

Determining the Efficient Weighing Area for Food Commodities in Port by Discrete Event Simulation

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Abstract - DF Inc. is a company provided in port services. One of its activities is the loading and unloading of food commodities such as soybeans, corn, wheat, and so on. There are around 500 trucks that want to carry out the loading and unloading process at DF Inc. so that there is a queuing of trucks in the weighing area. This study aims to determine the location of an efficient weighing area to minimize the queuing of trucks. The simulation is designed using a discrete event simulation. There are 10 scenarios of improvements for locations with load bills. Scenario 10 is the best scenario by placing 1 scale on the ABCDE scale, 1 scale in the FGHIJ warehouse and 2 scales near the station 7. The number of trucks that can be served by the existing model is 722 units. While the best scenario is 944 units. The percentage of scales utilization in the existing model is 41.72% and the best scenario is 35.85%. With this simulation provides a policy choice for companies to make decisions on the placement of an efficient weighing area.

Keywords: food commodities, discrete event simulation, port, utilization, queuing.

I. INTRODUCTION

One of the important facilities in Indonesia as an archipelago is port. Port is a facility that is located at the end of the island for the place of berthing ships and moving objects such as cargo or passengers. Therefore, we need to increase the quality in terms of time and efficient the use of resources, in the process of moving objects in the port. DF Inc. is a company provided in port services.

DF Inc. has a specialization in operating as a port terminal for cargoes, especially dry bulk. DF Inc. gives a total solution to handle bulk materials. Numerous facilities are managed by DF Inc., such as the dock, dealing with equipment, supporting equipment, supporting facilities, warehouses, and safety and security. Dynamic activities in business, industry and investment are becoming more convenient in the integrated port and industrial estate of DF Inc. The area where DF Inc. runs the operation affects the efficiency and the practicality of import and export activities. Port management try to improve the performance so that it becomes an attractive port and could be competitive [12].

Looking at the conditions in an average day, it can be around 500 trucks that want to carry out the loading and unloading process at DF Inc. This makes the queue to the trucks both in each station and even more so in the weighing process. In the weighing process, DF Inc. has 4 scales in the

same location. In the weighing process, empty trucks that want to go to the dock or truck that has passed through the dock are obliged to weigh in the absence of the rules of empty trucks or trucks loaded into the scale. In other words, trucks are free to enter any scale. Moreover, this weighing location is close between station 5 and station 2, the entry point to the dock so that if the loading and unloading process at the dock occurs delay or accumulation due to the vessel arrival making a queue. Then the weighing location is also close to the access point to PK Inc. so that the full queue occurs at station 5 towards the dock. The location of this weighing area is not far from the dock but far from station 1, the entrance station and station 3, the out station.

Many researchers have utilized the discrete event simulation in some area [9; 13; and 15]. [9] reduced the congestion on the east Cilegon toll gate. [13] Solved the problem of parking space limitations. [15] Improved the layout of the finished product warehouse. Regarding the complex systems in ports, [10] investigated to decrease the lost cargo in port with system dynamics approach. [8] developed a model of the port operation system with a focus on time, quality, and profit. Also, [11] developed model of the port performance metrics by integration six sigma and system dynamics. The relocation of efficient weighing area in port by discrete event simulation has not yet considered by previous studies.

With the various problems mentioned above and the previous study, the researchers want to relocate the weighing area to a strategic location to minimize the stack of queues on the truck and the bottleneck on the dock. This study aims to determine the location of an efficient weighing area to minimize the queuing of trucks by Discrete Event Simulation.

II. LITERATURE REVIEW

Port is known as two terms related to the meaning of the port, which is the harbor and the port. According to [7], there are ten main types of terminals that can be differentiated as follows:

1. Conventional general cargo terminal is traditionally constructed for handling of break bulk and unitized general cargo.
2. Multi-purpose terminal merges conventional break-bulk with a container and/or Ro/Ro cargo.

