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Evaluation of Container Yard Locations Using Discrete Simulation Method

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ABSTRACT

The loading and unloading process are activity of unloading goods from ships with cranes and then being brought and arranged in temporary warehouses. PT Prima Termina Petikemas is a subsidiary of Pelindo which is engaged in shipping container loading and unloading services. For customer satisfaction, one of the indicators of the company is the truck round time (TRT) which is 33 minutes. Currently, the external truck round time (TRT) for delivery is 43.62 minutes with waiting time by 16.32 minutes and truck round time (TRT) receiving is 37.72 minutes with waiting time by 9.75 minutes. The discrete event simulation method aims to evaluate the determination of effective alternative container yard locations to anticipate truck round time (TRT). For all improvement scenarios carried out, the selected scenario for delivery using 4 blocks and 6 units of Automated Rubber Gantry Tyred (1 unit reach stacker) and the percentage of each block load is 20%. This can reduce the truck round time (TRT) 27.37 minutes with the waiting time is to 8.93 minutes. For receiving activity using 5 blocks and 6 units of Automated Rubber Gantry Tyred (ARTG) and the percentage of each block load is 20%. The waiting time become 9.92 minutes and this reduces the truck round time (TRT) by 33.67 minutes.

Keyword: Container Yard, Discreate Event Simulation, Truck Round Time, Waiting Time

ABSTRAK

Proses bongkar muat merupakan kegiatan membongkar barang dari kapal dengan menggunakan *crane* untuk selanjutnya dibawa dan ditata di gudang sementara. PT Prima Termina Petikemas merupakan anak perusahaan Pelindo yang bergerak di bidang jasa bongkar muat petikemas. Untuk kepuasan pelanggan, salah satu indikator perusahaan adalah *truck round time* (TRT) yaitu 33 menit. Saat ini *truck round time* (TRT) truk eksternal untuk kegiatan *delivery* adalah 43,62 menit dengan waktu tunggu 16,32 menit dan *truck round time* (TRT) untuk *receiving*-adalah 37,72 menit dengan waktu tunggu 9,75 menit. Metode simulasi kejadian diskrit bertujuan untuk mengevaluasi pentuan alternatif lokasi penumpukan yang efektif untuk mengantisipasi *truck round time* (TRT). Dari seluruh skenario perbaikan yang dilakukan, scenario *delivery- unloading* menggunakan 4 blok dan 6 unit *Automated Rubber Gantry Tyred* (1 unit *Reach Stacker*) dan persentase muatan tiap blok sebesar 20%. Hal ini mampu mengurangi *truck round time* (TRT) menjadi 27,37 menit 8,93 menit dengan waktu tunggu 8,93 menit. Untuk *receiving- loading* yang dipilih dengan jumlah 5 blok dan 6 unit *Automated Rubber Gantry Tyred* (ARTG) serta persentase beban masing-masing blok sebesar 20%. Waktu tunggu menjadi 9,92 menit dan mengurangi waktu *truck round time* (TRT) menjadi 33,67 menit.

Kata Kunci: Lokasi Penumpukan, Simulasi Diskrit Even, Truck Round Time (TRT), Waktu Tunggu

1. Introduction

Trade activities using sea transportation media are a promising alternative to advances in the field of information technology. Loading and unloading activities are the activities of unloading imported goods and / or inter-island / interinsurer goods from the ship using a crane then from the dock inserted and organized into the nearest warehouse [1]. With the rise in container traffic every year, competition between container terminals is increasing rapidly. The speed of large container ships continues to increase and demands the operational efficiency of container terminals [2]. With the high increase in container trade, trucking companies face a very high demand to transport containers to and from the port. The number of trucking companies bringing trucks to the terminal at the same time will cause a large number of trucks to arrive at the terminal, resulting in high levels of congestion at the terminal gates [3].

