Optimizing the Number of Internal Trucks Based on Berth Allocation and Quay Crane Assignment at a Container Terminal

Muchammad Alfan Lutfianto*, Nurhadi Siswanto, Ahmed Raecky Baihaqy
Program Department of Industrial and Systems Engineering, Faculty of Industrial and Systems Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

*Email: muchammadalfan86@gmail.com

DOI: https://doi.org/10.31284/j.jtm.2026.v7i1.8048
Received July 23th 2025; Received in revised December 30th 2025; Accepted January 6th 2026; Available online January 30th 2026
Copyright: ©2026 Muchammad Alfan Lutfianto, Nurhadi Siswanto, Ahmed Raecky Baihaqy
License URL: https://creativecommons.org/licenses/by-sa/4.0

Abstract

The increase in international trade and production automation has led to a global container traffic surge at ports, including Terminal Peti Kemas X, one of Surabaya's main domestic terminals. This situation requires more effective and efficient management of handling equipment, particularly internal trucks that link the dock and the stacking yard, to avoid congestion and operational delays. However, the loading and unloading performance and vessel service at this terminal are not optimal due to fluctuating container flows and suboptimal equipment allocation, particularly for quay cranes (QC) and internal trucks (IT). This study aims to optimize the number of internal trucks based on quay allocation and quay crane assignment tailored to the volume of containers being loaded and unloaded, using discrete event simulation as the primary approach. Performance is measured using two leading indicators: box/crane/hours (BCH) and vessel turnaround time (TRT). Under existing conditions, the BCH and TRT values are 23.43 boxes and 15.24 hours, respectively. Several improvement scenarios were developed by varying the number or ratio of quay crane and internal truck assignments, without adding new equipment. The scenario analysis found that the best scenario has a container volume configuration of <150 boxes with 2 QC and 7 IT assignments, while a container volume of >150 boxes has 2 QC and 11 IT assignments. This configuration can increase BCH to 25.33 boxes and reduce TRT to 11.82 hours. These findings indicate that this approach is practical in significantly improving system performance.

Keywords: *Berth Allocation, Container Terminals, DES, Internal Trucks, Quay Crane Assignment*

1. Introduction

Global trade and production automation growth have significantly increased port activities worldwide in recent years. This is evidenced by the global container volume handled, which has tripled from 224 million TEUs in 2019 to approximately 840 million TEUs in 2021 [1]. This situation demands that ports possess integrated infrastructure and sufficient handling capacity to accommodate large container vessels that now dominate the global shipping fleet.

Terminal effectiveness highly depends on sound operational management, particularly in handling equipment such as quay cranes (QC), yard cranes (YC), and internal trucks (IT). IT is a connector between the berth and the container yard and plays a crucial role in transportation. Imbalances in the number of this equipment or the assignment ratio can lead to delays and congestion within the terminal system, ultimately reducing operational performance [2].

The performance of loading and unloading operations and vessel service at container terminals is generally measured using two key indicators, box/crane/hour (BCH) and turnaround time (TRT). BCH reflects the productivity of a crane in handling containers per hour of crane operation. At the same time, TRT indicates the total duration a vessel spends in the port from berthing to the completion of service [3]. These two indicators are essential for evaluating container terminals' efficiency and effectiveness in supporting the logistics system's smooth operation.

Container terminal X is part of the national logistics system serving domestic container flows in Surabaya, which have relatively high traffic intensity. The terminal has key handling equipment such as quay (QC), rubber-tyred gantry cranes (yard cranes), and internal trucks. The target BCH set by the container terminal is 25 boxes per hour. However, in several months of 2024, this target was not optimally achieved due to fluctuations in container flow and imbalances in the assignment of container handling equipment. This condition also affected vessel service, particularly the time required for vessel completion (TRT).

Several previous studies have addressed container terminal operations; however, most of them have focused on a single aspect only, such as berth allocation [4], [5], [6], [7] or quay crane assignment [8], [9], [10], [11]. The synchronization among operational areas (quay area, transfer area, and yard area) and the coordination of handling equipment (QC, IT, and YC) are crucial in achieving overall performance.

For this level of complexity, a discrete event simulation-based approach is considered appropriate due to its capability to model complex systems arising from variability and interdependencies within the system [12]. This approach contrasts with pure optimization methods, which often require model simplification, potentially omitting essential aspects of the system [13].

