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Study of Demand for Container Transportation and Facilities at Makassar Port, Indonesia

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***Abstract*—The increasing number of loading/unloading activities at container terminal of Soekarno-Hatta Port Makassar, Indonesia has urged the port administrator to increase the number of port moorings and deck length in 3 (three) stages until 2025. The main purpose of the present research is to find a model of demand flow for container capacity and ship traffic as well as the appropriateness of the current mooring facility and the development plan at Soekarno-Hatta port Makassar. The methods used are based on queueing theory, empirical approaches, and multiple linear regressions. Analysis results show that the average growth of ship visits to the port is 7.07% per year and flow of container loading/unloading is 6.4 % per year. Therefore, it could be concluded that the current mooring facility would be sufficient until year 2025 but it will need 1 (one) unit mooring until 2019 and 2 (two) units mooring until 2025. These predictions are consistent with the development plant made for this port.**

Keywords*—container port; mooring facility; queueing theory; berth occupancy ratio; port development

I. INTRODUCTION

In recent years, ports play an important role on the sea transportation system [1, 2] for an archipelago country such as Indonesia [3]. A port is a node between the sea transportation system and the land system in order to support [4, 5] and actuate economic developments of a region or a country [6]. It is also a place for loading/unloading (L/U) activities of trade commodities [7] and the embarkation or debarkation of passenger ships [8]. Therefore, planning the sea transportation system needs to consider and integrate many aspects, such as ship services, port infrastructures such as container yard, the potency of a region and the network of land transportation to hinterland region, etc. [6].

In supporting economic development, approximately 95% of freight transportation and services are carried out by sea transportation. In this regard, a port is a node location of origin-destination for loading/unloading of commodities and passenger before they are distributed to the port hinterland.

In the reformation era in Indonesia, decentralization of government regulation leads to the competition among local regency governments in developing multi-modal transportation infrastructures including container ports development. Furthermore, influenced by the Master Plan of Indonesia Economic Development (MP3EI) program and development plans of urban areas in South Sulawesi Province, the ports development by each local regency government are growing rapidly. Consequently, the number of ports in South Sulawesi increase significantly in recent years. However, the arrival number of ships are constrained on some particular ports that having capacity equipments for loading-unloading activities of commodities and service.

Regarding the above crucial problems, the ports development in south Sulawesi by each local regency government needs to be managed efficiently and fully integrated in the future. In order to contribute in this field, this paper attempts to propose a holistic framework on efficiency on the ports development in South Sulawesi Province, Indonesia in supporting the multi-modal transportation system. The paper is conceptual in nature. Its objective is to find a model of demand flow for container capacity and ship traffic as well as the appropriateness of the current mooring facility and the development plan at Soekarno-Hatta port Makassar.

II. TRANSPORTATION INFRASTRUCTURES

In South Sulawesi province, Indonesia, there are many ports which suppose to serve sea transportation demand in South Sulawesi region. Their locations extend from southern part to northern part of the province. Most of the ports have functions as general ports for loading-unloading activities of passengers and goods. However, some of them also are functioned as container ports, ferry ports, special ports, and traditional ports. The ports include Makassar port and Parepare port (general and container ports), Bantaeng port, Bulukumba port, Wajo port (ferry and general ports), Sinjai port (general port), Bone port (ferry port), Pangkep port (special port), Barru port (traditional port), Palopo port (general port), and Malili port (general port and special port in Soroako).

Among those ports, only 2 (two) ports, i.e. Makassar port serving for container, general cargo activities, and passenger; and Parepare port serving general cargo and passengers. In recent years, the number of ports in South Sulawesi increases due to the increasing number of ports development by each local regency government in the province.

Most freight transport and services by sea transport have been utilizing Soekarno-Hatta Port in Makassar City for their loading and unloading activities because the port has complete and sufficient equipment to be categorized as an international container port. However, because long travel distances from goods origin or destination to or from Makassar City, their travel time become longer as well. For example, Makassar-Malili 543 km, Makassar-Masamba 421 km, Makassar-Palopo 367 km, Makassar-Rantepao 328 km, Makassar-Makale 310 km, Makassar-Watampone 292 km, Makassar-Sinjai 220 km, Makassar-Enrekang 236 km, Makassar-Pinrang 183 km, Makassar-Sengkang 192 km, etc. Moreover, the capacity and physical quality of roads among the origin-destination places are still in poor condition.

