Queuing Simulation and Container Crane Utilization at the Makassar Container Terminal

Eris Nur Dirman, Saleh Pallu, Isran Ramli

Abstract: The background of this research is the shift of the cargo pattern from the original cargo general cargo to the cargo in the container causing the current volume of container transport in all ports, especially in the PT. Pelindo IV (Persero) is getting higher. This study aims to determine the performance of container loading and unloading service using container cranes at the Makassar Container Terminal (TPM). This research is more imposed on the analysis of the service system from the dock side, especially container crane (CC) facilities with queuing methods which the solution uses simulation and analytical methods as calculations. This study began with the collection of container export and import activities at the Makassar Container Terminal, South Sulawesi GRDP data, and container loading and unloading activity data by container crane facilities. Data were analyzed using statistical analysis to get the projected value. Based on the projection results, performance calculations are performed using the queuing simulation method and analytical methods. The results showed that the number of containers for export and import increased from year to year. In 2018 the export flow of containers was 634,885 boxes per year. The performance of container crane services at Makassar Container Terminal until 2016 has not been found in the queue. Queues in the new system occur in 2017 and occur on 1 container crane only. It can be explained that until 2016 the service conditions at TPM were still under operated. Performance improvements began in 2017 with the addition of container cranes.

Keywords: Container Crane, Loading, Unloading, Queuing simulation

I. INTRODUCTION

In an integrated transportation system, there are three modes of transportation that are distinguished by media or place of movement, namely: land transportation, sea transportation and air transportation. Transportation is the lifeblood of an economy and it derived demand from economic activities, so that the economic growth of a country or region is reflected in the increase in the intensity of its transportation [1, 2]. Indonesia is an archipelago country and sea transportation system has a very large role in social life, economy, government, politics and national defence and security. It also plays a role as important link in the international conveyance system [3]. The existence of a very wide sea allows greater movement of cargo at a more efficient cost compared to other modes of transportation [4].

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One of the important infrastructure components in the sea transportation system for an archipelago country like Indonesia is the port. The port has an important role as a mode of sea transportation by land.

As an infrastructure that has an important role in the economic growth of a region, the port is required to continue to improve its performance [5]. The high cost of logistics and the rapid economic growth of an area cannot be separated from the increasingly high productivity of loading and unloading of goods at the port. To increase the productivity of loading and unloading, it is very important to pay attention to the readiness of loading and unloading equipment and other infrastructure facilities at the port. The better infrastructure and port superstructure readiness to service causing the loading and unloading process to run smoothly, effectively and efficiently which can accomplish the increasing of the container in future [6]. The container terminal is an important link in the goods transportation system by sea. The increase in the number of goods traded in the last year requires the role of container terminals to be higher with better performance so as to ensure smooth transportation of goods. Container terminal performance is an indicator needed to assess the smooth operation of the container terminal in serving goods transportation activities and its future development [7]. In planning a container terminal, it is necessary to assess the use of the effectiveness of an investment in terms of future operating estimates [8]. Since the founding of the Makassar container terminal, the productivity of loading and unloading goods in the Makassar port has been increasing. One indicator of this increase in productivity can be seen from the decreasing number of ship queues in the port and the higher growth of containers at the container terminal. This increase in productivity is accompanied by the addition and improvement of superstructure and infrastructure at the TPM. The loading and unloading equipment owned by the container terminal must be fully utilized to carry out container loading and unloading activities in and out of the terminal. Previous research was conducted by Haryanto (2005), who used queuing simulations in analyzing the performance of container terminals at TanjungEmas Port in Semarang with the simulation results showing the performance of Transtainer facility services until 2007 had not found queues in the system and new queues occurred in 2008 [9]. Therefore, in line with the existing problems, this study aims to determine the level of container loading and unloading service performance using container cranes at the Makassar Container Terminal (TPM).

II. METHODOLOGY

Research Design

This research was conducted at the Makassar Container Terminal (TPM) supported by PT. Pelindo IV (Persero) as TPM is the largest container terminal in Eastern Indonesia (KTI) and has long been operating and fulfilling the requirements as a container terminal with a standard full container system, PT. Pelabuhan Indonesia IV (2012) [10]. This type of research is quantitative on the value of container terminal performance analysis and compares the performance of the TPM to service standards.

Method of Collecting Data

The data collection used in this study is in the form of literature studies on secondary data from sources related to this research, especially those sourced from PT. PELINDO IV as a port operator in Eastern Indonesia and other library sources. The data is also strengthened by the results of direct observations to obtain primary data at the Makassar container terminal [7].

Data Analysis Method

The analytical method used in this study is quantitative analysis method based on the obtained secondary and primary data by using Microsoft Excel application [11]. The elements that are taken into account are the GDP projection, the projection of the flow of exports and imports as in the conceptual scheme. The analysis was carried out by performing simulation calculations on the container loading and unloading service queues and comparing the acquisition value with the applicable performance standards based on the growth of the acquisition value in the last 5 years [12].

III. RESULT AND DISCUSSION

Based on the results of the analysis, the projection of the GDP of South Sulawesi shown in Table 1 has increased both in pessimistic, moderate and optimistic conditions. However, the value used is moderate value with an average increase of 12%. Based on the GRDP growth, the projection results for the export and import activities in 2020 is shown in Table 2 and Table 3 with moderate at 963,636 boxes and 471,365 boxes respectively.