PT Prima Terminal Petikemas itself has four main activities, namely loading, discharging, receiving and delivery. The receiving process is the terminal activity of receiving a number of containers from the depot to be stored in the export container yard until the container is transported to a ship. While the delivery process itself is the process of receiving containers from the ship's side where the containers will be unloaded and temporarily stored in the import container yard to be picked up by an external truck.

Currently, queues are still found before entering the container yard with the average external waiting time of trucks (ET) delivery and receiving being 16.32 minutes and 9.75 minutes with the company standard being a maximum of 7 minutes. Queuing involves the arrival of service requests, the creation of a waiting list of these requests, a disciplined system for selecting which request in the queue will be served next, and the actual service process [4], [5], [6].

The benchmark for the smoothness of delivery and receiving activities is the length of time required by external trucks to pick up their containers, which is calculated from the time the truck enters and is served by the gate in officer until the truck is served at the gate out or called Truck round time (TRT). The ideal TRT set by the company is 33 minutes, but in reality, the TRT for receiving and delivery activities are 37.72 minutes and 43.62 minutes.

To improve the handling efficiency of container terminals, optimizing storage space is still a challenge for container terminal managers. A large number of freight companies bringing trucks to the terminal at the same time will cause a large number of trucks to arrive at the terminal, resulting in high levels of congestion at the terminal gates [3]. A mathematical model is proposed to optimize the total delay to the estimated end time of all task groups without uncertainty and additional losses with a GA-based framework combined with a three-stage algorithm [7], [8].

The high truck round time at the PT Prima Terminal Petikemas terminal itself is due to various factors. One of them is caused by the allocation of the container yard which is not yet optimal for loading and unloading activities based on available facilities. The allocation of container terminal export container yard storage determines the efficiency of container loading [9]. Allocating the right amount of yard truck to quay crane to ensure better productivity levels in the berth and yard subsystems [10]. Determining container yard utilization focused on determining the optimal number of dock gates according to the Yard Occupancy Ratio (YOR) performance in the loading and unloading process provides the best solution [11].

Container yard or placement strategy is an operational level strategy where the main function of the container placement strategy is the efficient use of the container yard and the efficiency of container movement time [12], [13]. Integrated scheduling of all handling equipment, to minimize the loading component of vessel berthing time, which is a crucial indicator of operational efficiency at container terminals, in order to minimize the loading time of the ship's berthing period [14], [15].

To solve the problems of PT. Prima Container Terminal, it is necessary to develop a model with discrete simulation of the loading and unloading system. Most case analysis goals are to find ways to improve the performance of existing systems or design new systems. In this case the model must undergo several parametric and structural configuration changes and be completed for each alternative scenario. The simulation model is focused on obtaining alternative optimal import and export location based on loading and unloading activities and to anticipate more effective truck round time. The amount of container yard will be changed according to the scenario prepared to find the lowest combination of facility utility and truck waiting time.

2. Methodology

The system of interest in this research is characterized as a discrete system. Loading and unloading operations at the terminal have several uncertainties and some movements are very difficult to determine using mathematical calculations and heuristic techniques, so simulations need to be carried out. Data is required from parameters that affect all processes. Some of the required data include ship arrival schedules, the number of containers unloaded and loaded including the size of the containers, the length of loading and unloading operational time per ship and other history data. All these data are processed to obtain the distribution that is closest to the real system [16]. The research flow diagram can be seen in Figure 1.