3. Ro-Ro terminals appropriate for ships with quarter and/or side ramps at marginal quay.
4. Container terminal. The storage of containers on the terminal often occurs for several days until several weeks.
5. Liquid bulk terminal is suitable for oil, chemicals or liquid gas, all of these terminals have one thing in common.
6. Dry bulk terminal is constructed and built for one specific type of cargo, e.g.: iron ore, coal, fertilizer, grain, etc.
7. Fruit terminal are distinguished by refrigerated warehouses that are placed near the waterfront.
8. Fish handling facilities may differ from a simple beach arrival to a standard harbor.
9. Inland barge terminal, the layout relies on the type of handled cargo.
10. Ferry and cruise terminal are focused on the rapid and secure movement of passengers.

The model is a description or analogy used to help describe something that cannot be observed directly [3]. In general the model is defined as a representation of a real system. The real system is a system that is taking place in the real world and the point of the problem that being studied. Thus, modeling is the process of building or forming a model of a real system. According to [2] the model is classified into 3 categories: definitive models, descriptive or predictive models, and normative models.

Simulation is an imitation of the operating process of a real condition or system over time [1]. Simulation is a reliable analytical tool for planning, designing, and controlling complex system processes. Promodel is a simulation software that can be used to simulate and analyze production systems of various types and sizes.

The element structure contained in Promodel includes:

1. Location
Represent an area where raw materials, semi-finished materials or ingredients are subjected to or waiting for the process, delay, save, and some other activities.
2. Entities
An object that will be observed from the system, for example a work part or operator.
3. Arrival
It shows the mechanism of the entry of the entity into the system, both the number of locations where the arrival place or the arrival of frequency and time periodically according to certain intervals.
4. Processing
It describes what is experienced by an entity from the moment the entity enters until it exits the system.
5. Resources
A resource that is used to perform certain operations in the performance of a system.
6. Path Network

It determines the direction and path taken by the resource or entity when moving from one location to another.

Verification and validation are stages to test the credibility/suitability of a real system with a simulation model. Verification relates to conceptual conditions whether the model is in accordance with the desired concept [1]. Model validation on simulation output based on average error and variation error. If the model is not verified and not validated, then back to define the system and identify the variables [5].

Independent Sample T-Test is a comparative test or different test to find out whether there is a difference in the mean or average when two samples are independent and when the sample is taken from two populations that are close to normal distribution. There are four states of two mean similarity test, the variance is known and equal, the variance is known and different, the variance is unknown and is assumed to be equal, the variance is unknown and is assumed differently.

The replication theory is to run a simulation model using a certain random number flow, which in turn causes random events from the sequence of numbers. Variance analysis is a method for deciphering total diversity into components that measure various sources of diversity. In this analysis, we always assume that the random sample chosen comes from the normal population with the same variance, unless the sample chosen is large enough, assumptions about normal distribution are not needed [16].

III. RESEARCH METHODOLOGY

The simulation is designed using a discrete event simulation by Promote software. There are 10 scenarios of improvements for locations with load bills. The following is the research flow chart contained in research conducted at DF Inc.:

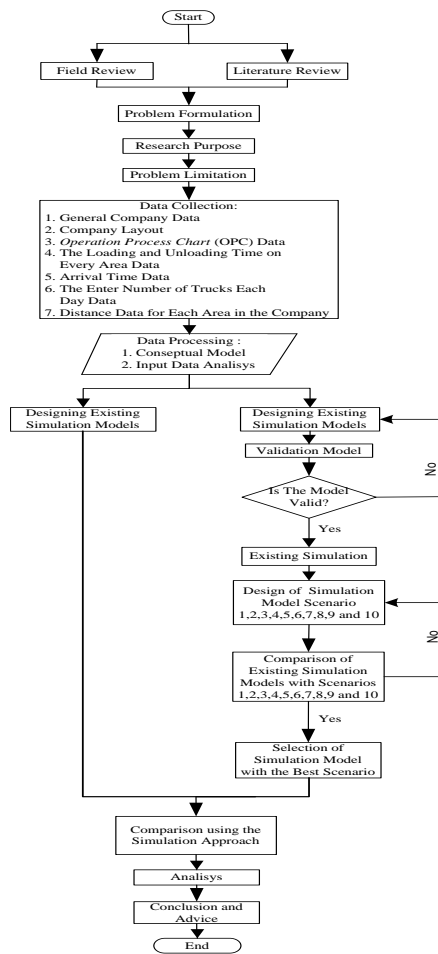


Fig. 1 Research Flow Chart

IV. RESULT AND DISCUSSION

A. Layout of Research Area

The following is layout of DF Inc. with a focus on the simulation area of the scale that will be relocated as shown in Figure 2 above.