Table. 1 Projection value of GRDP in South Sulawesi

Year	Projection value of GRDP (in Billions of Rupiah)		
	Pessimistic	Moderate	Optimistic
2014	192,811	196,426	200,041
2015	211,080	220,905	230,730
2016	229,349	247,738	266,127
2017	247,618	277,286	306,954
2018	265,887	309,966	354,044
2019	284,156	346,257	408,359
2020	302,425	386,715	471,006

Table. 2 The projected value of export flows

Year	Projection of export flows		
	Optimistic	Moderate	Pessimistic
2014	347,526.76	325,557.79	303,552.81
2015	408,170.72	379,146.05	350,121.38
2016	486,814.58	445,324.35	403,834.12
2017	591,055.57	528,421.30	465,787.03
2018	732,527.49	634,885.86	537,244.24
2019	929,652.22	774,658.03	619,663.83
2020	1,212,546.38	963,636.97	714,727.56

Table. 3 Projection of import flows

Year	Projection of import flows		
	Optimistic	Moderate	Pessimistic
2014	262,910	213,664	164,418
2015	303,243	244,075	184,908
2016	349,764	278,566	207,368
2017	403,422	317,762	232,101
2018	465,312	362,384	259,455

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2019	536,696	413,265	289,833
2020	619,032	471,365	323,698

Based on the projections of export and import activities at the Makassar container terminal (TPM), queuing simulation was conducted and the result is shown in Table 4 in order to determine the level of queues using container crane facilities at the TPM. Based on the results of queuing simulation it is known that until 2016 the TPM is still under operated. New queues occur in 2017 and that only happens on 1 crane.

Table. 4 Simulation results of CC facility queues for export and import activities

Parameter	2014	2015	2016	2017	2018	2019	2020
Number of arrivals (box / hour)	27	31	37	43	52	64	79
Number of facilities (7 CC)	7	7	7	7	7	7	7
Average arrival interval (minutes)	2.66	2.45	2.37	2.38	2.54	2.17	2.11
Average service time (minutes)	2.52	2.25	2.65	2.35	2.14	2.56	2.11
Average waiting time (minutes)	0.00	0.00	0.00	0.03	0.07	0.12	0.25
Total pause time (minutes)	232.31	293.92	242.14	276.77	285.66	208.85	235.53
Time in the system (merit)	48.20	53.90	46.60	46.50	55.80	56.30	47.40
Average pause time (per CC)	7.77	8.62	8.33	7.24	7.03	7.22	7.02
Number of busy servers (CC)	0	0	0	1	1	2	2

As a comparison in the calculation of performance, the calculation of CC equipment utilization up to 2020 is executed and shown in Table 5. Based on these calculations, the same results obtained with the simulation queue calculation, which tool utilization until 2016 is still at 50% and the equipment utilization exceeds 50% in 2017. This means, in 2016, container cranes were 7 at TPM can still serve the flow of exports and imports, but in 2017 the utilization of equipment has exceeded 60% or the existing container cranes cannot perform services optimally so that the addition of container cranes is necessary

Table. 5 Results of performance analysis with analytical methods (combination of exports and imports)

Year	X	Ncc	Ycc	BWT	Wd	Ucc(%)
2014	539,221.61	7	20	24	365	43.9678
2015	623,221.52	7	20	24	365	50.8171
2016	723,890.48	7	20	24	365	59.0256
2017	846,182.87	7	20	24	365	68.9973
2018	997,269.42	7	20	24	365	81.3168
2019	1,187,922.63	7	20	24	365	96.8626
2020	1,435,001.87	7	20	24	365	117.009

Based on Table 4, the result indicated the value of the waiting time is still equal to zerountil 2016, meaning there is no queue in the system. New queues occur in 2017 where the arrival rate reaches 37 boxes / hour. In that year, the number of queues only occurred on 1 server or in this case CC. However, the general trend shows that the average waiting time in the system increases with the increase in the rate of arrival of containers. In general the average time lag in the system shows a significant decrease as shown in Table 4. The rate of decline reaches around 18% for loading activities and 20% for unloading activities. But even if there is a decline, the emergence of pauses in each year indicates that the system is still under operated or there is no queue even though in 2017 there has been a queue (indicated by the waiting time), but it only occurs in 1 facility and the queue does not occur during the simulation period (1 hour) this is evidenced by the delay in the system. So it can be said that until 2016 CC facilities were still able to effectively serve the arrival rate of containers. Based on the results of the analysis, we can see that there is a tendency to increase the time needed by the system in serving the arrival rate of containers. This rate of increase reaches an average of 12% for loading activities and 16% for unloading activities. This system will continue to increase along with the increasing number of container arrivals that must be served. Besides that, the characteristic of the relationship between the average waiting time and the average interval is negative. This means that the increasing average waiting time in the system will reduce the time lag for service facilities in the system.The characteristics of the relationship between the level of arrival and the total system time are positive. This means that the increase in the arrival rate of containers will be accompanied by an increase in system time or the time needed for the system to serve all containers in one hour, with service conditions that will last for the next 7 years. As a comparison of the results of performance calculations using simulations, performance calculations are also performed using analytical methods. The analytical results show that for both export and import activities, the results show that CC equipment utilization has increased from year to year along with the increasing rate of exports in the TPM.

To prevent the occurrence of ship queues, an analytical simulation is carried out by adding 1 Container at the Makassar Container Terminal as many as 1 piece starting in 2017.

IV. CONCLUSION

Based on the results of the analysis and discussion that has been carried out, it is known that the CC facility (7 units) in Makassar container terminal is still under operated or still able to fully service the arrival of containers both loading and unloading until 2016 and improving the performance of Container Crane facilities after 2017 done by increasing the number of Container Crane facilities at the TPM. Therefore, the outcome of this study could be taken into consideration for the development of holding Makassar container ports in order to build a new container terminal to handle containers entering the Makassar port in the coming years.

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