Based on this, the present study aims to develop a simulation model that can be a decision-support tool for determining the optimal number of internal truck assignments. The model considers berth allocation strategies and quay crane assignments based on the volume of containers carried by vessels and the terminal's operational conditions. The developed model is used to evaluate and improve the performance of loading and unloading operations and vessel services, measured by box/crane/hour (BCH) and vessel turnaround time (TRT).

2. Methods

System identification aims to understand the actual conditions and operational issues and define its constituent components: elements, variables, and system performance [12]. Table 1 presents the details of system identification.

Table 1. Information collection in system identification

Component	Subcomponent	Item
Element System	Entity	Vessels and containers
	Resources	Berth, quay cranes, internal trucks, yard cranes, and container yard
	Aktivity	Berth selection, quay crane assignment, container unloading process, container transfer from berth to yard, container loading process, container transfer from yard to berth, delivery and receiving processes
	Control	Vessel-to-berth assignment, equipment assignment and allocation, container yard capacity limit
Variable System	Decision	Number of berths, number (or ratio) of assigned quay cranes, and internal trucks
	Response	Box/crane/hours, turn around time kapal
	Status	Berth status (vacant/occupied), quay crane status (discharging/loading/idle), number of containers unloaded, number of containers loaded, and yard capacity.
Performance System	-	Productivity: Box/crane/hours, Service: Vessel turnaround time

Data Collection and Processing

Data serve as a crucial element in providing input for simulation model development, as their quality and completeness directly affect the accuracy of the results. Data are classified into three categories: structural, operational, and numerical [12], and are obtained from both primary sources (direct observation) and secondary sources (company records). Table 2 summarizes the data types, sources, and collection methods.

After the data are collected, processing is carried out through distribution fitting to match the data with empirical and theoretical distributions. This process is followed by further analysis to determine the probability of events, which serves as input for the simulation model. The fitted data include vessel interarrival times, the number of containers to be unloaded and loaded, quay crane handling time, internal truck transport time, yard crane handling time, and delivery and receiving interarrival times.

Table 2. Collected data and acquisition methods

Data Type	Data	Acquisition Method	Source
Structural	Container terminal layout	Secondary data	Company records
	Yard capacity	Secondary data	Company records
	Types of resources used	Primary data	Observation
	Number of available resources	Primary data	Observation
	Types of container handling activities	Primary data	Observation
Operational	Container terminal operating hours	Secondary data	Company records
	Assignment ratio and resource allocation	Secondary data	Company records
	Container handling process flow	Primary data	Observation
Numerical	Vessel interarrival time	Secondary data	Company records
	Number of containers to be unloaded	Secondary data	Company records
	Number of containers to be loaded	Secondary data	Company records
	Quay crane (QC) handling time	Primary data	Observation
	Internal truck (IT) transport time	Primary data	Observation
	Yard crane (YC) handling time	Primary data	Observation
	Delivery interarrival time	Secondary data	Company records
	Receiving the interarrival time	Secondary data	Company records

Model Development

The next stage is model development. This process begins with constructing a conceptual model, the foundation for building the simulation model. The simulation model is then divided into five separate submodels.

Submodel 1: Berth Allocation

The first submodel illustrates berth allocation based on vessel arrivals. Each vessel is assigned to one of the two available berths; if both are occupied, the ship must wait in a queue. The vessel entity is assigned an interarrival time attribute, while the container entity carries attributes for the number of containers to be unloaded and loaded. Figure 1 presents the logic of Submodel 1.