Flow of container freight at Soekarno-Hatta port in the last 5 (five) years (2007 – 2012) continuously increases each year, namely: export-import have increased from 17223 Teus to 286320 Teus (3,86 %) per year and inter island increases from 286320 Teus to 506050 Teus (8.85 %) per year. This trend gives an indication that domestic shipping tends to use container. Moreover, ship traffic increases from 336 call to 1034 call or growing 7,52 % in average per year. This situation has forced the port administrator PT. PELINDO IV to develop the port as an anticipation measure for high ship traffic and container service demand. Limited facilities available at ports such as dock length (150 m), harbor depth (9,7 MLWS), port pool depth (9 MLWS), pool wide (15.2 Ha), container storage area (114,446 m^2) and other facilities have become major obstacles in anticipating high ship traffic at the port.

Port administrator has a plan to develop the port which consists of 3 stages which are:

1) In 2007 – 2015: pool dredging will be carried out with volume around 3.200.000 m^3, harbor deck will be lengthened to be 570 m (with 3 moorings) and container storage area will be expanded to be 100.000 m^2.

2) In 2015 – 2025: dredging 3.290.112 m^2 of the pool will be carried out, harbor deck will be lengthened to be 680 m (with 3 moorings) and container storage area to be 348.038 m^2.

3) In 2050: a new conventional port will be built.

Fig. 1. Current layout of Soekarno-Hatta container port

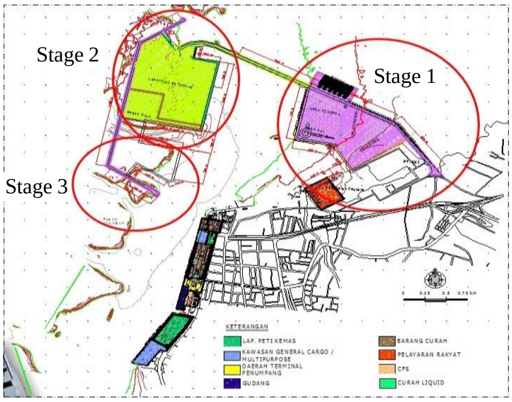


Fig. 2. Soekarno-Hatta port development plan

Current layout and development plant of Soekarno-Hatta port are shown in Figs. 1 and 2, respectively (source : PT. Pelindo IV). Dredging is necessary by considering that the flow of sedimentation from Jeneberang and Tallo rivers cannot be resolved which makes building docks and adding other facilities are not efficient and effective to be carried out at the port.

III. STUDY OBJECTIVES

The main objective of this study is to find how large the demand for container transportation and ship traffic at container terminal port of Soekarno-Hatta as well as the performance of the current available facilities and facilities need to be built in the future.

Other objectives of the study are to find a model of demand for container transport and ship traffic as well as mooring facility readiness until year 2025 at Soekarno-Hatta port Makassar, Indonesia.

IV. LITERATURE REVIEW

Based on Manurung [10], a multiple linear regression forecasting method can be used by using (1).

$$Y = A + B_1X_1 + B_2X_2 + ... + B_nX_n \quad (1)$$

where :

Y : dependent variables

A : regression constant

X_1 ... X_n : independent variables

B_1 ... B_n : regression coefficients

Moreover, according to M.Y. Jinca [10], deck utilization rate can be determined using Berth Occupancy Ratio (BOR) which is based on the most frequently anchoring ship lengths based on (2).

$$BOR = \frac{\sum_{i}^{n} \text{(ship lengths+10) x (anchor time)}}{\text{available dock length x 24 hours}} x100\% \quad (2)$$

According to Erlang in [11], BOR value can be determined using queueing theory as shown in (3).

$$L_q = \frac{P_0(\lambda/\mu)^{c+1}}{(c-1)\left(c-\frac{\lambda}{\mu}\right)} \quad (3a)$$

$$L = L_q + \frac{\lambda}{\mu} \quad (3b)$$

$$C' = L - L_q \quad (3c)$$

$$BOR = \frac{C'}{C} \, x \; 100\% \quad (3d)$$

where

C' : number of moorings used

C : number of available moorings

L_q : average number of ships in queue

Performance measurement for dock utilization refers to Directorate General of Sea Transportation Decree No. UM.002/38/18/DJM.11 which says that standard performance of a port operational service in BOR for container terminal is 70%.

V. STUDY METHODOLOGY

The research was conducted in South Sulawesi province to obtain primary data. Secondary data was obtained from Soekarno – Hatta port which includes L/U container flow data and ship traffic flow as well as sosio-economic data in 5 hinterland port areas in 2008-2013. Analysis method for forecasting ship traffic and L/U container flow was performed statistically using multiple linear regressions and queueing theory. Moreover empirical approaches are also used for mooring facilities utilization.

