The International Maritime Transport and Logistics Conference

"Marlog 10"

Digitalization in Ports & Maritime Industry

10 Marlog 2021

A SIMULATION MODEL FOR ANALYZING AND OPTIMIZING CONTAINER-TERMINAL OPERATIONS

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DIGITALIZATION IN CONTAINER TERMINALS

THE MAIN STEPS

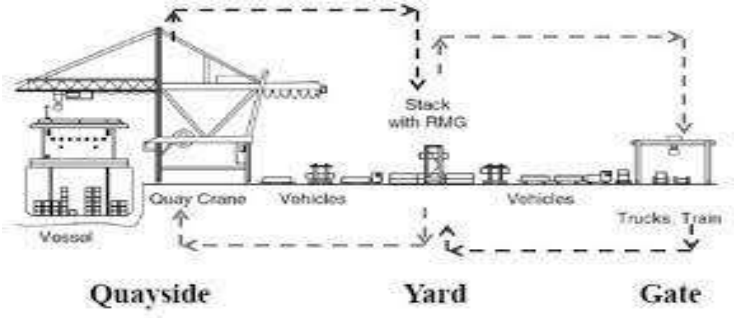
- Data collection
- Scenarios
- Simulation
- Decision making

THE CONTAINER TERMINALS

WHAT IS THE CONTAINER TERMINAL?

The container terminal is a facility where containers are transshipped between different transport vehicles, container vessels, and land vehicles, for example, trains or trucks.

It is divided into 3 main sections quayside, yard, and gates. The containers are discharged from vessels on the quayside where they are stored in temporary buffers called a yard. The terminal is usually connected with the external environment through its gates to in/out the empty and full containers.



THE MAIN OPERATIONAL TARGETS IN THE CONTAINER TERMINALS

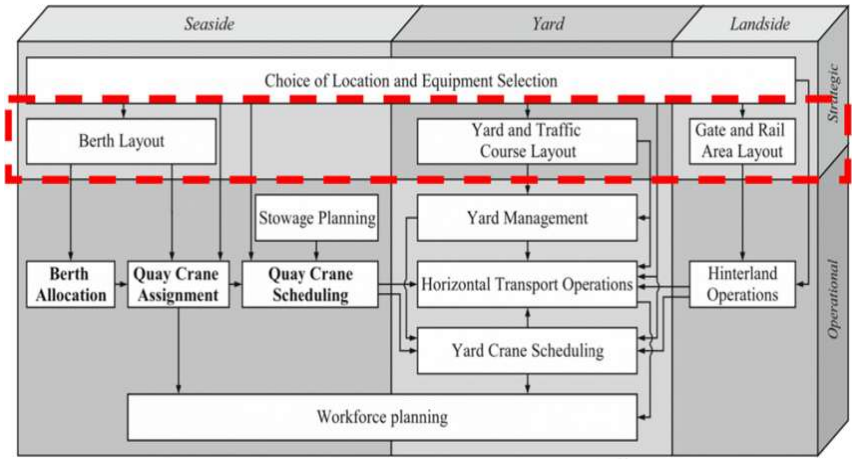
(1) Decreasing the operating duration of vessels to satisfy customers.

(2) Achieving the maximum possible usage of resources to decrease the operating costs.