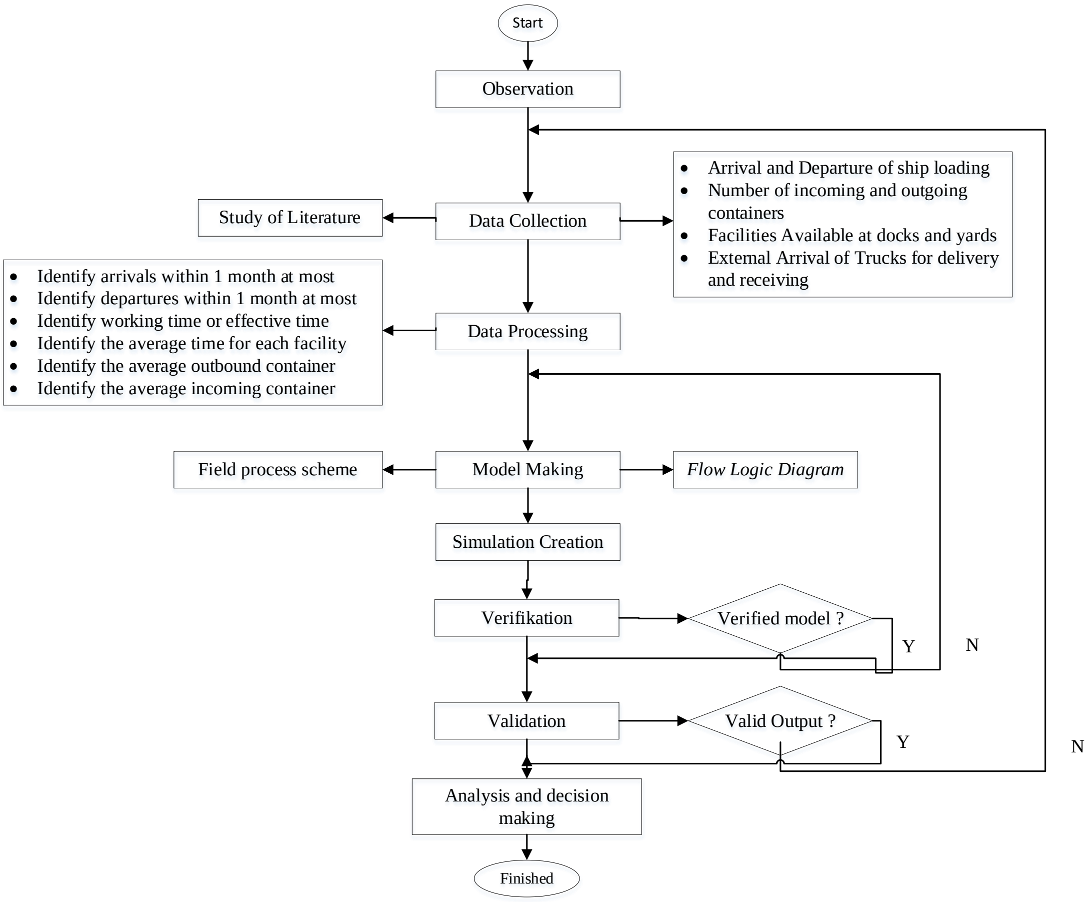


Figure 1. Research Flow Chart

Simulation-based optimization methods are frequently used to study container terminal operations. So it used to develop a scoring system in which the input and output parameters of the optimization model are evaluated and analyzed using a discrete simulation model [3]. The basic concepts of discrete event simulation are entities, properties, events, resources, queues, and time. Entities are objects that have properties, experience events, use resources, and enter queues over time [17]. Discrete event simulation is a frequently used testing method that allows modeling at a high level of detail as it can model assumptions regarding buffer space, time allocation processing, or distribution priorities [18].

The experiment conducted in this study is to determine the number of container yard dedicated to import and export. The number of container yard to be simulated is 9 blocks with 12 ARTGs (existing conditions). Variations are made to determine the most optimal number of container yards and ARTGs based on the existing capacity served by PT Prima Terminal Petikemas.

From Figure1., it is explained that the creation of a simulation model is carried out by identifying the flow of processes, as shown in Figure 2, and activities in the system described in a logic diagram for visualization of the conceptual model, as illustrated in Figures 3 and 4. From the conceptual model, the logic of activities and behavior in the system will be used to create a discrete simulation model using ARENA 14 software [19], [20]. Then several simulation scenarios will be made on the current system conditions and will then be verified to equalize the logic of the simulation model with the conceptual model. The simulation model will also be validated to ensure that the model built is in accordance with the reality of the system [11] and the last is decision making from several analyzes carried out.

