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Contributions regarding the simulation of the optimization of the operation mode in a container terminal

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1. INTRODUCTION

The paper presents:

-the terminal's infrastructure, the loading's plans, the equipment's details, the operational data onboard, the systemic analysis of the terminal.

-In order to highlight the operational optimization in the cargo terminal, operating scenarios are proposed, to which *simulation models* are attached. Enter parameters such as towing units, return / load / unload speed, the distance between parallel and opposite parking rows and the load pick-up time, using working diagrams. It simulates the operability in the terminal. In the analyzed terminal, the expected size of the ship is not found in the equations attached to a simulation model, because the degree of berth occupancy is actually related to the number of access points, where a frame can be placed and not the length available berth. The terminal usually operates by scheduling ships in advance and therefore arrival times are usually planned in advance and follow a strict schedule.

- The simulation results (performance indicators) lead to the estimation of the values for the optimal quay time, in relation to the number of units for loading in the proposed scenarios. It takes into account whether the arrival pattern is random or scheduled and the time of service provided by the terminal.

2. METHODOLOGY

2.1. Operations on board the ship

The ship's details are: length of the ship- 180-200m; ship width- 27-30m; draft: 6.8-7.2m (loaded); load: 100-200 standard trailers / semi-trailer trucks (13.5-16.5m); cargo percentage: 30% trailers / 70% semi-trailer trucks; travel: from Constanta, Romania to Turkey; distance: 280Nm (nautical miles); duration of the trip- 10 hours from port to port, with an average speed of 21 knots; parking in the port- maximum 2 hours.

2.2. Operating details and performance indicators

Quality indicators found in the literature are waiting time during service (W / S), berth occupancy rate and total return time - and its two components, service time (bay worked) and waiting time for equipment. Over-*waiting time* (W / S) is an indicator that expresses the idea that ships with little cargo to unload cannot afford the same downtime as a 100% loaded ship. *The berth occupancy rate*, in turn, is commonly used as a means of expressing the degree of congestion facing the terminal. *The total stationary (or return) time* the ship spends in the terminal is an easier indicator to understand for transport companies.

2.3. The systemic analysis of the terminal

The three subsystems considered will be: anchoring, storage and delivery and receipt, as shown in Figure 5. The gate of ship container terminal is the channel for container cargo trucks. The container terminal must described with equipment and facilities. For these reasons, must build the models for different facilities of terminal. Usually, there are four parts of facilities: the gate system, yard, apron, and berth [8]. The model of different programs of simulation [11] is model building-time. In order to build the model using software, the elements necessary for the study and the technical details related to these elements must be described according to the desired facilities. The respective elements are divided into physical, logical and reporting and as a result, they enter the menu bar of the simulation software and describe concretely by names, types and quantities all the elements. It will have to run data such as: inputs / outputs, types, quantities, working/waiting times.

3. DATA

3. 1. Data for quay operability

These data depend on the operating scenarios. The time for the operation of the machines as actual goods means that the value taken must take into account the average distance traveled from the storage area to the ramp, loading (and vice versa, unloading), the maximum permitted traffic speed, the number of drivers. on the van used for stacking, as well as the number of vans. Figure 6 [2] shows some graphs for time / units and different configurations and towing units; in this case the number of loading units is similar to the number of unloaded units.

3.2. The waiting & working times

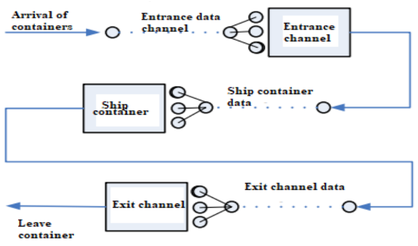
Simulation is the usual choice to estimate the waiting time in the radar and the probability that it will occur. As the purpose of these calculations is to determine how to assess the capacity of the terminal and not its congestion in a specific situation, the analysis is performed on the highest usual values recorded in the operation of the terminal (Table 1, Table 2).

3.3. Arrival scheduling

Figure 7 [3] represents the different variables on a time axis being 0 when the ship "*i*" arrives in port. Two different examples are exemplified: the overlap between ship "i" and ship "*i + 1*" does not occur (equation 3 is not met) and when there are overlaps, which results in the waiting time in the radar.

3.4. Random arrivals

From the data obtained from the analysis of several terminals, it was found that the assumption is valid for some terminals [12]. The arrivals are independent of each other, and the time between successive arrivals has a negative exponential, while the service time for any arrival is considered normal. (Figure 10) [2].



Two ships programmed successively (top figure), the operating time of the first ship is exceeded and therefore the second ship is waiting.

$$\overline{t_{si+1}} \leq t_{si} \quad (4)$$

From the study of the terminal in Constanta, it was observed that the time difference for arrival in terms of the program follows a log-normal distribution, with an average of one hour later than the initial program. However, as the average delay applies to all arrivals, it is not necessary to take it into account in the formulas and only its variation can be used.