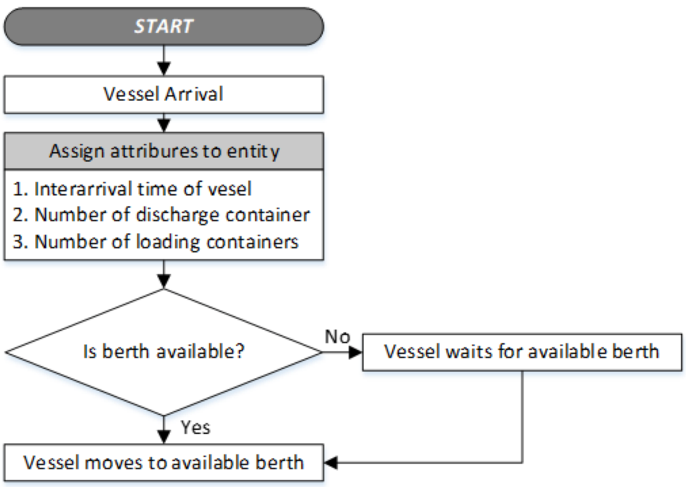

Figure 1. Flow diagram of submodel 1

Submodel 2: Quay Crane Assignment and Loading/Unloading Operation

Submodel 2 models quay cranes (QCs) assignment in the container loading and unloading. Containers are unloaded from the vessel to internal trucks and loaded from internal trucks onto the ship using quay cranes. The number of assigned QCs is adjusted based on the container volume, with 1 QC allocated for fewer than 150 containers and 2 QCs for more than 150 containers. This submodel also records statistics on the number of entities served and the time each entity spends in the system to calculate box/crane/hour (BCH) and vessel turnaround time (TRT) after the completion of container handling. Figure 2 presents the flow diagram of Submodel 2 logic.