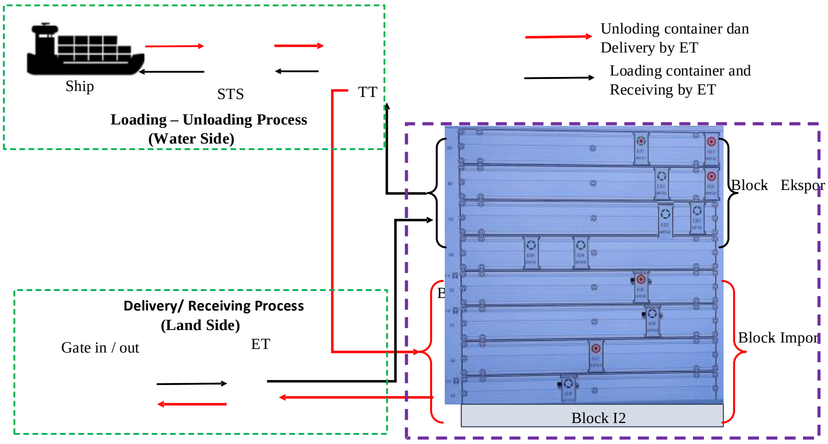
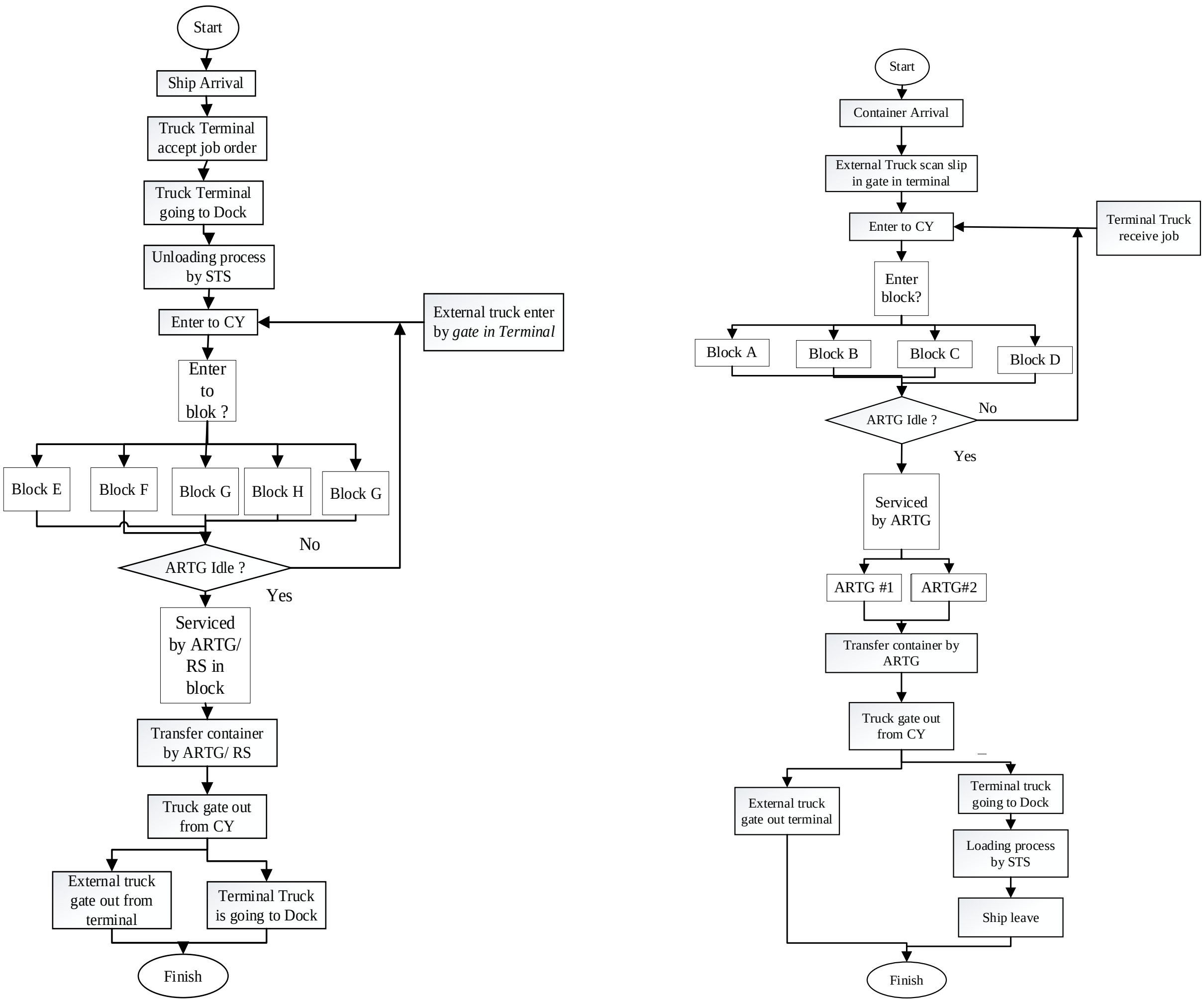