Given that $b_i = \overline{t_{si+1}} - t_{si}$, then the ship "*i + 1*" will have to wait whenever $b_i \leq 0$ and, as long as both terms in the equation follow a normal course, the equation (5) is satisfied .

$$b_i = N(\overline{b_i}, \sigma^2_{bi}) = N(\overline{t_{si}} - \overline{t_{si}}, \sigma^2_{tsi} + \sigma^2_{tsi+1}) \quad (5)$$

As $\bar{b}$ increases, the probability of taking place to frame another ship between two successive arrivals, without changing the actual scheduling, increases dramatically (Figure 8).

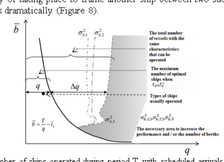


Figure 8. Determining the number of ships operated during period T, with scheduled arrivals.

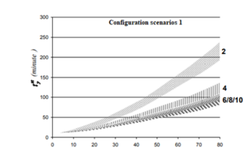


Figure 6. Estimation of values for the optimal quay time, in relation to the number of loading units in scenario 1.

$$t_s = t_0 + t^t + t_y^{st} + t_v^{st}$$

$$\bar{b} = \frac{\sum_i^n b_i}{n} = \frac{T - \sum_i^n t_{si}}{n}$$

$$T = \sum_i^n t_{si} - \sum_i^n b_i$$

Equation (6) shows the number of ships that could be added, where $(\frac{\bar{b}}{t_{si}})^-$ - is the maximum number of ships that would fit in $\bar{b}$ with an operating time t_{si} and the minus signal means that it is rounded to the nearest whole number (Figure 9).

$$\Delta q = Pr\left[\bar{b}_i \geq (\frac{\bar{b}}{t_{si}})^- t_{si}\right] \cdot (\frac{\bar{b}}{t_{si}})^- q] \quad (6)$$

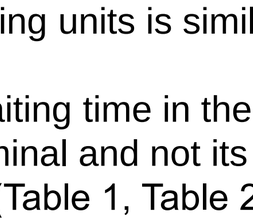


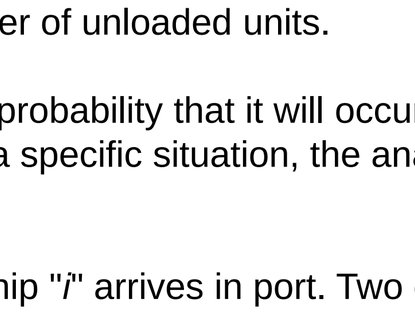
Figure 9. Relationship between the probability of waiting δ, the number of arrivals and the variability of arrival times q and operating time.

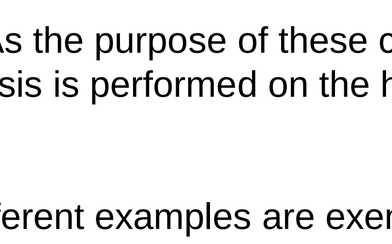
Table 1. Information about time's operation of the vessel.

Vessel's name	Times (Month/day/year/hour)				Berth utilization (%)	Delays before and after last lift
	Berthed	Sailed	First lift	Last lift		
COSCO SHIPPING PANAMA	6/11/22 12:00	6/13/22 5:10	6/11/22 13:30	6/13/22 4:10	1.94%	3.00
CMA CGM TIGRIS	6/14/22 0:50	6/16/22 3:15	6/14/22 2:20	6/16/22 2:45	2.36%	3.00
CMA CGM TANYA	6/18/22 6:45	6/19/22 21:45	6/18/22 7:55	6/19/22 21:10	1.84%	3.59
COSCO SHIPPING SEINE	6/26/22 4:40	6/27/22 23:45	6/26/22 7:35	6/27/22 22:45		4.65

Table 2. Information about time's utilization of cranes on different vessels

Number of utilization	Type of vessel	Time's percent of utilization
401	Main	10.79%
665	Feeder	17.88%
0.00	Common	0.00%





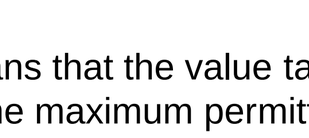


Figure 7. The times of arrivals in port.[3]

$$t_s = t_0 + t^t + t_y^{st} + t_v^{st}$$

$$t_s = 16 \cdot d + 3 \cdot R + 20$$

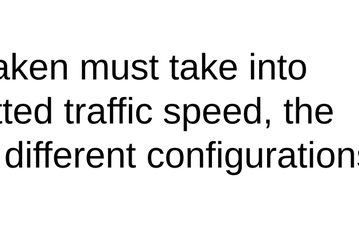


Figure 10. The probability of waiting, given over an average distance b_i and with a random arrival process.

4.RESULTS AND INTERPRETATIONS-1) ships operated for a given average distance and ships that could be served without changing scheduled arrivals at the RO-RO terminal in the Port of Constanta. 2) Relationship between the probability of waiting δ, the number of arrivals q and the variability of arrival times and operating time .Adding the actual values obtained, can be determined what could be the number of ships per day served for operation in optimal conditions (according to planning and operating times).

5. CONCLUSIONS. In the last part of the paper were presented the performance indicators and related calculations. It takes into account whether the arrival pattern is random or scheduled and the time of service provided by the terminal (average value and reliability). The simulation results lead to the estimation of the values for the optimal quay time, in relation to the number of units for loading in the proposed scenarios.

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