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# Analysis Risk labor assessment by queuing theory of berth and craft waiting containers to professional's formation in Hazard prevention risk.

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## Abstract

The training in the personnel graduated in the master degree of prevention of hazard risk needs to instruct in time which allows container load to the ship at Dakar port is critical to determinate time anchored ships offshore. The aim of these papers is determinate time necessary to amble each step to carry out the containers from the port stock to the ship .Queuing theory permits to calculate the effect in waiting queue both numbers of container and time promethium critical time in any case. This study analyzes two specific cases with one and two cranes to perform the containers load operations. Thus, instead of actually implementing the solution, the advantages and disadvantages of the suggested solution are studied by simulation technique.

**Keywords**: Senegal, queuing Theory; Labor risk, working time process, occupational prevention services, Professional formation Hazard prevention risk.

## 1. INTRODUCTION

Operations at port are very complicated. The complete situation at the port is very difficult to formulate as a single problem and can be divided into various sub-problems. Each sub-problem in turn can be solved to achieve optimum results **and needs an specifically formation**. The sub-problems thus solved, may not achieve optimum results for the complete problem. Technically we can say that the local optima thus obtained may not lead to global .In addition to this, condition at every port is different and demands various solutions. An attempt therefore is made here to analyze the situation and obtain a generalized solution, which can be applied at various ports. The research may also try to look into similar condition at airports, railways, etc.

The general condition at any sea port can be explained as follows:

1. Containers are stacked in the yards. Stacking can be done as per convenience.
2. .Quays at the ports can have one or more berths.
3. Berths can be of various lengths.
4. Ship-size is also variable.
5. Allocation of berths to ship depends on the length of the ship and berth.
6. Allocation of berth to the ship also depends on the location of containers, depth at the berth, tidal conditions, availability of gantry cranes, manpower allocation, processing time required by the ships.
7. The change in the itinerary may also affect the overall processing time of the vessel.
8. Sometimes the ships do not directly come to the berth. The ship is anchored in the sea and the containers are transported to the ships by small crafts.
9. The queues thus seen are for the containers as well as for the ships.
10. In addition to loading, the containers from ships are to be unloaded at the ports.

This unloading of containers from ships is beyond the scope of this problem.

The main objective here is to reduce the queue of containers at the port and determinate minimum time necessary to security each step by **the security formation in prevention risk Hazard by Post-Graduate Master Degree**. An obvious solution to the problem is to increase the facilities at the port to reduce the queues. Increase in facilities involves increase in number of cranes, increase in number of berths, adding new machinery at the port, and increase in working hours at berths and proper allocation of resources. The investment for these facilities is very high.

Hence it is necessary to verify whether increase in facilities leads to reduction in queues or not. Investments in Ports throughout the world are mainly done on the basis of intuitions. The costs involved are so high that the situation needs rational calculations.

Although the situations at various ports seem to be alike, the situation at each port is unique in its sense. Even minor variations in these situations demand a separate queue model at each and every port. It is not feasible to have a separate system for varying situations at each port. Various situations can be designed, formulated and simulated to obtain results under these situations [1] analyzed various queue models for imports and gave a guideline for investments and proved that increase in cranes and berth facilities does not reduce the queues in the same proportion.

Hence a proper cost analysis is to be carried out to compare various options [2] discussed the practical implications of optimal space allocation and pricing.

Opportunity costs of cargoes, handling costs and price elasticity of dwelling time are the main considerations. [3] discussed ship to shore transfer of cargo from ships that are located offshore. In this case, transport is done using smaller crafts. These crafts cycle back and forth. The queues discussed in this case are that of cargoes at loading and unloading points. [4] looked at this problem from the point of view of optimizing berth and crane combinations in container ports. They optimized the design and operation of container at port. The model thus developed minimizes total port cost.

Efficient planning of berth location for container terminals in Asia was studied and discussed [6]. The objective here was to utilize the terminal efficiently for container ports. The paper focuses on berth allocation that minimizes dissatisfaction of the ships in terms of berthing order and minimizing the sum of the time the ships spend waiting for berths.