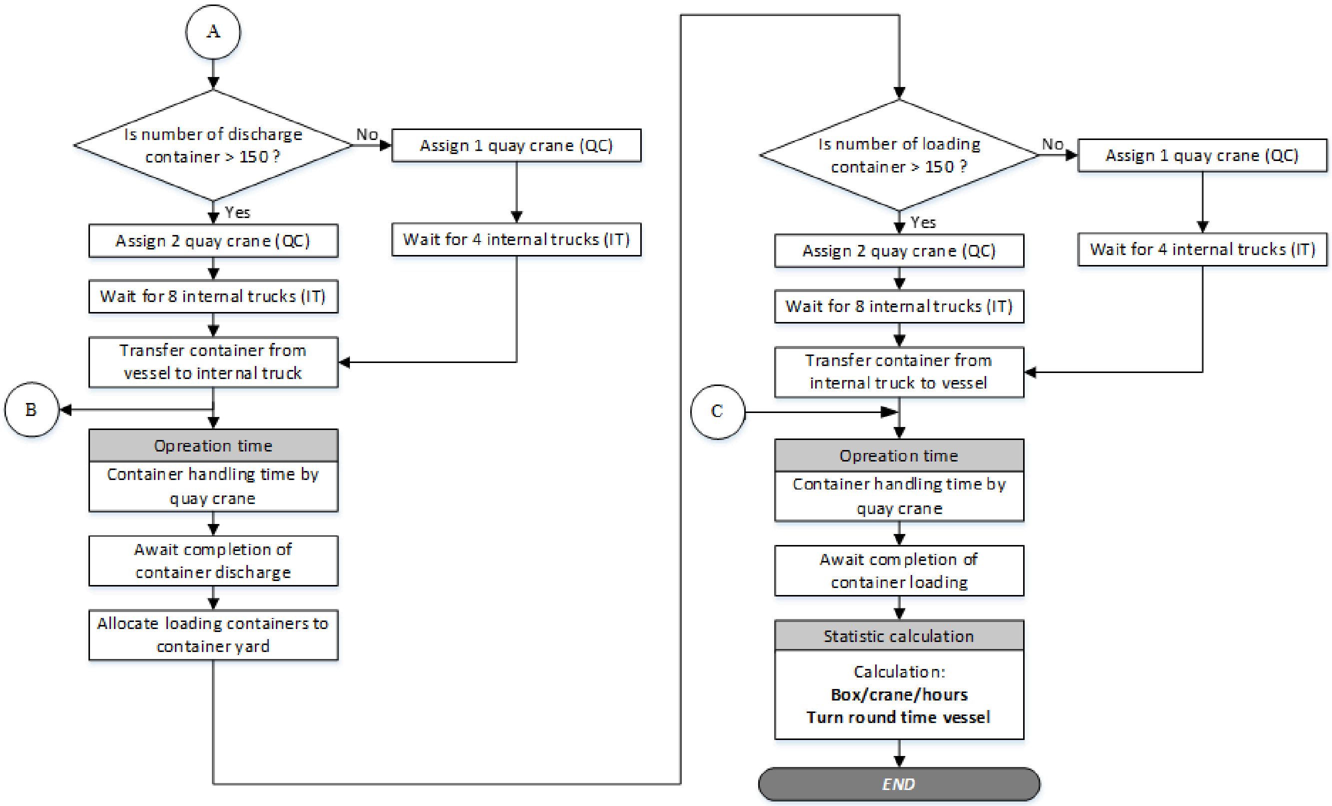

Figure 2. Flow diagram of submodel 2

Submodel 3: Container Haulage

The next developed submodel is Submodel 3, which models the container transportation process by assigning internal trucks (ITs) for unloading and loading containers. It transports unloading containers from the berth to the yard, and loading containers from the yard to the berth. The number of ITs assigned is based on the number of operating quay cranes (QCs), namely 4 ITs for 1 QC and 8 ITs for 2 QCs. The input for IT transport time is used to represent the operation duration. The transportation is carried out sequentially, from unloading containers to loading containers. Figure 3 illustrates the assignment of internal trucks in container haulage operations.

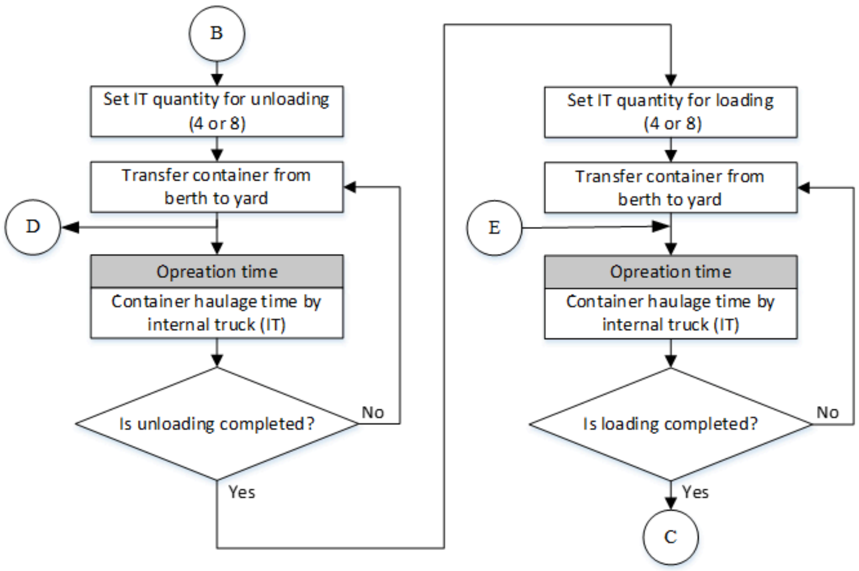

Figure 3. Flow diagram of submodel 3

Submodel 4: Container Stacking in the Yard

Submodel 4 is developed to represent the container stacking process in each available yard block using yard cranes (YCs). This process includes transferring import containers from internal trucks to yard blocks and export containers from yard blocks to internal trucks. Additionally, this submodel is linked to the delivery and receiving processes, which involve the transfer of containers between yard blocks and customer vehicles (external lorries). The yard crane's container handling activity is associated with input data representing its operational handling time. Figure 4 presents the flow diagram of Submodel 4.

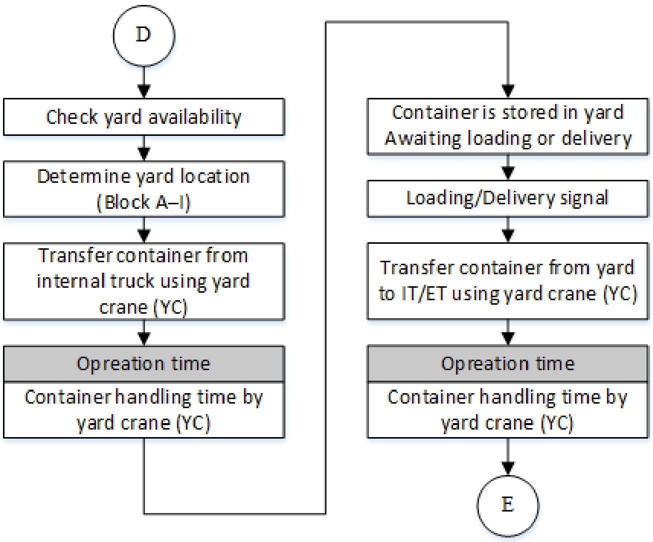

Figure 4. Flow diagram of submodel 4

Submodel 1: Delivery and Receiving External Trucks

The final submodel developed is Submodel 5, which describes container delivery and receiving processes at the yard using external trucks. The delivery process involves customers picking up containers to be transported out of the terminal. In contrast, the receiving process involves customers handing over containers temporarily stored at the yard until the next handling stage. Each entity entering the system is assigned an interarrival time attribute for the delivery and receiving processes. Figure 5 presents the logic of Submodel 5.