LOGISTIC DECISIONS IN CONTAINER TERMINALS

RELATED TO PLANNING LEVELS

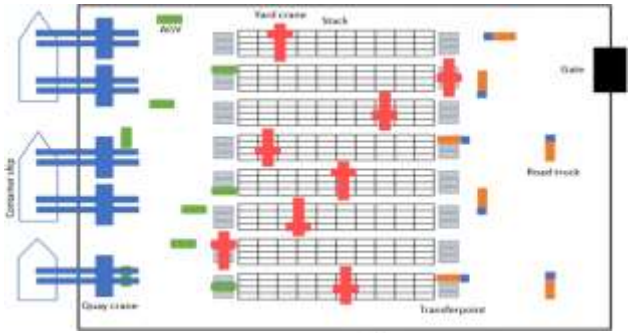
- Strategic
- Tactical
- Operational



EQUIPMENT DEPLOYMENT OPTIMIZATION PROBLEM

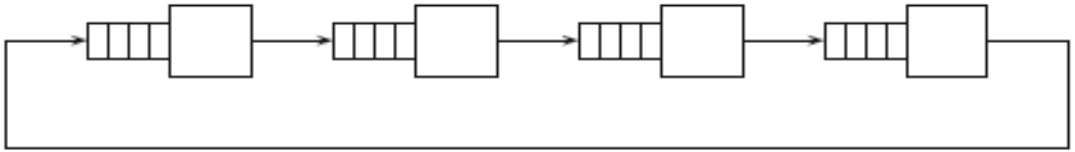
The equipment deployment problem is considered one of the optimization problems. In container terminals, the deployment optimization problem is the problem that relates to the optimal decision of distributing handling equipment in quayside, gates, and yards.

The equipment deployment problem is designed, in container terminals, to get the optimal quantities of equipment in each working point which does not bring the system to the saturation case, long queues, or traffic congestion.



THE EQUIPMENT DEPLOYMENT PROBLEM IN CONTAINER TERMINALS CAN BE SEEN AS A CLOSED QUEUEING NETWORK SYSTEM

In the closed queueing network systems, there are a fixed number of customers who move between some servers. At each server, a service, that takes some time, is provided. Customers approach the servers and processing immediately if the server is idle. Otherwise, customers line up in front of the server and wait to receive service



Accordingly, the system in container terminals can be seen as a closed queueing network system if quay cranes, yard cranes are considered servers and tractors are customers.

DISCRETE EVENT SIMULATION (DES)

Discrete Event Simulation (DES) is a method used to model real-world systems that can be decomposed into a set of logically separate processes that autonomously progress through time. Each event occurs on a specific process and is assigned a logical time (a timestamp). The result of this event can be an outcome passed to one or more other processes. The content of the outcome may result in the generation of new events to be processed at some specified future logical time. The underlying statistical paradigm that supports DES is based on queuing theory. The fact that such models often give "worst-case" scenario evaluations appeal to system designers who prefer to include a safety factor in their designs. Also, the form of the solution of models often provides insight into the form of the solution to a queuing problem whose detailed behavior is poorly mimicked.

PORT SAID CARGO AND CONTAINER HANDLING COMPANY (PSCCHC)

THE DISTINGUISHED LOCATION OF PSCCHC

PSCCHC was constructed on 31/7/1984 in a distinguished location on the north entrance of the Suez Canal in the northeast of Egypt.

This location gives PSCCHC a unique feature, far from marine erosion, which allows vessels to save stability under the quay cranes and to conduct handling operations most days of the year.

Container handling volume reached 623 thousand TEU 2020.

THE OPTIMIZATION CIRCUMSTANCES IN PSCCHC

(1) STORAGE RULES.

Storing containers on slots according to containers' types (local, export, or transit) where different customs procedures are performed

(2) IRREGULAR LAYOUT SHAPE

long distances needed to be crossed by tractors, that might reach up to 2.2 K.M

THE PROPOSED (DES) MODEL

The optimization process after assigning quay cranes on PPSD vessel

Objectives		Constraints	
(1)	Minimizing the average idle percentages of quay cranes, to ensure the lowest operating time for the vessel PPSD in PSCCHC.	(1)	Considering the storage rules in PSCCHC.
(2)	Minimizing the recruited number of handling equipment in the operating processes to ensure the lowest operating cost.	(2)	Overcoming all bottlenecks in the system.