System queuing waiting theory presented in the paper, which identifies non-inferior solutions to the berth allocation problem. The berth allocation problems generally discussed are static in nature, in the sense that the allocations are not changed with respect to time. But in actual practice, the change in the itinerary, tidal conditions, non-availability of resources, etc. affect the allocation of ships to various berths [7] developed a heuristic procedure based on Lagrangian relaxation. They conducted a large amount of computational experiments to show that the proposed algorithm could be easily adapted in the real life conditions. Berth al location planning for the ships in the public berth system was done us in genetic [8]. A heuristic procedure was developed based on genetic algorithm. The algorithm was tested using various real life problems and it was found that the algorithm was adaptable to real life situations. Major differences between standard vehicle routing scheduling problems and ship routing problem [9] are:

1. Each ship has unique operating characteristics such as capacity, speed, cost structure, etc. Due to market fluctuations, even two identical ships may have different cost structure.
2. The scheduling environment depend storage at extension the mode of operation of the ship.
3. Ships do not return necessarily return to their origin.
4. Higher uncertainty is involved in scheduling ships due to longer voyages.
5. Ships are operated round the clock while vehicles are usually not operated during the night (except few vehicles such as truck). Thus ships do not have planned idle periods, which absorb delays in operations.
6. Destination of ships may be changed at sea.

## 2. METHODS

There view phasises the fact that the objective of ship routing and scheduling is not always clear, especially in cases where not all cargoes available are known in advance. Linear operations try to maximize the profit per time unit in the long run but may divert from this objective in the short run in order to gain market share. A conceptual model for high speed vessels was developed by [10]. The paper reviews the role of high speed vessels in the context of the total supply chain. A mode choice is presented in the paper within the context of supply chain transport strategies. The model relates mode choice to volume supply, product cost, shipping distance, frequency of service, transit time and product type. The emphasis in this paper is on selection of mode of transport. Containers to be transported by ships at various locations face a very common problem of high waiting times at the port. Export containers arrive at the port before the arrival of the ship.

These containers are stacked at the back of the berths and wait for 3 to 4 days. These containers are then transported to berth and then to the ship. This movement of containers is done through cranes and straddle carriers. The maximum capacity of crane is to handle 30 containers per hour. This handling capacity cannot be achieved at all times because of breakdown of cranes and/or straddle carriers. However, a fairly realistic rate of 18 containers per hour can be considered as good actual rate [1]. The containers are then transported to the ship, which is docked at the berth. There is a possibility of congestion of port and unavailability of berths due to which ships cannot directly come to the port. Sometimes this may happen due to low tide situation or insufficient port facility or early arrival at port. In such cases, the ship is anchored offshore and the containers are transferred to the ship through small crafts. The containers transported from the stack to the berth are loaded on the sea crafts, which in turn transport the containers to the ships, instead of loading the containers to the ships directly. As number containers loaded per crafts is 50, the time taken by the crane to transport the containers to the berth his 2.65 hours (Handling time of crane: 20 containers per hour). The average time of loading the containers to the crafts is considered as 250 min. These small crafts transport the containers further of the ship. The transport time of the crafts depends on the distance of the ship from the berth and the speed of the craft. The mean transport time is considered to be 47.6 min. The containers are finally unloaded from the crafts and loaded to the ship. The average time of unloading of containers from the craft and loading to the ship is considered to be 55.8 min. The entire process of loading the containers to the ship through small crafts is considered to be divided in five processes as follows:

1. Transport to berth by crane: Time for transporting the containers to berth (2.65 hrs).
2. Craft loading: Time to load the containers onto the craft (250/60=4.17 hrs.).
3. Craft transport: Time of transport of the crafts nearer to ship (47.6/60=0.79 hrs.).
4. Ship loading: Time to load the containers into the ship (55.8/60= 0.71 hrs.).

This can be represented schematically. Large queues of containers are formed at the port, when the ship is a chored off shore and the containers are transferred to the ship through small crafts. An attempt is made in this study, to reduce the queue of containers thus formed, using simulation technique. These queuing of processes in option A are simulated to find out the queue at the port. Three more options, which are considered as solution to the problem, are also studied. The number of crane sis increased in these options and in the last option one more berth is introduced. In Option O, only one crane is considered with one berth, as shown in fig. 1. For Option B, two cranes are considered with one berth only, as shown in fig. 2.