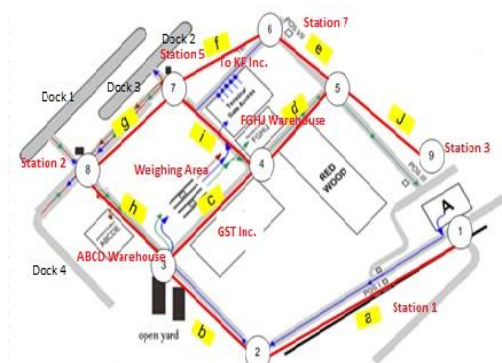


Fig. 2 Layout of Research Area

System element

The following is the components that will be used as a model in Pro model Software:

1. Entities

Entities are objects that are processed in a model that presents the inputs and outputs of the system. In this problem, the entities used by trucks are:

- Outer Truck, an external truck that comes into the company
- Truck of ABCDE Warehouse
- Truck of FGHIJ Warehouse
- Truck of PK Inc.
- Truck of GST Inc.

2. Location

Locations are places where an entity is processed, waiting, stored, given a decision, or doing other activities (Harell, 2004). Several locations in the loading and unloading process which include:

- Station 1 (Entrance) is the entrance to every truck that wants to enter the dock.
- Scales is a weighing area for both empty trucks and truck contents.
- ABCDE warehouse is a loading and unloading place for trucks going to the ABCDE warehouse.
- FGHIJ warehouse is a loading and unloading place for trucks going to the FGHIJ warehouse.
- Open Yard is a place to put cargo or raw materials especially for open yard trucks.
- GST is a factory where raw materials are put in place.
- Dock 1 is a place for loading and unloading process.
- Dock 2 is a place for loading and unloading process.
- Station 2 is the place to enter the dock 1.
- Station 5 is a place to enter the dock 2.
- Station 7 is the entry and exit gate for PK Inc. Trucks.
- Station 3 is the exit gate for DF Inc.
- The travel letter is a check out of the company.
- The load bill is a check truck process to enter the scale (if used).
- The terminal is a place to queue.

3. Arrivals

Arrivals are a mechanism for determining how entities enter a system [6]. In this study there are six arrivals for each entity, namely trucks that are involved in the loading and unloading process in the company.

B. Input Data Analysis

Analysis of input data includes estimating parameters of assumptions testing on data, namely independence and homogeneity tests and distribution fittings to determine the data distribution. The data were collected on the loading and unloading process time in the dock, the process time on the

scale, the loading and unloading processing time in the warehouse.

C. Design of the Existing Model

Lay out of Existing Model can be seen in Figure 2. After the simulation is run, the results are shown in Table I.

TABLE I
NUMBER OF TRUCKS IN AND OUT OF THE WEIGHING AREA

| Replication | Number of trucks |
|-------------|------------------|
| 1 | 716 |
| 2 | 718 |
| 3 | 718 |
| 4 | 728 |
| 5 | 718 |
| 6 | 731 |
| 7 | 740 |
| 8 | 719 |
| 9 | 722 |
| 10 | 708 |
| Average | 721.8 |
| S | 9.00 |

4.4.1 Replication test

The following is a replication calculation as follow:

$$t_{n-1, \alpha/2} = t_{(10-1), (0,05/2)} = 2,262$$

$$s = 9$$

$$n = 10$$

$$e = \frac{(t_{n-1, \alpha/2})s}{\sqrt{n}} = \frac{2,262 \times 9,00}{\sqrt{10}} = 6,43$$

$$n = \left[\frac{(Z_{\alpha/2})s}{e} \right]^2 = \left(\frac{1,96 \times 9,00}{6,43} \right)^2 = 7,52 \approx 8$$

So the number of replications needed is 8, so it can be concluded that by replicating 10 times there is enough minimal replication needed.