VI. RESULTS AND DISCUSSIONS

A. Model of Ships Flow Demand

Ship traffic flow is modeled based on the obtained sosio-economic data on hinterland areas. Dependent variable is number of ship visits (*Y*) while independent variables include population (X_1), plantation (X_2), agriculture (X_3) and regional gross domestic product (X_4) which are suspected to be influential. Iteration result obtained the following equation.

$$Y = -1353{,}90623 + (0{,}00152303\,X_2) + (0{,}00012292\,X_3) + (0{,}0106215\,X_4) \quad (4)$$

From (4), ship visits increase from 1034 (2013) unit to 2350 (2025) unit per year or have average growth 7,07 % each year. This result is illustrated in Fig. 3. This situation will also definitely influence readiness of container load and unloading and distribution to service areas (hinterland).

B. Container Flow

Based on the demand model shown in (5), total flow container loading and unloading (L/U) in year 2015 and 2025 are 669492 Tues and 1119925 Tues, respectively or growing 5,48 % in average.

$$Y(L/U) = 139510 + 0{,}02791X_3 + 0{,}01419661X_4 \quad (5)$$

Moreover, demand of domestic transport shown in (6) in year 2015 is 536281 and 593673 Tues in year 2015 or growing 2.98 % per year in average and export- import (E/I) in (7) is 29127 Tues and 40839 Tues in 2025 or growing 4,44% per year in average.

$$Y(L/U) = -1686729{,}3432 + 0{,}259499\,X_1 \quad (6)$$

$$Y\,(E/I) = -11679{,}27693 + 0{,}668871\,X_4 \quad (7)$$

Some of the compulsory facilities are dock length and number of moorings which are expected to serve arriving ships so that each ship does not need to wait for a long time at the port and/or dock. Other facilities needed are sufficient container storage, appropriate lifting equipment (cranes), modes of load transport for distribution from and to available hinterland areas, and other facilities.

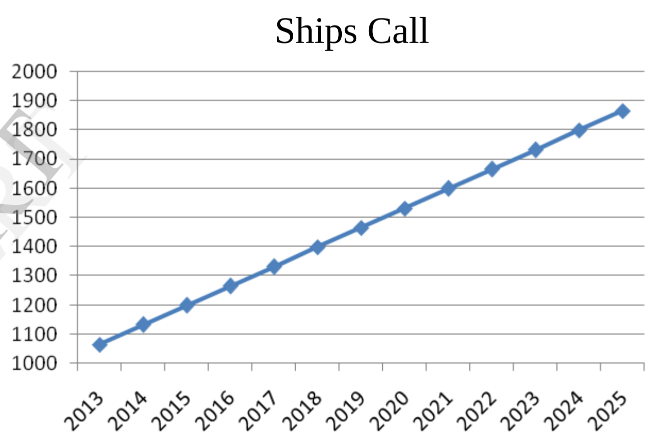


Fig. 3. Growth of container ship visits

By observing the prediction result of ship traffic L/U flow and container export and import in Fig. 4, it can be noticed that they experience a positive growth or increase each year. This will also affect the performance of facilities available at Soekarno–Hatta port Makassar as well as the distribution of the container. This is because Makassar port is the only container port in South Sulawesi Province.

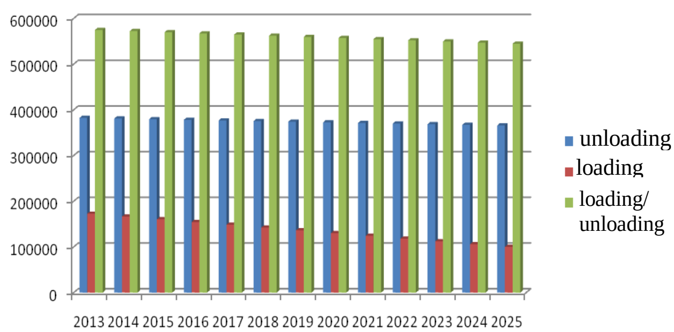
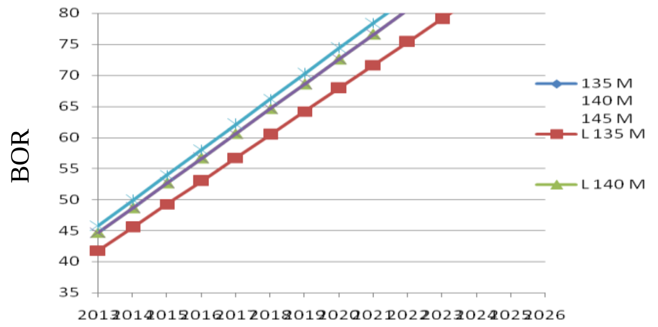