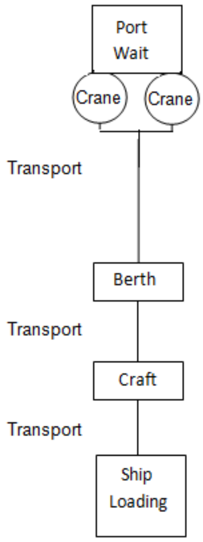

**Figure 1.** One Crane system

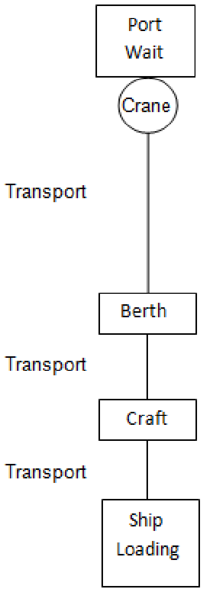

**Figure 2.** Two Cranes system

This can be represented schematically as shown fig 1 and 2, large queues of containers are formed at the port, when the ship is anchored offshore and the containers are transferred to the ship through small crafts. An attempt is made in this study, to reduce the queue of containers thus formed, using simulation technique. The sequence of processes in simulated to find out the queue at the port. Three more options, which are considered as solution to the problem, are also studied. The number of cranes is increased in these options and in the last option one more berth is introduced. In Option A, only one crane is considered with one berth, as shown fig 1. For Option B, two cranes are considered with one berth only, as shown fig 2

### 2.1 Mathematical Models

To use this model, the values for the number of loaders operating, the arrival rate of new trucks, and the service rate per loader must be known to be used as inputs to the model. The necessary inputs were defined previously.

The arrival rate, λ, is the average rate at which new trucks arrive at the loader. The service rate, μ, is the service rate of an individual loader. In cases with more than one loader in operation, all loaders are assumed to be equivalent, so μ would be the average service rate of the loaders. The arrival rate, λ, and service rate, μ, should both be input in the form of trucks per hour [11,12]. Both the arrival rate and the service rate are independent of queue length. The queue will not have impatient customers, since it would be unrealistic for haul trucks to not join the line to be loaded, regardless of how many trucks are already waiting. There would also be no jockeying for position since trucks form a single line to wait to be loaded, with the first truck going to the next available loader. The model uses this information to calculate a variety of outputs about the truck and shovel system.

### 3.1 Equations

Based on this queuing system and input variables, the variables r and ρ are defined as,

$$r = \lambda / \mu \qquad (1)$$

$$\rho = r/c = \lambda / c\,\mu \qquad (2)$$

Where r is the expected number of trucks in service, or the offered workload rate, and ρ is defined as the traffic intensity or the service rate factor. This is a measure of traffic congestion. When ρ > 1, or alternately λ > c μ where c is the number of loaders, the average number of truck arrivals into the system exceeds the maximum average service rate of the system and traffic will continue back up. For situations when ρ > 1 [11,12], the probability that there are zero trucks in the queuing system is defined as

$$P_O = \sum_{n=0}^{C-1} \frac{r^n}{n!} + \left(\frac{r^c}{c!(1-\rho\,)}\right) - 1 \qquad (3)$$

Where n is the number of trucks available in the haulage system. Even in situations with high loading rates, it is extremely likely that trucks will be delayed by waiting in line to be loaded. The queue length will have no definitive pattern when arrival and service rates are not deterministic, so the probability distribution of queue length is based on both the arrival rate and the loading rate [11]. The expected number of trucks waiting to be loaded can be calculated based on using the following equation.

$$L_q = \left(\frac{r^c}{c!(1-\rho\,)}\right) P_0 \qquad (4)$$

The average number of trucks in the queuing system, L, and the average time a truck spends waiting in line, can be found by applying Little's formula which states that the long term average number of customers in a stable system, L, is equal to the long term average effective arrival rate, λ, multiplied by the average time a customer spends in the system.