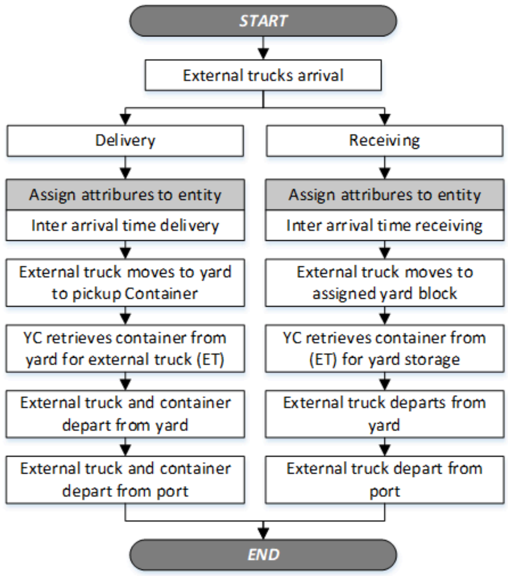

Figure 5. Flow diagram of submodel 5

Replication, Verification, and Validation

The model must be executed multiple times in simulation because it involves random variables in both input and output (random input–random output/RIRO). This process, known as replication, aims to ensure that the simulation results can more accurately represent the real system conditions. In this study, the number of replications was determined based on the values of the half-width (hw) and the expected half-width (hw') [14]. Replications are considered sufficient when the condition hw < hw' is met. In this study, after conducting 10 replications, this condition was satisfied. Therefore, ten replications were deemed sufficient to represent the actual system behavior reliably.

The next stage is verification, ensuring the developed simulation model functions as intended [12]. This study conducted two types of verification: syntactic error verification and semantic error verification. In general, verification aims to ensure that the simulation model is free from errors.

The final stage in simulation model development is validation, which aims to ensure that the developed model can accurately represent the real system [15]. In this study, validation was conducted by comparing the simulation results with actual data using the t-test statistical method. Three parameters were used for comparison: box/crane/hour (BCH), vessel turnaround time (TRT), and the number of ships served. The test results showed no statistically significant differences between the simulation model outputs and system data. Therefore, the model is considered valid and suitable to represent the real system.

3. Results and Discussion

Existing Condition

The simulation model was run over 90 days (3 months) with 10 replications to obtain results that could be objectively compared with the actual system conditions. Table 3 presents the simulation results related to the performance indicators, namely BCH and vessel TRT. The table displays the performance indicator values for each replication and the mean and standard deviation as statistical representations of the simulation results.

Table 3. Simulation model result

Replikasi	BCH (*box*/jam)	TRT (Jam)
1	23.42	14.31
2	23.44	14.38
3	23.42	14.86
4	23.45	14.77

5	23.44	14.57
6	23.42	16.47
7	23.43	17.03
8	23.42	15.33
9	23.44	14.30
10	23.40	16.31
Mean	**23.43**	**15.24**
St. Dev	**0.014**	**1.010**

Based on the simulation results, the existing condition shows an average BCH of 23.43 boxes/hour with a standard deviation of 0.014, while the TRT reaches 15.24 hours with a standard deviation of 1.010. It can also be observed that the BCH performance in each replication is still suboptimal compared to the terminal's expected target of 25 boxes/hour. This shortfall also contributes to the higher TRT value. These two indicators will compare whether the proposed improvement scenarios perform better or worse than the existing condition.

Experimentation

This experimentation stage was carried out by developing improvement scenarios. In constructing these scenarios, the number of container handling equipment owned by the terminal is maintained, with no additional units introduced. The improvement scenarios focus on adjusting the ratio or number of equipment assignments previously applied in the system, considering the volume of containers to unload or load. In the exact condition, the container terminal is equipped with two berths, four quay cranes (2 units per berth), 24 internal trucks, and 9-yard cranes distributed across the yard blocks. Table 4 provides details on the equipment assignment ratios under the existing condition.