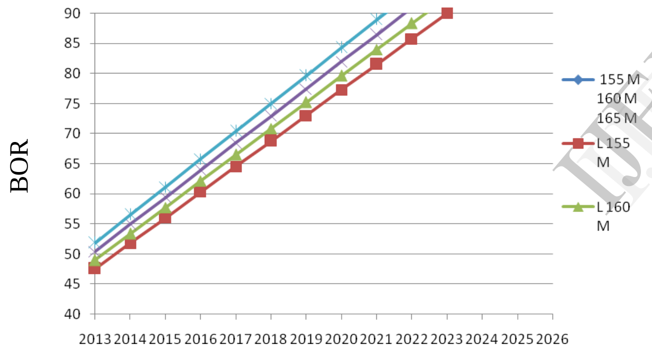
Fig. 4. Flow of container loading and unloading from 2013 to 2025

C. Evaluation of Number of Available Mooring and Development Plan

Current dock length at container terminal is 850 m, ships length (LOA) are in the range 100 to 170 m, the largest ships visit frequency is for LOA 150 m, 223 unit (22,53 %), the second largest is for LOA 90 m, 197 unit (19,05 %), the third largest is for LOA 130 m, 146 unit (14,12 %) and number of ship visits for LOA 100 m and 150 m are 739 unit (94 %). BOR value based on ships length shows that the present dock length is not optimal until 2016. In order to be optimal in year 2017 for ship length 170 m, BOR value should be 70,41 %, while for ship length 160 m in year 2018, BOR value should be 70,86 %.



(a)



(b)

Fig. 5. BOR values based on ship visits prediction until year 2025

Especially for ships that have largest frequency (LOA 150 m), BOR value is approaching optimal in year 2019 with BOR value equals to 66,17 % as shown in Fig. 5 above.

D. Number of Mooring Optimization

Distribution of ship arrivals at Soekarno-Hatta port is random and follows Poisson distribution while ship services time at dock follows pattern of negative exponential distribution or Erlang pattern distribution as shown in Figs. 6 and 7.

When using queueing theory approach and using average anchoring ships length with longest frequency which is LOA 150 m to be the main input data, analysis results (Table 1) show that in year 2019 - 2020, BOR value has reached a value greater than the prerequisite value which is from 69,54 to 73,58%, with number of mooring is 5 units. The value exceeds required value can be overcome by optimizing the existing services systems in the port, minimizing docking time at the pier, reducing L/U time, and adding L/U service facilities so that waiting time can be minimized.

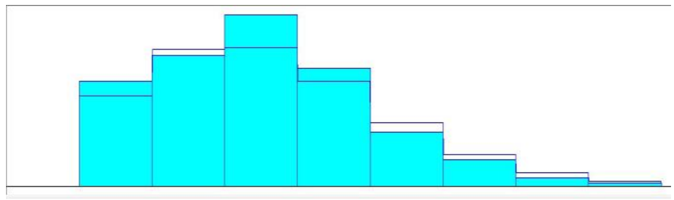


Fig. 6. Ship visits distribution (Poisson distribusion)

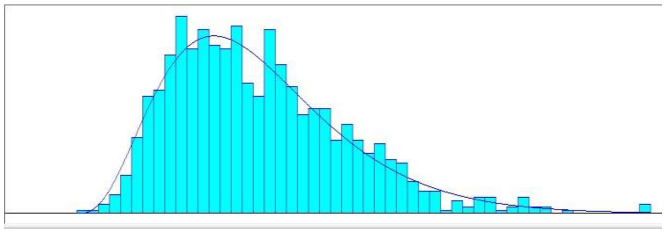


Fig. 7. Ship services distribution at port (negative exponential)

Adding the number of mooring can be carried out in year 2019 – 2011, 1 (one) unit of mooring. The addition of 1 (one) next mooring can be done in year 2022 – 2024, and in year 2025, 1 (one) unit mooring or the need until year 2025 as many as 3 (three) units berth or lengthening dock length to 495 m.