4.4.2 Validation Test

The following is a calculation of the validity test as shown in Table II.

TABEL II
DATA OF THE VALIDATION TEST

| Replication | The Simulation Output | The Actual Calculation |
|-------------|-----------------------|------------------------|
| 1 | 716 | 650 |
| 2 | 718 | 452 |
| 3 | 718 | 682 |
| 4 | 728 | 702 |
| 5 | 718 | 628 |
| 6 | 731 | 848 |
| 7 | 740 | 762 |
| 8 | 719 | 764 |
| 9 | 722 | 604 |
| 10 | 708 | 650 |

Statistical validation of the model is done to prove whether the model simulation results differ much from the actual model. All the outputs (calculation and simulation) are normally distributed and tested using the independent two-sample t-test ($\alpha=0.05$) using MS Excel with the hypothesis:

$H_0: \mu_1 = \mu_2$, meaning the two groups have no differences with respect to their mean values

$H_1: \mu_1 \neq \mu_2$, meaning the two groups have differences with respect to their mean values

where μ_1 is the simulation output, and μ_2 is the actual calculation output.

The result of the independent two-sample t-test is shown in Table III above.

TABLE III
THE RESULT OF VALIDATION TEST

| | Actual | Simulation |
|------------------------------|-------------|-------------|
| Mean | 674.2 | 721.8 |
| Variance | 11602.17778 | 81.06666667 |
| Observations | 10 | 10 |
| Hypothesized Mean Difference | 0 | |
| Df | 9 | |
| t Stat | 1.392596249 | |
| P(T<=t) one-tail | 0.098592095 | |
| t Critical one-tail | 1.833112933 | |
| P(T<=t) two-tail | 0.19718419 | |
| t Critical two-tail | 2.262157163 | |

The test result shows an absolute t-stat value of each group that is smaller than the t-critical two-tailed value, this means that H_1 should be rejected; in other word the average values of both groups show no differences.

D. Design of Improvement Scenarios

Some scenarios are designed to determine the efficient weighing area. There are 10 scenarios of improvements for locations with load bills.

Table IV is the simulation results analysis. Based on the simulations that have been done, the best results are scenario 10 by placing on scale on the ABCDE scale, 1 scales in the FGHIJ Warehouse and two scales near the station 7. The number of trucks can be served is 944 units and the percentage utilization of scales is 35.85 %.