Table 4. Equipment assignment ratios in the actual system

Number of Containers (Unload/Load)	Number of Assigned Quay Cranes (QCs)	Number of Assigned Internal Trucks (ITs)
Containers < 150	1	4
Containers > 150	2	8

The improvement scenarios were developed based on the equipment assignment ratios in the system by adjusting the number of quay cranes and internal trucks according to the volume of containers being loaded and unloaded. Adjustments were made to the maximum available equipment capacity for the loading and unloading process at the berth and the container transfer process between the berth and the yard. Conversely, Table 5 presents the scenario configurations developed based on the equipment assignment ratios in the actual system. After running the simulation model using the developed improvement scenarios, the output results of these scenarios were generated and are presented in Table 6.

Table 5. List of developed scenarios

Scenario	Number of Containers (Unload/Load)	Number of QCs	Number of ITs	Scenario	Number of Containers (Unload/Load)	Number of QCs	Number of ITs
1	Containers <150	1	5	9	Containers <150	1	9
	Containers >150	2	9		Containers >150	2	12
2	Containers <150	2	5	10	Containers <150	2	9
	Containers >150	2	9		Containers >150	2	12
3	Containers <150	1	6	11	Containers <150	1	10
	Containers >150	2	10		Containers >150	2	12
4	Containers <150	2	6	12	Containers <150	2	10
	Containers >150	2	10		Containers >150	2	12
5	Containers <150	1	7	13	Containers <150	1	11
	Containers >150	2	11		Containers >150	2	12
6	Containers <150	2	7	14	Containers <150	2	11
	Containers >150	2	11		Containers >150	2	12
7	Containers <150	1	8	15	Containers <150	1	12

	Containers >150	2	12		Containers >150	2	12
8	Containers <150	2	8	16	Containers <150	2	12
	Containers >150	2	12		Containers >150	2	12

Table 6. Result of Improvement Scenarios

Scenario	BCH		TRT		Scenario	BCH		TRT	
	Mean	**St. Dev**	**Mean**	**St. Dev**		**Mean**	**St. Dev**	**Mean**	**St. Dev**
1	23.41	0.027	15.58	1.383	9	24.12	0.696	13.97	0.972
2	23.42	0.017	15.79	1.383	10	24.62	0.425	12.03	0.831
3	23.51	0.060	15.52	1.485	11	23.62	0.110	14.43	0.922
4	23.55	0.081	13.88	1.228	12	23.64	0.106	14.72	1.168
5	24.14	0.651	14.04	0.596	13	23.42	0.019	15.21	1.779
6	25.33	0.738	11.82	0.971	14	24.61	0.426	14.82	1.187
7	24.12	0.659	13.91	1.111	15	24.72	0.479	14.39	1.059
8	25.35	0.371	11.45	1.062	16	25.09	0.707	13.37	0.933

It is important to emphasize that a scenario is considered to demonstrate improved performance if it results in a higher BCH value and a lower vessel turnaround time (TRT) compared to the existing condition. Visually, Table 6 shows that nearly all of the developed scenarios yield better results than the existing condition. However, a one-way ANOVA analysis was applied to both performance indicators to confirm whether these differences are statistically significant. The results of the one-way ANOVA analysis for BCH and vessel TRT are presented in Figures 6a and 6b, respectively.

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	16	79,18	4,9485	26,69	0,000
Error	153	28,37	0,1854		
Total	169	107,55			

(a) BCH Value

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	16	278,3	17,395	11,76	0,000
Error	153	226,3	1,479		
Total	169	504,6			

(b) TRT Value

Figure 6. One-way ANOVA results

A one-way ANOVA test was conducted with a significance level (α) of 5%. Based on Figure 6, both p-values fall below this threshold, indicating that at least one population group among the existing condition and the improvement scenarios differs significantly. Therefore, the next stage involves selecting the optimal improvement scenario. This step aims to identify alternative scenarios that have the potential to enhance system performance. The selection is made by identifying scenarios that demonstrate superior performance compared to the existing and other scenarios. To support this process, Fisher's Least Significant Difference (LSD) approach is applied, using the same 5% significance level as the previous one-way ANOVA test.