Figure 2. Field Process Scheme

3. Results and Discussion

The simulation model is created based on the field process scheme, as shown in Figure 2, and the flow logic diagram, as illustrated in Figure 3. The next step is to verify the model to ensure that it accurately represents the real system [21]. The appearance of the pop-up message "no error or warning in model" in the desktop window indicates that the model built in the system has no errors.



(a) Delivery – Unloading (b) Receiving- Loading

Figure 3. Flow Logic Diagram

Model validation is carried out by comparing model performance with the actual system performance using statistical tests. The truck round time parameter for the delivery-unloading process is the total time the external truck is served, from entering the terminal through gate-in until leaving the gate-out with the container. This include the service time for each entity by all terminal facilities, and the waiting time parameter is the time the truck waits before being served by Automated Rubber Tyred Gantry (ARTG) at the stacking location, as detailed in Table 1.

Table 1. Comparison Table of Actual and Simulated Time (Delivery)

Replication	Actual Time (Minutes)			Simulation Time (Minutes)		
	Total Time	Service Time	Wait Time	Total Time	Service Time	Wait Time
1	42.47	27.11	15.36	39.04	19.15	19.89
2	39.40	24.15	15.25	43.30	19.09	24.21
3	49.00	30.64	18.36	47.53	19.24	28.29

The results of the t-Test: Paired Two Sample for Means by using analysis tools in Microsoft Excel to see the validity of the data between simulation and actual with a confidence level of 95% ($\alpha = 0.05$), obtained that the t stat value exceeds or still covers the critical t value, if the t stat value does not exceed the critical t value then the test data is valid [11]. The results of the t-Test: Paired Two Sample for Means total time (truck round time) is in Table 2 and Table 3 t-Test results of truck waiting time.

Table 2. Uji-t Parameter of Total Time (Truck round time) Delivery

t-Test: Paired Two Sample for Means	Variable 1 (Actual)	Variable 2 (Simulation)
Mean	43.623333	43.29
Variance	24.037633	18.0201
Observations	3	3
Pearson Correlation	0.6644201	
Hypothesized Mean Difference	0	
Df	2	
t Stat	0.1521386	
P(T<=t) one-tail	0.4465194	
t Critical one-tail	2.9199856	
P(T<=t) two-tail	0.8930389	
t Critical two-tail	4.3026527	