Algebraically, this is expressed as,

$$L = \lambda W \qquad (5)$$

and can also be applied in the form

$$Lq = \lambda W_q \qquad (6)$$

Using these equations, the average time a truck spends waiting to be loaded, can be calculated as follows.

$$W_q = \left(\frac{r^c}{c!(c\mu)(1-\rho)^2}\right) P_{0} = L_q / \lambda \qquad (7)$$

The average time a truck spends in the system, W, is defined as

$$W_q = \frac{1}{\mu} + \left(\frac{r^c}{c!(c\mu)(1-\rho)^2}\right) P_0 \qquad (8)$$

The model currently supports up to seven loaders operating in parallel, but could easily be adjusted to include more. There is no limit on haul truck fleet size, provided the arrival rate of trucks to the loading system does not increase to the point of overwhelming the loading capacity. This model is only valid for values of ρ, the traffic intensity per server, that are less than one. If ρ were to increase above one, the system would back up indefinitely, as the arrival rate of empty trucks would be greater than the loaders are capable of handling.

Symbols and Abbreviations Po = Probability of system being idle or probability of no customers are being server.

*Ws = Expected waiting time for a customer in the system.*
*Wq = Expected waiting time in queue.*
*Ls = Expected number of customers in the System or length of the system.*
*Lq = Expected number of customers in queue.*
*Uf = Utility factor.*
*μ = Service Pattern.*
*C = Number of Servers in the System. = Arrival rate.*

## 3. RESULTS

**Table 1.** Status data Process, Option A / One Crane

| | **1 Crane** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Process Time | | Capacity to carry out (Loads) | Capacity Load to carry out (Min) | Load Cumulated by previous step time | Capacity Load | Maximum queue |
| Berth by crane at port | 159,00 Min | 2,65 Hours | 19 Loads/hours | 3,18 Min/Load | | | |
| Craft loading | 250,00 Min | 4,167 Hours | 12 Loads/hours | 5,00 Min/Load | -7 Loads/hours | 1,82 Min/Load | **27,47 Loads** |
| Craft transport | 47,60 Min | 0,79 Hours | 63 Loads/hours | 0,95 Min/Load | 75 Loads/hours | 5,95 Min/Load | **8,40 Loads** |
| Ship loading | 55,80 Min | 0,93 Hours | 54 Loads/hours | 1,12 Min/Load | -9 Loads/hours | 0,16 Min/Load | |

**Table 2.** Status data Process Option B / Two Crane

| | **2 Crane** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Process Time | | Capacity to carry out (Loads) | Capacity Load to carry out (Min) | Load Cumulated by previous step time | Capacity Load | Maximum queue |
| Berth by crane at port | 79,50 Min | 1,325 Hours | 38 Loads/hours | 1,59 Min/Load | | | |
| Craft loading | 500,00 Min | 8,33 Hours | 6 Loads/hours | 10,00 Min/Load | -32 Loads/hours | 4,21 Min/Load | **11,89 Loads** |
| Craft transport | 47,60 Min | 0,79 Hours | 63 Loads/hours | 0,95 Min/Load | 57 Loads/hours | 2,26 Min/Load | **22,10 Loads** |
| Ship loading | 55,80 Min | 0,93 Hours | 54 Loads/hours | 1,12 Min/Load | -9 Loads/hours | 0,16 Min/Load | |

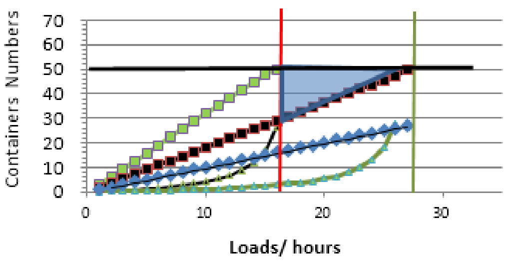

Fig 3 :Variation of percentage waiting time with change in arrival Berth rates with **one Crane**

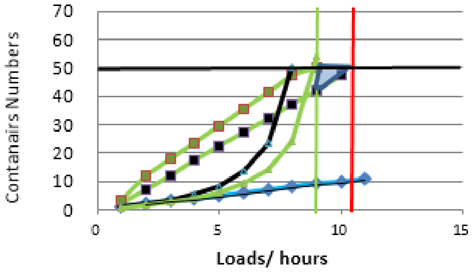

Fig 4 :Variation of percentage waiting time with change in arrival Craft rates with **one Crane**