Grouping Information Using the Fisher LSD Method and 95% Confidence

Factor	N	Mean	Grouping
Skenario 8	10	25,352	A
Skenario 6	10	25,334	A
Skenario 16	10	25,087	A B
Skenario 15	10	24,723	B C
Skenario 10	10	24,615	C
Skenario 14	10	24,614	C
Skenario 5	10	24,136	D
Skenario 7	10	24,125	D
Skenario 9	10	24,124	D
Skenario 12	10	23,6407	E
Skenario 11	10	23,6182	E
Skenario 4	10	23,5530	E
Skenario 3	10	23,5137	E
0 (Eksisting)	10	23,4280	E
Skenario 2	10	23,4210	E
Skenario 13	10	23,4164	E
Skenario 1	10	23,4105	E

Means that do not share a letter are significantly different.

(a) BCH Value

Grouping Information Using the Fisher LSD Method and 95% Confidence

Factor	N	Mean	Grouping
Skenario 2	10	15,786	A
Skenario 1	10	15,580	A
Skenario 3	10	15,515	A
0 (Eksisting)	10	15,236	A B
Skenario 13	10	15,209	A B
Skenario 14	10	14,824	A B C
Skenario 12	10	14,719	A B C
Skenario 11	10	14,434	B C D
Skenario 15	10	14,387	B C D
Skenario 5	10	14,036	C D
Skenario 9	10	13,965	C D
Skenario 7	10	13,909	C D
Skenario 4	10	13,882	C D
Skenario 16	10	13,366	D
Skenario 10	10	12,027	E
Skenario 6	10	11,817	E
Skenario 8	10	11,449	E

Means that do not share a letter are significantly different.

(b) TRT Value

Figure 7. Results of Fisher's LSD test

Based on Figure 7a, it can be observed that the BCH performance of Scenarios 8, 6, and 16 does not show statistically significant differences, and all three demonstrate better performance compared to the existing condition and other scenarios. Meanwhile, Figure 7b indicates that, in terms of TRT, Scenarios 8, 6, and 10 also do not exhibit statistically significant differences, and all three outperform both the existing condition and the other scenarios. From these results, Scenarios 8 and 6 consistently demonstrate superior performance in both BCH and TRT. Therefore, the next step is determining which scenario to select between Scenario 8 and Scenario 6.

The best scenario between Scenario 8 and Scenario 6 can be determined based on cost efficiency. Referring to Table 5, Scenario 8 employs a higher equipment assignment ratio than Scenario 6. However, the analysis results indicate that the adjustment in equipment assignment ratios between Scenario 8 and Scenario 6 does not lead to a significant difference in performance. Therefore, Scenario 6 is selected as the most suitable alternative, as it provides comparable performance to Scenario 8 but with lower operational costs, making it a more efficient and rational option for implementation.

4. Conclusion

Container terminal operations are sensitive to fluctuations in the volume of containers handled. This aspect can disrupt terminal performance regarding loading and unloading operations and vessel service, which are measured using BCH and TRT indicators. Therefore, synchronization between handling equipment across operational areas is crucial, particularly through adjusting assignment ratios. This is especially important for transfer equipment such as internal trucks, which transport containers between the berth and the yard, and vice versa. This study employs Discrete Event Simulation (DES) to support decision-making in determining the optimal number of internal trucks based on berth allocation and quay crane assignment.

Based on the simulation model's results, the average BCH and TRT values were 23.43 containers/hour and 15.24 hours, respectively. These results indicate that the performance under the existing condition is not yet optimal when compared to the established standards, and there is a correlation between the low BCH and the high TRT values. These two indicators will be the basis for comparing whether the developed improvement scenarios demonstrate better or worse performance than the existing condition.

The experimentation was conducted to identify the best improvement scenario by considering operational cost efficiency. Based on the results, Scenario 6 was selected as the most recommended scenario, with an equipment assignment ratio configured according to the volume of containers handled: for volumes less than 150 containers, two quay cranes (QCs) and seven internal trucks (ITs) are assigned, while for volumes greater than 150 containers, 2 QCs and 11 ITs are assigned. The selected optimal scenario successfully improves loading and unloading performance and vessel service by increasing the BCH to 25.33 containers/hour and reducing the TRT to 11.82 hours.