Table 3. Uji-t Parameter of Wait Time Delivery

t-Test: Paired Two Sample for Means	Variable 1 (Actual)	Variable 2 (Simulation)
Mean	16.3233333	24.13
Variance	3.11403333	17.6448
Observations	3	3
Pearson Correlation	0.84121741	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-4.6968966	
P(T<=t) one-tail	0.02123143	
t Critical one-tail	2.91998558	
P(T<=t) two-tail	0.04246286	
t Critical two-tail	4.30265273	

The truck round time parameter for the receiving-loading process is the total time that external trucks are served from entering, carrying containers to the terminal through gate in until leaving the gate out of the terminal. This include the service time for each entity by all terminal facilities and the waiting time parameter, which is the time the truck waits before being served by Automated Rubber Tyred Gantry (ARTG) at the stacking location as shown in Table 4.

The results of the t-Test: Paired Two Sample for Means by using analysis tools in Microsoft Excel to see the validity of the data between simulation and actual with a confidence level of 95% ($\alpha = 0.05$), total time (truck round time) are in Table 5 and t-Test: Paired Two Sample for Means truck waiting time can be seen in Table 6.

Table 4. Comparison Table of Actual and Simulated Time (Receiving)

Replication	Actual Time (Minutes)			Simulation Time (Minutes)		
	Total Time	Service Time	Wait Time	Total Time	Service Time	Wait Time
1	35.47	27.39	8.08	35.44	23.71	11.73
2	41.12	29.09	12.03	35.33	23.72	11.61
3	36.57	27.42	9.15	35.78	23.70	12.08

Table 5. Uji-t Parameter of Total Time (Truck Round Time) Receiving

t-Test: Paired Two Sample for Means	Variable 1 (Actual)	Variable 2 (Simulation)
Mean	37.72	35.51666667
Variance	8.9725	0.055033333
Observations	3	3
Pearson Correlation	-0.544329406	
Hypothesized Mean Difference	0	
Df	2	
t Stat	1.219532287	
P(T<=t) one-tail	0.173471416	
t Critical one-tail	2.91998558	
P(T<=t) two-tail	0.346942832	
t Critical two-tail	4.30265273	

Table 6. Uji-t Parameter of Wait Time Receiving

t-Test: Paired Two Sample for Means	Variable 1 (Actual)	Variable 2 (Simulation)
Mean	9.753333333	11.80666667
Variance	4.173633333	0.059633333
Observations	3	3
Pearson Correlation	-0.485447829	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-1.637412091	
P(T<=t) one-tail	0.121598206	
t Critical one-tail	2.91998558	
P(T<=t) two-tail	0.243196412	
t Critical two-tail	4.30265273	

The scenario of the improvement simulation model that will be carried out is based on the number of different uses of the container yard and Automated Rubber Tyred Gantry (ARTG) for each loading and unloading activity, and the activity is also influenced by the number of facilities in the dock area. The combination of 9 blocks and 12 Automated Rubber Tyred Gantry (ARTG) units, resulting in 12 scenarios. With the number of replications in the delivery- unloading activity is as many as 3 times and 2 times in the receiving- loading activity. From the delivery- unloading scenario, the results are shown in Table 7.

Table 7. Average Data of Scenario Delivery- Unloading Running Results

Scenario	*Semi automation +* 1Manual (Blok)	% Blok	ARTG + 1RS	STS	Service Time	Wait Time	TRT
1A	4	17.5	5	3	19.25	27.74	46.98
1B	4	17.5	6	3	19.14	20.82	39.96
1C	4	17.5	7	3	19.31	16.71	36.02
1D	4	17.5	8	3	19.24	15.22	34.46
2A	3	20	6	3	19.62	42.89	62.50
2B	3	20	5	3	18.40	29.64	48.04
2C	3	20	4	3	18.39	41.35	59.74
2D	3	17.5	5	2	17.73	13.77	31.50
3A	3	17.5	4	2	17.73	13.77	31.50
3B	3	20	4	2	18.44	14.52	32.96
3C	3	20	5	2	18.42	11.62	30.03
3D	3	20	6	2	18.38	8.94	27.32