TABLE I. PERFORMANCE OF CONTAINER PORT TERMINAL BEFORE AND AFTER ADDITION OF NUMBER OF MOORINGS

Year	CALL (Unit)	λ (ships/ day)	C1	C'	BOR before (%)	C2	BOR after (%)
2012	1034	3	5	2	41,27	5	41,27
2013	1135	3	5	2	45,3	5	45,3
2014	1236	3	5	2	49,34	5	49,34
2015	1337	4	5	3	53,38	5	53,38
2016	1439	4	5	3	57,42	5	57,42
2017	1540	4	5	3	61,46	5	61,46
2018	1641	4	5	3	65,5	5	65,51
2019	1742	5	5	3	69,54	6	57,95
2020	1844	5	5	4	73,58	6	61,32
2021	1945	5	5	4	77,62	6	64,68
2022	2046	6	5	4	81,66	7	58,33
2023	2147	6	5	4	85,7	7	61,21
2024	2249	6	5	4	89,74	7	64,12
2025	2350	6	5	5	93,78	8	58,61

where C1 : available ships

C' : Unused Ships

C2 : Planned ships

According to the port master development plan based on ministerial decree No. 2 of 2004, lengthening the dock length to 570 consisting of 3 moorings in 2007 – 2015 is not yet needed because the existing dock length is still able to serve the

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incoming container ships until year 2018. Detail of analysis results are shown in columns 6 and 8 in Table 1.

VII. Discussion on Port Development Plan

Even though the port has met the required standard service shown in column 8 of Table 1, several matters are still important to be considered which include:

- Increasing the number of moorings could be carried out to anticipate the increase of ship visits and container demand flow every year. However, shallow port pool depth becomes an obstacle due to continuous transport of sediment from Tallo and Jeneberang rivers which requires quite expensive dredging cost
- If the development plan can be well executed according to the master plan, it would be an attraction for user of port services, yet the distribution of goods to the hinterland area with considerable distance will increase land transport cost. Therefore, arrival of goods to the destination becomes slow which make the value of those goods to be expensive, so it becomes not effective and efficient.
- The increase of container transport frequencies to the hinterland area results in traffic jam and acceleration of physical damage of road infrastructures from and to hinterland area.
- Another impact to be considered is the readiness of land transportation mode, readiness of container storage and the impact of in/out traffic to the port.

VIII. FUTURE STUDIES

In order to anticipate the likely impact stated previously the following studies are needed:

1) Establishing a hierarchy and defining the functions of each existing ports such as for ferry port, general cargo port, and container port.

2) Making function configurations of each exiting ports by dividing them into several main clusters and several sub clusters. These sub clusters should support the main clusters.

3) East coast of South Sulawesi (Bone Bay) is near to ALKI III shipping lane and Soekarno–Hatta Makassar port which is also in ALKI II. This allows an alternative container port to be built outside Makassar City so that container transport distance can be shortened to be more effective and efficient.

4) Reducing distribution by land with pusher barge system to several existing ports in Bone bay and Makassar Strait. This system can anchor at ports with small depth of pool and can be operated with rivers flow. The size and capacity of the barges can be customized according to the need or demand at specific purpose. Moreover, it can be dropped unit by unit as shown in Fig. 8 below.

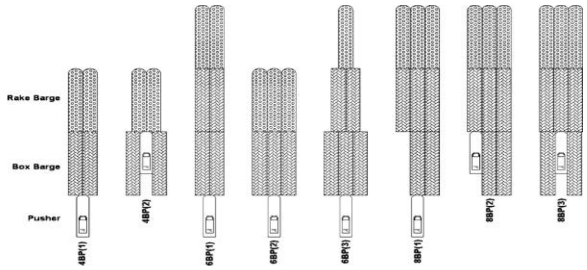

Fig. 8. Container transport with push barge system (Koh King Koh, Hironori Yasukawa, Noritaka, Hirata 2008)

IX. CONCLUSION AND RECOMMENDATION

The demand flow of ships visits until year 2025 shows an increase trend with an average growth of 7,07% and total container transport flow increases at an average of 6,42%. Facilities utilization performance (BOR) until year 2018 shows that increasing number of moorings is not yet required. Increasing the number of moorings can be carried out in year 2019 from 5 to 8 moorings, which is consistent with the second stage of development plan in 2015-2025.

Moreover, it is necessary to conduct a study to function a port in south Sulawesi to be an alternative container port other than Soekarno-Hatta port in order to make goods distribution to be more effective and efficient by making a configuration with several main and sub clusters.

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