References

[1] The World Bank, "Container port traffic (TEU: 20-foot equivalent units)," 2021. https://data.worldbank.org/indicator/IS.SHP.GOOD.TU. (accessed Sep. 28, 2024).

[2] H. J. Carlo, I. F. A. Vis, and K. J. Roodbergen, “Transport operations in container terminals: Literature overview, trends, research directions and classification scheme,” *Eur. J. Oper. Res.*, vol. 236, no. 1, pp. 1–13, 2014, doi: 10.1016/j.ejor.2013.11.023.

[3] K. Bichou and R. Gray, “A logistics and supply chain management approach to port performance measurement,” *Marit. Policy Manag.*, vol. 31, no. 1, pp. 47–67, 2004, doi: 10.1080/0308883032000174454.

[4] A. Budipriyanto, B. Wirjodirdjo, I. N. Pujawan, and S. Gurning, “A Simulation Study of Collaborative Approach to Berth Allocation Problem under Uncertainty,” *Asian J. Shipp. Logist.*, vol. 33, no. 3, pp. 127–139, 2017, doi: 10.1016/j.ajsl.2017.09.003.

[5] S. Mnasri and M. Alrashidi, “A comprehensive modeling of the discrete and dynamic problem

of berth allocation in maritime terminals," *Electron.*, vol. 10, no. 21, 2021, doi: 10.3390/electronics10212684.

[6] S. C. Chang, M. H. Lin, and J. F. Tsai, "An Optimization Approach to Berth Allocation Problems," *Mathematics*, vol. 12, no. 5, pp. 1–15, 2024, doi: 10.3390/math12050753.

[7] A. M. Aljuaid, M. Koubâa, M. H. Ammar, K. Kammoun, and W. Hachicha, "Mathematical Programming Formulations for the Berth Allocation Problems in Container Seaport Terminals," *Logistics*, vol. 8, no. 2, pp. 1–17, 2024, doi: 10.3390/logistics8020050.

[8] G. Alsoufi, X. Yang, and A. Salhi, "Combined quay crane assignment and scheduling with crane inter-vessel movement and non-interference constraints," *J. Oper. Res. Soc.*, vol. 69, no. 3, pp. 372–383, 2018, doi: 10.1057/s41274-017-0226-3.

[9] S. Zhang, "Optimisation for quay crane scheduling problem under uncertainty using PSO and OCBA Hongtao Hu Xiazhong Chen," vol. 11, pp. 196–215, 2019.

[10] K. Chargui, T. Zouadi, A. El Fallahi, and M. Reghioui, "A quay crane productivity predictive model for building accurate quay crane schedules," *Supply Chain Forum An Int. J.*, vol. 00, no. 00, pp. 1–21, 2020, doi: 10.1080/16258312.2020.1831889.

[11] N. Kenan, A. Jebali, and A. Diabat, "The integrated quay crane assignment and scheduling problems with carbon emissions considerations," *Comput. Ind. Eng.*, vol. 165, no. September 2021, p. 107734, 2022, doi: 10.1016/j.cie.2021.107734.

[12] C. Harrell, B. K. GHOSH, and R. BOWDEN, *Simulation Using ProModel, 2nd Edition*. California: California: MC. Graw Hill, 2004.

[13] G. C. Pflug, *Optimization Of Stochastic Models The Interface Between Simulation and The Kluwer International Series In Engineering And Computer Science*. London: Kluwer Academic Publishers, 1999.

[14] N. Siswanto, E. Latiffianti, and S. E. Wiranto, *Simulasi Sistem Diskrit Implementasi dengan Software Arena*. ITS Tekno Sains, 2017.

[15] R. G. Sargent, "Verification and validation of simulation models," *J. Simul.*, vol. 7, no. 1, pp. 12–24, 2013, doi: 10.1057/jos.2012.20.

How to cite this article:

Lutfianto MA, Siswanto N, Baihaqy AR. Optimizing the Number of Internal Trucks Based on Berth Allocation and Quay Crane Assignment at a Container Terminal. *Jurnal Teknologi dan Manajemen.* 2026 January; 7(1): 1-10. DOI: 10.31284/j.jtm.2026.v7i1.8048