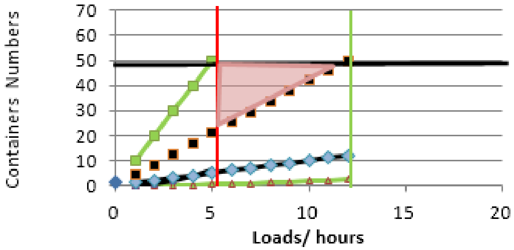

Fig 5 :Variation of percentage waiting time with change in arrival Berth rates with **Two Crane**

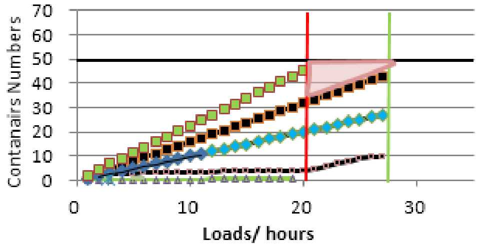

Fig 6 :Variation of percentage waiting time with change in arrival Craft rates with **Two Crane**

Waiting times evaluations in each stage depends on the number of containers can be carry out and else be receive by next step per hour.

**-Case A** with one crane allows carry out 19 Loads/hours while craft loading can only get in 12 per hour, that create a queue 7 loads per hours.

**-Case B** with two cranes let's get out 38 Load/hours ,load admitted to berth is 6 Loads/Hours which created a queue 32 Loads/hours.

Fig 3 , Fig 5 shows difference between load which can deliver and the other which can support the system according to the limitations of the time craft load limitation. Waiting time is higher in fig 3 in the case one crane.

Fig 4, Fig 6 Shows the Loads difference capacity according to the process order priority system, waiting time is lower with one crane. Queue time determinate each phase safety time necessary to conditions to be able to work in an ordered system

Queuing network model is a very useful tool to analyze the performance of a system from an abstract model, transformation technique is proposed to predict queuing network time model. This approach avoids the need for a prototype implementation since we can determine the overall performance from the architectural formation models design which describes with supply chain is modeled.

**Table 3.** Summary of relevant simulated result.

| | Option A | Option B |
|---|---|---|
| Maximum queue at port | **28,00** | **12,00** |
| Maximum queue at berth | **7,00** | **22,00** |
| Crane utilization | **98,00%** | **92,50%** |
| Average waiting time per craft | 6,36 Hrs | 11,97 Hrs |

## 4. CONCLUSIONS

The system simulated for all the four situations and there results obtained follows:

1. Queue at the port decreases by increasing the number of cranes and determinate time necessary to each safety step. Each Step time process Compression is very important to the future professional to improve system process.
2. Although the simulation results show that the maximum queue contents at the port are reduced, this simulation does not consider the breakdown of the cranes, which is a common feature. In addition to this, parallel movement of the cranes is not possible in all cases.
3. Number of cranes is determinate to modification the average time system.
4. The crafts have to wait before coming to berth since they are getting loaded faster due to increase in number of cranes.
5. The increase in queue at berth demands a cost benefit analysis o be done before adding cranes and berth.

