparing to served the increase capacity of the truck that they carry such as labour, the size of ground slot or information technology at the gate. at this present in the terminal the biggest truck only carry 6 cars in the chassis, but in the other countries the car terminals can be served 8 cars or even 10 cars per truck so this is also challenges to the terminal management and truck companies to build and serve more bigger capacity their truck in Indonesia.

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## 1. Appendix 1 K-S test for truck time between arrivals

a. Hypothesis:

$H_0$: the population distribution of truck time between arrivals F(x) is the same as $F_0(x)$ which follows the exponential distribution.

$H_1$: the population distribution of truck time between arrivals F(x) is not the same as $F_0(x)$ which follows the exponential distribution.

b. Critical value $D_\alpha$ for level of significance (α) 95%: $D_{0,95} = \frac{1,36}{\sqrt{29,667}} = 0,008$

c. Cumulative distribution function of truck time between arrivals

| *Interval* | | | *Empirical Distribution* | | | Specified Distribution | | Different |
|---|---|---|---|---|---|---|---|---|
| | | | *Frequency* | *Probability* | Cum Prob. $F_n(X)$ | *Probability* | Cum Prob. $F_0(X)$ | D |
| 0 | - | 1.9 | 9687 | 0.3265 | 0.3265 | 0.3325 | 0.3325 | 0.006 |
| 1.9 | - | 3.87 | 6800 | 0.2292 | 0.5557 | 0.2285 | 0.5611 | 0.005 |
| 3.87 | - | 5.77 | 4350 | 0.1466 | 0.7024 | 0.1460 | 0.7070 | 0.005 |
| 5.77 | - | 7.67 | 3164 | 0.1067 | 0.8090 | 0.0974 | 0.8044 | 0.005 |
| 7.67 | - | 9.57 | 1965 | 0.0662 | 0.8752 | 0.0650 | 0.8695 | 0.006 |
| 9.57 | - | 11.47 | 1032 | 0.0348 | 0.9100 | 0.0434 | 0.9129 | 0.003 |
| 11.47 | - | 13.37 | 864 | 0.0291 | 0.9392 | 0.0290 | 0.9418 | 0.003 |
| 13.37 | - | 15.27 | 702 | 0.0237 | 0.9628 | 0.0193 | 0.9612 | 0.002 |
| 15.27 | - | 17.17 | 500 | 0.0169 | 0.9797 | 0.0129 | 0.9741 | 0.006 |
| 17.17 | - | 19.07 | 237 | 0.0080 | 0.9877 | 0.0086 | 0.9827 | 0.005 |
| 19.07 | - | 20.97 | 150 | 0.0051 | 0.9927 | 0.0058 | 0.9885 | 0.004 |
| 20.97 | - | 22.87 | 131 | 0.0044 | 0.9971 | 0.0038 | 0.9923 | 0.005 |
| 22.87 | | 24.77 | 65 | 0.0022 | 0.9993 | 0.0026 | 0.9949 | 0.004 |
| 24.77 | | 26.67 | 18 | 0.0006 | 0.9999 | 0.0017 | 0.9966 | 0.003 |
| 26.67 | | 28.57 | 1 | 0.0000 | 1.0000 | 0.0011 | 0.9977 | 0.002 |
| 28.57 | | 30.47 | 1 | 0.0000 | 1.0000 | 0.0008 | 0.9985 | 0.002 |
| | | | 29667 | 1.0000 | | | | |

d. Conclusion:

Base on the calculation D = 0.006 and $D_{0.95}$ = 0.008, thus $D \leq D_{\alpha}$, and $H_0$ is accepted. It means that statistically the truck time between arrivals follow an exponential distribution.

## 2. Appendix 2 K-S test for truck time between arrivals

a. Hypothesis:

$H_0$: the population distribution of truck time between arrivals F(x) is the same as $F_0(x)$ which follows the exponential distribution.