Table 8. Average Data of Scenario Receiving- Loading Running Results

Scenario	Number Blok	% Blok	ARTG + 1RS	STS	Service Time	Wait Time	TRT
1A	4	25	7	3	23.96	12.89	36.85
1B	4	25	6	3	23.75	12.66	36.41
1C	4	25	5	3	23.71	12.67	36.37
1D	4	25	4	3	23.78	12.35	36.12
2A	5	20	8	3	23.78	9.66	33.44
2B	5	20	7	3	23.73	8.75	32.48
2C	5	20	6	3	23.75	9.92	33.67
2D	5	20	5	3	23.75	23.76	47.50
3A	3	33.33	6	3	22.71	15.31	38.02
3B	3	33.33	5	3	22.76	16.73	39.49
3C	3	33.33	4	3	22.72	16.35	39.07
3D	3	33.33	3	3	22.79	17.95	40.74

In the improvement scenario results, in addition to combining the number of container yard blocks, the Automated Rubber Tyred Gantry (ARTG) also considers the number of ships to shore (STS) and the percentage of each block container yard. These factors will affect the waiting time and truck round time. For the delivery-unloading activity, the optimal scenario is the 3D scenario with 4 blocks (3 semi automation, 1 manual), 6 Automated Rubber Gantry Tyred (ARTG) units plus 1 unit reach stacker unit, and a 20% load percentage for each block.

For receiving-loading activities, the best scenario is scenario 2C with 5 blocks, 7 Automated Rubber Gantry Tyred (ARTG) units, and a block loading percentage of 20% each. If using the current location (blocks) and existing facilities for both delivery-unloading and receiving-loading activities, then the chosen scenario for receiving-loading activities is scenario 2B, which includes 5 blocks and 6 Automated Rubber Gantry Tyred (ARTG) units. This can reduce the truck round time (TRT) for external delivery and receiving trucks to 27.37 minutes and 33.67 minutes, respectively, as seen in Figure 4.

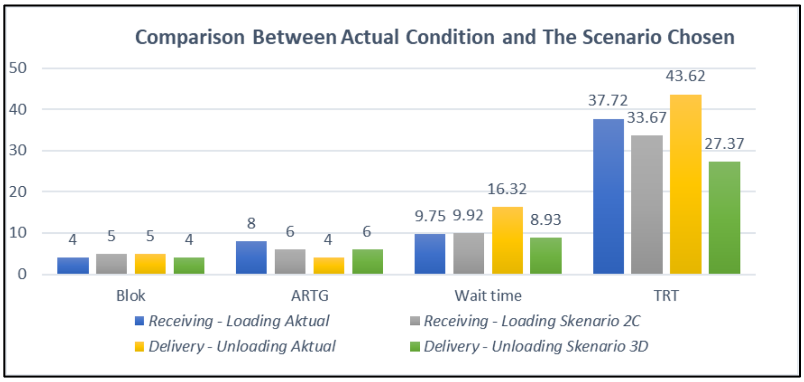


Figure 4. Comparison Between Actual Condition and The Scenario Chosen

4. Conclusion

Based on the results of data processing and analysis, this study concluded that determining the optimum container yard location will affect the waiting time and truck round time of external trucks. The best and selected scenario for delivery- unloading is scenario 3D with 4 blocks, 6 units Automated Rubber Gantry Tyred (ARTG) units, plus 1 reach stacker unit. This scenario can reduce the waiting time and truck round time (TRT) to 8.93 minutes and 27.37 minutes. The selected scenario for receiving-loading is scenario 2B with 5 blocks and 6 Automated Rubber Gantry Tyred (ARTG) units. This scenario does not decrease the waiting time, it reduces the truck round time (TRT) to 9.92 minutes and 33.67 minutes.

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