TABLE IV
SIMULATION RESULT ANALYSIS

| Scenario | Number of trucks in the scale (unit) | Utilization of the scale (%) | Utilization of the dock (%) | | Content of the dock (unit) | | Number of the Exit trucks (unit) | Total time of truck in system (minute) | Blocked time of truck in system (minute) | Weight value | Rank |
|----------|--------------------------------------|------------------------------|-----------------------------|-----------|----------------------------|-----------|----------------------------------|--|--|--------------|------|
| | | | Dock 1 | Dock 2 | Dock 1 | Dock 2 | | | | | |
| 1 | 546 (5) | 31.98 (3) | 22.87 (3) | 90.42 (3) | 14.63 (3) | 25.31 (3) | 222 (8) | 351.28 (10) | 8.36 (5) | 43 | 4 |
| 2 | 328 (8) | 19.71 (5) | 27.29 (2) | 93.04 (1) | 17.46 (2) | 26.05 (1) | 142 (9) | 304.7 (9) | 6.76 (3) | 40 | 3 |
| 3 | 601 (3) | 19.26 (7) | 5.84 (6) | 80.84 (4) | 3.73 (6) | 22.63 (4) | 290 (6) | 251.99 (8) | 7.79 (4) | 48 | 5 |
| 4 | 942 (2) | 54.28 (1) | 12.44 (4) | 72.22 (6) | 7.96 (4) | 20.22 (6) | 408 (2) | 189.07 (3) | 5.78 (2) | 30 | 2 |
| 5 | 221 (9) | 13.23 (8) | 4.43 (8) | 26.86(10) | 2.83 (8) | 7.52 (10) | 236 (7) | 246.34 (7) | 159.48 (10) | 77 | 9 |
| 6 | 202 (10) | 9.73 (9) | 79.70 (1) | 92.22 (2) | 51.01 (1) | 25.82 (2) | 41 (10) | 141.07 (2) | 83.91 (6) | 43 | 4 |
| 7 | 377 (7) | 7.29 (10) | 3.94 (9) | 44.65 (9) | 2.52 (9) | 12.5 (9) | 306 (5) | 232.32 (5) | 142.97 (8) | 71 | 8 |
| 8 | 470 (6) | 19.44 (6) | 3.67 (10) | 49.78 (8) | 2.34 (10) | 13.93 (8) | 337 (4) | 234.29 (6) | 149.40 (9) | 67 | 7 |
| 9 | 555 (4) | 21.19 (4) | 5.52 (7) | 55.81 (7) | 3.53 (7) | 15.62 (7) | 380 (3) | 203.67 (4) | 117.22 (7) | 50 | 6 |
| 10 | 944 (1) | 35.85 (2) | 12.18 (5) | 77.25 (5) | 7.79 (5) | 21.63 (5) | 574 (1) | 89.64 (1) | 2.46 (1) | 26 | 1 |

The output of the existing model and the improvement scenario result can be seen in Table V.

TABEL V
OUTPUT OF THE EXISTING MODEL AND THE IMPROVEMENT SCENARIO

| Replication | Existing System | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 | Scenario 6 | Scenario 7 | Scenario 8 | Scenario 9 | Scenario 10 |
|-------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|
| 1 | 716 | 546 | 601 | 328 | 774 | 226 | 191 | 377 | 470 | 555 | 944 |
| 2 | 718 | 546 | 606 | 331 | 769 | 229 | 196 | 381 | 481 | 564 | 1039 |
| 3 | 718 | 545 | 592 | 331 | 762 | 231 | 202 | 376 | 489 | 551 | 1019 |
| 4 | 728 | 544 | 593 | 331 | 764 | 228 | 199 | 373 | 480 | 563 | 1077 |
| 5 | 718 | 555 | 605 | 327 | 761 | 227 | 197 | 382 | 496 | 543 | 932 |
| 6 | 731 | 552 | 617 | 330 | 764 | 228 | 199 | 378 | 474 | 552 | 950 |
| 7 | 740 | 559 | 595 | 329 | 776 | 226 | 199 | 377 | 466 | 550 | 985 |
| 8 | 719 | 559 | 604 | 325 | 764 | 226 | 195 | 374 | 480 | 550 | 861 |
| 9 | 722 | 548 | 589 | 338 | 764 | 229 | 196 | 378 | 474 | 558 | 1028 |
| 10 | 708 | 544 | 584 | 326 | 767 | 227 | 199 | 377 | 473 | 547 | 963 |

The output of the existing model and the proposed scenario result can be used to ANOVA (analysis of variance) test with a predetermined hypothesis:

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7 = \mu_8 = \mu_9 = \mu_{10} = \mu_{11},$$

there is no difference between the average output of the existing system and the improvement scenarios.

H_1 : there is at least one difference between the average output of the existing system and the improvement scenarios.

when :

μ_1 : the average output of the existing system

μ_2 : the average output of the improvement scenario 1

μ_3 : the average output of the improvement scenario 2

μ_4 :the average output of the improvement scenario 3
 μ_5 :the average output of the improvement scenario 4
 μ_6 :the average output of the improvement scenario 5
 μ_7 :the average output of the improvement scenario 6
 μ_8 :the average output of the improvement scenario 7
 μ_9 :the average output of the improvement scenario 8
 μ_{10} :the average output of the improvement scenario 9
 μ_{11} :the average output of the improvement scenario 10

Table VI is the calculation of the ANOVA test of the output truck that enters the weighing area using Ms. Excel software.