$H_1$: the population distribution of truck time between arrivals F(x) is not the same as $F_0(x)$ which follows the exponential distribution.

b. Critical value $D_\alpha$ for level of significance ($\alpha$) 95%: $D_{0,95} = \frac{1,36}{\sqrt{29,667}} = 0,008$

c. Cumulative distribution function of truck time between arrivals at gate

| *Interval* | | | *Empirical Distribution* | | | Specified Distribution | | Different |
|---|---|---|---|---|---|---|---|---|
| | | | *Frequency* | *Probability* | Cum Prob. $F_n(X)$ | *Probability* | Cum Prob. $F_0(X)$ | D |
| 0 | - | 1.58 | 9810 | 0.3307 | 0.3307 | 0.3331 | 0.3331 | 0.002 |
| 1.58 | - | 3.16 | 6750 | 0.2275 | 0.5582 | 0.2221 | 0.5553 | 0.003 |
| 3.16 | - | 4.74 | 4145 | 0.1397 | 0.6979 | 0.1481 | 0.7034 | 0.005 |
| 4.74 | - | 6.32 | 3010 | 0.1015 | 0.7994 | 0.0988 | 0.8022 | 0.003 |
| 6.32 | - | 7.9 | 1909 | 0.0643 | 0.8637 | 0.0659 | 0.8681 | 0.004 |
| 7.9 | - | 9.48 | 1300 | 0.0438 | 0.9075 | 0.0439 | 0.9120 | 0.004 |
| 9.48 | - | 11.06 | 845 | 0.0285 | 0.9360 | 0.0293 | 0.9413 | 0.005 |
| 11.06 | - | 12.64 | 711 | 0.0240 | 0.9600 | 0.0195 | 0.9609 | 0.001 |
| 12.64 | - | 14.22 | 521 | 0.0176 | 0.9776 | 0.0130 | 0.9739 | 0.004 |
| 14.22 | - | 15.8 | 240 | 0.0081 | 0.9856 | 0.0087 | 0.9826 | 0.003 |
| 15.8 | - | 17.38 | 172 | 0.0058 | 0.9914 | 0.0058 | 0.9884 | 0.003 |
| 17.38 | - | 18.96 | 141 | 0.0048 | 0.9962 | 0.0039 | 0.9923 | 0.004 |
| 18.96 | | 20.54 | 81 | 0.0027 | 0.9989 | 0.0026 | 0.9948 | 0.004 |
| 20.54 | | 22.12 | 28 | 0.0009 | 0.9999 | 0.0017 | 0.9966 | 0.003 |
| 22.12 | | 23.7 | 3 | 0.0001 | 1.0000 | 0.0011 | 0.9977 | 0.002 |
| 23.7 | | 25.28 | 1 | 0.0000 | 1.0000 | 0.0008 | 0.9985 | 0.002 |
| | | | 29667 | 1.0000 | | | | |

d. Conclusion:

Base on the calculation D = 0.005 and $D_{0.95}$ = 0.008, thus $D \leq D_{\alpha}$, and $H_0$ is accepted. It means that statistically the truck time between arrivals follow an exponential distribution.

### 3. Appendix 3 K-S test for truck time between arrivals

a. Hypothesis:

$H_0$: the population distribution of truck time between arrivals F(x) is the same as $F_0(x)$ which follows the exponential distribution.