TEST OF FIT RESULTS

USING INPUT ANALYZER PACKAGE

THE TEST OF FIT FOR THE WORKING RATE OF QUAY CRANES

Distribution Summary

Distribution: Triangular
Expression: TRIA(2.45, 2.84, 3)
Square Error: 0.093262

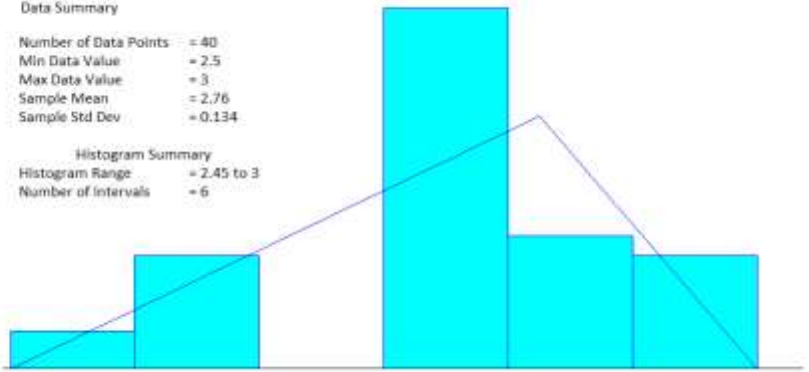
Chi Square Test
Number of intervals = 4
Degrees of freedom = 2
Test Statistic = 15.9
Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.165
Corresponding p-value > 0.15

Data Summary

Number of Data Points = 40
Min Data Value = 2.5
Max Data Value = 3
Sample Mean = 2.76
Sample Std Dev = 0.134

Histogram Summary
Histogram Range = 2.45 to 3
Number of Intervals = 6



THE TEST OF FIT FOR THE WORKING RATE OF YARD CRANES

Distribution Summary

Distribution: Triangular
Expression: TRIA(4.11, 4.9, 6)
Square Error: 0.092225

Chi Square Test
Number of intervals = 4
Degrees of freedom = 2
Test Statistic = 20.2
Corresponding p-value < 0.005

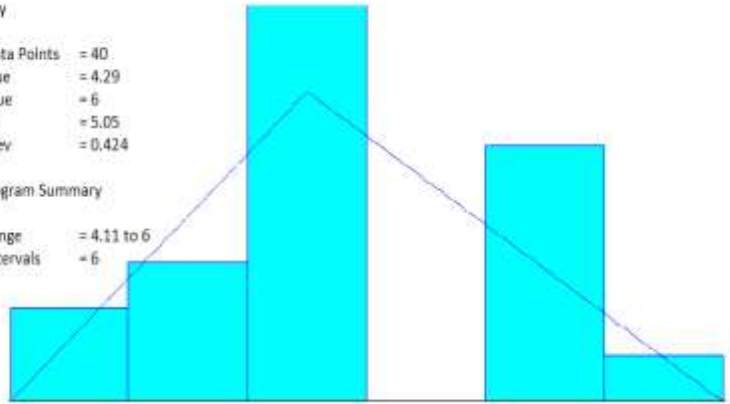
Kolmogorov-Smirnov Test
Test Statistic = 0.27
Corresponding p-value < 0.01

Data Summary

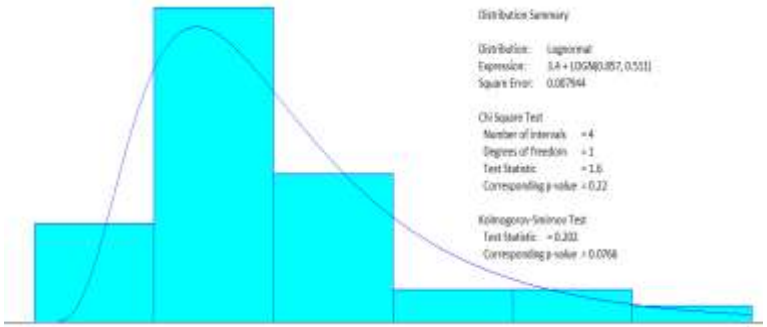
Number of Data Points = 40
Min Data Value = 4.29
Max Data Value = 6
Sample Mean = 5.05
Sample Std Dev = 0.424