TABLE VI

| Source of Variation | n | SS | Df | MS | F | P-value | F crit |
|---------------------|---|--------|----|---------|---------|---------|---------|
| Between | | | | | | | |
| n | | 568678 | | 568678 | 1433.91 | 2.3E | 1.92767 |
| Groups | 1 | 10 | | .1 | 2 | -102 | 9 |
| Within | | 39262. | | 396.591 | | | |
| Groups | 6 | 99 | | 9 | | | |
| | | 572604 | 10 | | | | |
| Total | 3 | 9 | | | | | |

ANOVA TEST RESULT USING MICROSOFT EXCEL

Based on Table VI, it can be seen that the calculated F value is 1433.912 and the F_{table} value is 1.9276 which is obtained from the following formula:

$$\begin{aligned}
 F_{table} &= F_{(\alpha; df \text{ SS Treatment}; df \text{ SS Error})} \\
 &= F_{(0.05; 10; 100)} \\
 &= 1.9276
 \end{aligned}$$

If the value of $F_{counts} > F_{table}$ then accept H_1 . Based on the values obtained, $F_{count} > F_{table}$ is $9560.742 > 1.985$ so it can be concluded that there are significant differences between existing systems with several improvement scenarios.

Once it is known that there are significant differences between the existing system and the improvement scenarios, it is tested after ANOVA by using Least Significant Differences (LSD) to determine the average of the different conditions or treatments. Based on the results of after ANOVA test, it is known that the lower bound and upper bound values for each comparison of output that does not exceed zero, then accept H_1 , which means that there is a significant difference between the average output of the existing system and the improvement scenarios. Table VII is the list of the best conditions from the existing results and improvement scenarios.

TABLE VII

LIST OF THE BEST CONDITION

| No. | Condition | AverageOutput(Truck) |
|-----|-------------|----------------------|
| 1 | Scenario 10 | 979 |
| 2 | Scenario 4 | 767 |
| 3 | Existing | 722 |
| 4 | Scenario 2 | 599 |
| 5 | Scenario 9 | 553 |
| 6 | Scenario 1 | 550 |
| 7 | Scenario 8 | 478 |
| 8 | Scenario 7 | 377 |
| 9 | Scenario 3 | 330 |
| 10 | Scenario 5 | 228 |
| 11 | Scenario 6 | 198 |

Based on Table 7, the scenario 10 with an average output of 979 trucks on the scale, then the scenario 4 with an average output of 767 trucks on the scale, then the existing condition with an average output of 722 trucks on the scale, then scenario 2 with an average output truck entering the weighing area of 599, then scenario 9 with an average output of 553 trucks, then scenario 1 with 550 trucks, then scenario 8 with 478 trucks, then scenario 7 is 377 trucks, then scenario 3 with 330 trucks, then scenario 5 with 228 trucks and the last is scenario 6 with 198 trucks.

IV. CONCLUSION

Based on the results of our research, the following conclusions are:

1. Simulation is designed using a discrete event simulation.
2. There are 10 scenarios of improvements for locations with load bills. Scenario 10 is the best scenario by putting one scale on the ABCDE Warehouse; one scale in the FGHIJ Warehouse; and two scales near the station 7.
3. The number of trucks that can be served by the existing model is 722 truck units. Whereas the best scenario is scenario 10 with 944 truck units.
4. The percentage of scales utilization in the existing model is 41.72% and the best scenario model is scenario 10 with 35.85%.

V. RECOMMENDATION

There are recommendations for the future research and the company to make decisions to solve the problems are:

1. It is necessary to minimize the looping process on the truck route (the existing condition: the looping process occurs when the weighing is empty and full).
2. It is necessary to minimize the administrative bureaucracy process (Load bills before the empty truck is weighed and the travel document after the truck is weighed).
3. The number of existing scales as many as four pieces, still sufficient to meet the demand for weighing.

4. If the service of the travel document and load bills is carried out in one location, it should be implemented in a two-way system.

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