$H_1$: the population distribution of truck time between arrivals F(x) is not the same as $F_0(x)$ which follows the exponential distribution.

b. Critical value $D_\alpha$ for level of significance ($\alpha$) 95%: $D_{0,95} = \frac{1,36}{\sqrt{29,667}} = 0,008$

c. Cumulative distribution function of truck time between arrivals at groundslot

| *Interval* | | | *Empirical Distribution* | | | Specified Distribution | | Different |
|---|---|---|---|---|---|---|---|---|
| | | | *Frequency* | *Probability* | Cum Prob. $F_n(X)$ | *Probability* | Cum Prob. $F_0(X)$ | D |
| 0 | - | 2.22 | 9700 | 0.3270 | 0.3270 | 0.3321 | 0.3321 | 0.005 |
| 2.22 | - | 4.44 | 6821 | 0.2299 | 0.5569 | 0.2218 | 0.5539 | 0.003 |
| 4.44 | - | 6.66 | 4180 | 0.1409 | 0.6978 | 0.1481 | 0.7021 | 0.004 |
| 6.66 | - | 8.88 | 2900 | 0.0978 | 0.7955 | 0.0989 | 0.8010 | 0.005 |
| 8.88 | - | 11.1 | 2021 | 0.0681 | 0.8637 | 0.0661 | 0.8671 | 0.003 |
| 11.1 | - | 13.32 | 1302 | 0.0439 | 0.9075 | 0.0441 | 0.9112 | 0.004 |
| 13.32 | - | 15.54 | 810 | 0.0273 | 0.9348 | 0.0295 | 0.9407 | 0.006 |
| 15.54 | - | 17.76 | 752 | 0.0253 | 0.9602 | 0.0197 | 0.9604 | 0.000 |
| 17.76 | - | 19.98 | 540 | 0.0182 | 0.9784 | 0.0131 | 0.9736 | 0.005 |
| 19.98 | - | 22.2 | 221 | 0.0074 | 0.9858 | 0.0088 | 0.9823 | 0.004 |
| 22.2 | - | 24.42 | 170 | 0.0057 | 0.9916 | 0.0059 | 0.9882 | 0.003 |
| 24.42 | - | 26.64 | 134 | 0.0045 | 0.9961 | 0.0039 | 0.9921 | 0.004 |
| 26.64 | | 28.86 | 90 | 0.0030 | 0.9991 | 0.0026 | 0.9947 | 0.004 |
| 28.86 | | 31.08 | 22 | 0.0007 | 0.9999 | 0.0017 | 0.9965 | 0.003 |
| 31.08 | | 33.3 | 3 | 0.0001 | 1.0000 | 0.0012 | 0.9977 | 0.002 |
| 33.3 | | 35.52 | 1 | 0.0000 | 1.0000 | 0.0008 | 0.9984 | 0.002 |
| | | | 29667 | 1.0000 | | | | |

d. Conclusion:

Base on the calculation $D = 0.006$ and $D_{0.95} = 0.008$, thus $D \leq D_{\alpha}$, and $H_0$ is accepted. It means that statistically the truck time between arrivals follow an exponential distribution.

## 4. Appendix 4 Calculation of additional ground slot area

To calculate the area required for additional ground slot capacity of 29667 trucks per year we use the same assumptions as explained in section 5.2.2 (p.54) as follows:

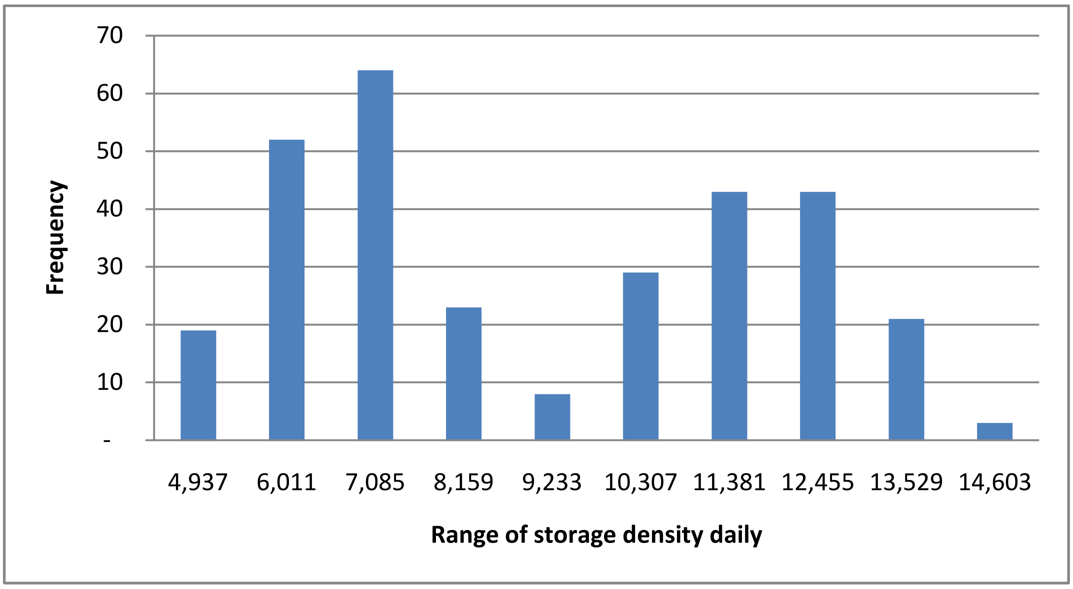
- Dimension of a ground slot is 30 m x 2.5 m.
- There is 1 gound slot for 1 truck.
- The proportion of export and import cargo is 51% and 49%.
- Dwelling Time (DT) for truck servive on a ground slot is 20 minute.
- Peaking factor (PF) is 2,5.
- Land utilization (U) ratio is 33%.
- Number of working days in a year (K) is 365 days and each day 10 hours operations = 219000 Minutes.

Truck Ground Slot (TGS) is calculated by the following formula:

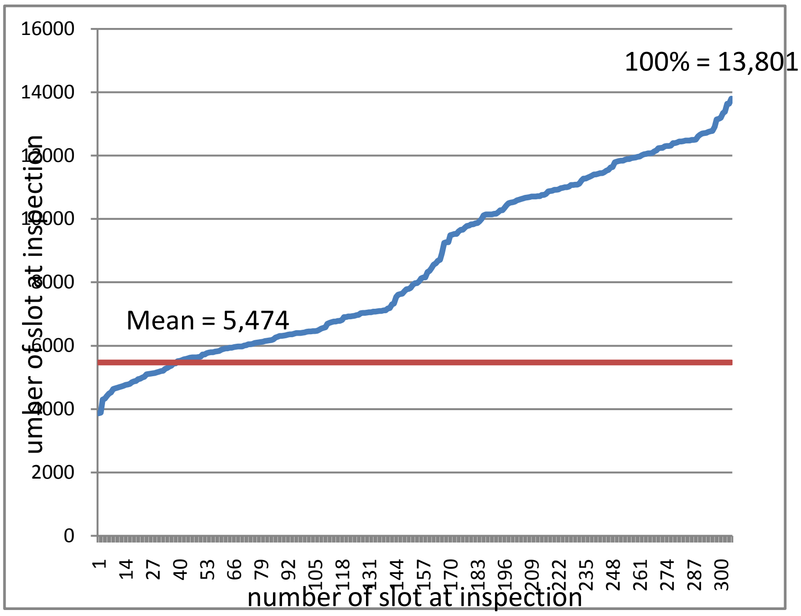
$$TGS = \frac{Capacity.DT.PF}{H.U.K} = \frac{29667.20.2,5}{1.0,33.219000} = 20 \text{ Ground slot}$$