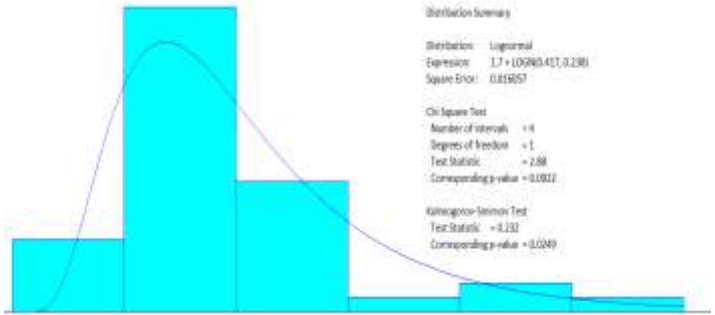
Histogram Summary

Histogram Range = 4.11 to 6
Number of Intervals = 6



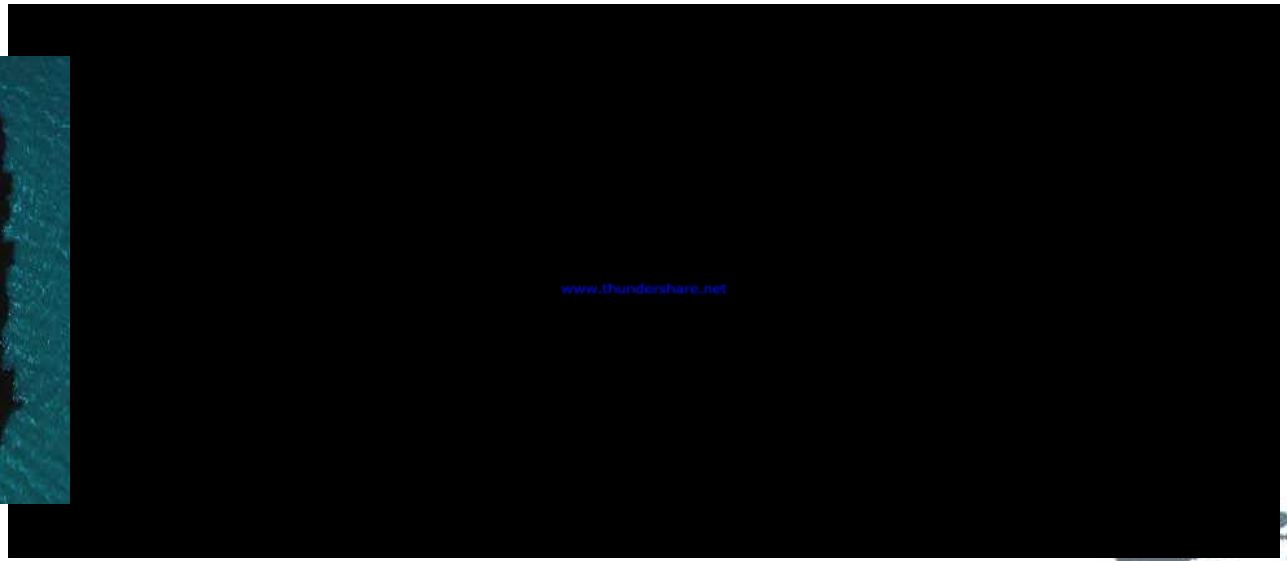
THE TEST OF FIT FOR THE WORKING RATES OF UN/LOADED TRACTORS, RESPECTIVELY





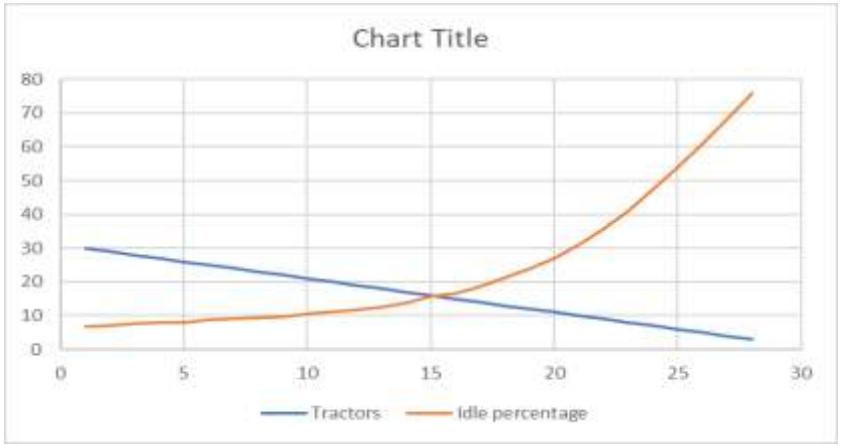
THE PROPOSED DES ON ARENA PACKAGE

QUAY SIDE



SIMULATION RESULTS

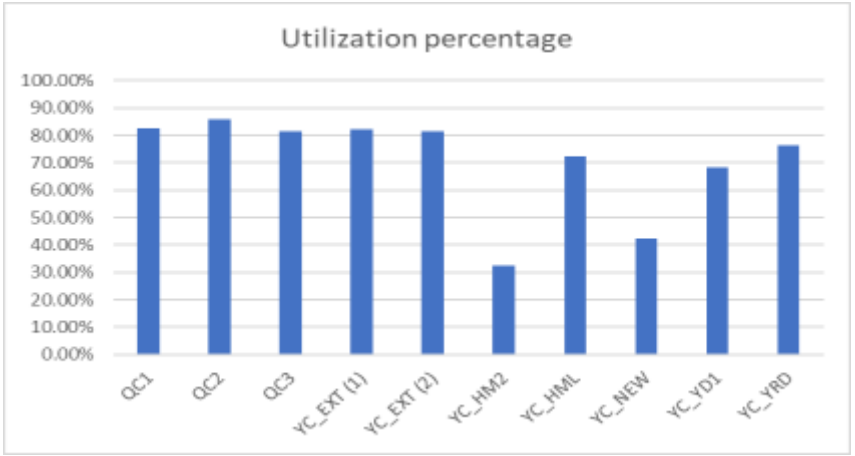
THE GRAPH OF TWO MAIN TARGETS IN PSCCHC



THE EXPECTED AVERAGE IDLE PERCENTAGES OF QUAY CRANES AND TOTAL WORKING TIME WITH THE INCREASING OF TRACTORS NUMBER

TRACTORS	TIME	IDLE PERCENTAGE		TRACTORS	TIME	IDLE PERCENTAGE
30	15:19:00	6.93%		16	16:45:39	15.71%
29	15:18:30	6.97%		15	16:58:20	16.76%
28	15:21:30	7.66%		14	17:20:42	18.59%
27	15:22:10	7.99%		13	17:56:55	21.34%
26	15:24:40	8.04%		12	18:56:53	23.74%
25	15:29:21	8.86%		11	19:22:00	27.09%
24	15:32:35	9.16%		10	20:31:50	31.16%
23	15:39:12	9.48%		9	21:59:58	35.76%
22	15:44:33	9.81%		8	23:56:49	41.00%
21	15:53:2	10.68%		7	26:52:00	47.43%
20	15:55:45	11.06%		6	30:35:59	53.86%
19	16:01:12	11.82%		5	36:00:30	60.77%
18	16:12:36	12.48%		4	44:24:20	68.19%
17	16:22:32	13.74%		3	58:29:25	75.86%

THE UTILIZATION PERCENTAGES OF CANES (QUAY-YARD) IN THE OPTIMAL SOLUTION POINT



CONCLUSION

THE PROPOSED DES SUCCUSSED IN

- Simulating the equipment deployment problem in the PSCCHC.
- Getting the expected bottleneck and solve the problem.
- Getting a set of optimal solutions, each has an expected operating time with accompanying tractors number.
- The chosen solution was 3 qc, 7 yc, and 15 tractors. This achieve 16.76% of the average idle times of quay cranes.

RECOMMENDATION

1. Apply the proposed system in the short-term planning process in the PSCCHC.
2. Use statistical data to reevaluate the un/load vessels and gate operations rules periodically to adjust the suitability of these rules with the continuous changes in the number of vessels and changeable workload in the PSCCHC.
3. Use statistical data to support planning in the PSCCHC, to perform new research that concentrates on the quay cranes deployment problem in the form of a working timetable for each vessel.

THANKS