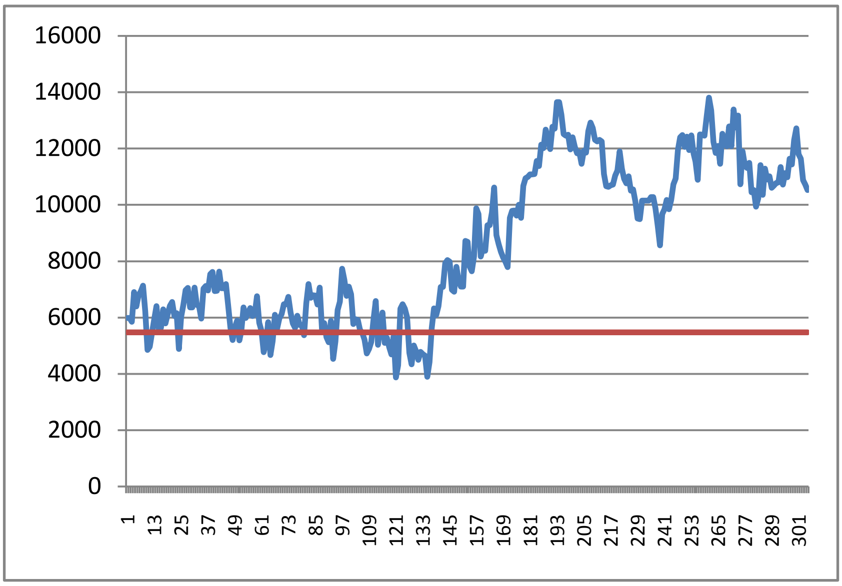
## 5. Appendix 4 Calculation of Peaking Factor

| Bin | Interval (hour) | | | Frequency |
|---|---|---|---|---|
| 1 | 3,863 | - | 4,937 | 19 |
| 2 | 4,937 | - | 6,011 | 52 |
| 3 | 6,011 | - | 7,085 | 64 |
| 4 | 7,085 | - | 8,159 | 23 |
| 5 | 8,159 | - | 9,233 | 8 |
| 6 | 9,233 | - | 10,307 | 29 |
| 7 | 10,307 | - | 11,381 | 43 |
| 8 | 11,381 | | 12,455 | 43 |
| 9 | 12,455 | - | 13,529 | 21 |
| 10 | 13,529 | - | 14,603 | 3 |
| Average | | 5,474 | Hours | |
| Total | | | | 305 |



| *Class* | *Interval* | | | *Empirical Distribution* | | | Specified Distribution | | Different |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *Frequency* | *Probability* | Cum Prob. $F_n(X)$ | *Probability* | Cum Prob. $F_0(X)$ | D |
| I | 3863.00 | - | 4937.05 | 19.00 | 0.0623 | 6 | 0.0880 | 0.0880 | 6.1415 |
| II | 4937.05 | - | 6011.10 | 52.00 | 0.1705 | 23 | 0.0723 | 0.1603 | 23.1184 |
| III | 6011.10 | - | 7085.14 | 64.00 | 0.2098 | 44 | 0.0594 | 0.2197 | 44.0426 |
| IV | 7085.14 | - | 8159.19 | 23.00 | 0.0754 | 52 | 0.0488 | 0.2685 | 51.5348 |
| V | 8159.19 | - | 9233.24 | 8.00 | 0.0262 | 54 | 0.0401 | 0.3086 | 54.1176 |
| VI | 9233.24 | - | 10307.29 | 29.00 | 0.0951 | 64 | 0.0330 | 0.3416 | 63.5928 |
| VII | 10307.29 | - | 11381.34 | 43.00 | 0.1410 | 78 | 0.0271 | 0.3687 | 77.6641 |
| VIII | 11381.34 | - | 12455.39 | 43.00 | 0.1410 | 92 | 0.0223 | 0.3910 | 91.7401 |
| IX | 12455.39 | - | 13529.43 | 21.00 | 0.0689 | 99 | 0.0183 | 0.4093 | 98.6071 |
| X | 13529.43 | - | 14603.48 | 3.00 | 0.0098 | 100 | 0.0150 | 0.4243 | 99.5757 |
| | | | | 305.00 | 1.0000 | | | | |



$$PF = \frac{Max}{Mean}$$

| | |
|---|---|
| Max (100%) | 13801 |
| Mean | 5474 |
| peaking factor | 2.521191 |