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## Anexes

Table 3:Variation of Various Queue characteristics with Change in Arrival Rate

Contaniers Number System by limitation **BERTH** admision **One CRANE**

| 1 Crane | | | | | | | |
|---|---|---|---|---|---|---|---|
| μ | λ | Po | % Utilitation | Lq | Wq | Total | Load |
| 28 | 1 | 0,96 | 4% | 0,00 | 0,00 | 0,08 | 1,82 |
| 28 | 2 | 0,93 | 7% | 0,01 | 0,00 | 0,16 | 3,64 |
| 28 | 3 | 0,89 | 11% | 0,01 | 0,00 | 0,26 | 5,46 |
| 28 | 4 | 0,86 | 14% | 0,02 | 0,01 | 0,36 | 7,28 |
| 28 | 5 | 0,82 | 18% | 0,04 | 0,01 | 0,47 | 9,10 |
| 28 | 6 | 0,79 | 21% | 0,06 | 0,01 | 0,58 | 10,92 |
| 28 | 7 | 0,75 | 25% | 0,08 | 0,01 | 0,71 | 12,74 |
| 28 | 8 | 0,71 | 29% | 0,11 | 0,01 | 0,86 | 14,56 |
| 28 | 9 | 0,68 | 32% | 0,15 | 0,02 | 1,02 | 16,38 |
| 28 | 10 | 0,64 | 36% | 0,20 | 0,02 | 1,19 | 18,20 |
| 28 | 11 | 0,61 | 39% | 0,25 | 0,02 | 1,39 | 20,02 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 28 | 12 | 0,57 | 43% | 0,32 | 0,03 | 1,61 | 21,84 |
| 28 | 13 | 0,54 | 46% | 0,40 | 0,03 | 1,86 | 23,66 |
| 28 | 14 | 0,50 | 50% | 0,50 | 0,04 | 2,14 | 25,48 |
| 28 | 15 | 0,46 | 54% | 0,62 | 0,04 | 2,47 | 27,30 |
| 28 | 16 | 0,43 | 57% | 0,76 | 0,05 | 2,86 | 29,12 |
| 28 | 17 | 0,39 | 61% | 0,94 | 0,06 | 3,31 | 30,94 |
| 28 | 18 | 0,36 | 64% | 1,16 | 0,06 | 3,86 | 32,76 |
| 28 | 19 | 0,32 | 68% | 1,43 | 0,08 | 4,52 | 34,58 |
| 28 | 20 | 0,29 | 71% | 1,79 | 0,09 | 5,36 | 36,4 |
| 28 | 21 | 0,25 | 75% | 2,25 | 0,11 | 6,43 | 38,22 |
| 28 | 22 | 0,21 | 79% | 2,88 | 0,13 | 7,86 | 40,04 |
| 28 | 23 | 0,18 | 82% | 3,78 | 0,16 | 9,86 | 41,86 |
| 28 | 24 | 0,14 | 86% | 5,14 | 0,21 | 12,86 | 43,68 |
| 28 | 25 | 0,11 | 89% | 7,44 | 0,30 | 17,86 | 45,5 |
| 28 | 26 | 0,07 | 93% | 12,07 | 0,46 | 27,86 | 47,32 |
| 28 | 27 | 0,04 | 96% | 26,04 | 0,96 | 45,00 | 50,00 |

Table 4:Variation of Various Queue characteristics with Change in Arrival Rate
Contaniers Number System by Real performance **CRANE** Capacity **One CRANE**

| 1 Crane | | | | | | | |
|---|---|---|---|---|---|---|---|
| μ | λ | Po | % Utilitation | Lq | Wq | Total | Load |
| 18 | 1 | 0,94 | 6% | 0,00 | 0,00 | 0,20 | 3,10 |
| 18 | 2 | 0,89 | 11% | 0,01 | 0,01 | 0,42 | 6,36 |
| 18 | 3 | 0,83 | 17% | 0,03 | 0,01 | 0,67 | 9,54 |
| 18 | 4 | 0,78 | 22% | 0,06 | 0,02 | 0,95 | 12,72 |
| 18 | 5 | 0,72 | 28% | 0,11 | 0,02 | 1,28 | 15,90 |
| 18 | 6 | 0,67 | 33% | 0,17 | 0,03 | 1,67 | 19,08 |
| 18 | 7 | 0,61 | 39% | 0,25 | 0,04 | 2,12 | 22,26 |
| 18 | 8 | 0,56 | 44% | 0,36 | 0,04 | 2,67 | 25,44 |
| 18 | 9 | 0,50 | 50% | 0,50 | 0,06 | 3,33 | 28,62 |
| 18 | 10 | 0,44 | 56% | 0,69 | 0,07 | 4,17 | 31,80 |
| 18 | 11 | 0,39 | 61% | 0,96 | 0,09 | 5,24 | 34,98 |
| 18 | 12 | 0,33 | 67% | 1,33 | 0,11 | 6,67 | 38,16 |
| 18 | 13 | 0,28 | 72% | 1,88 | 0,14 | 8,67 | 41,34 |
| 18 | 14 | 0,22 | 78% | 2,72 | 0,19 | 11,67 | 44,52 |
| 18 | 15 | 0,17 | 83% | 4,17 | 0,28 | 16,67 | 47,70 |
| 18 | 16 | 0,11 | 89% | 7,11 | 0,44 | 26,67 | 50,00 |

Table 5:Variation of Various Queue characteristics with Change in Arrival Rate
Contaniers Number System by Real performance **BERTH** Capacity **One CRANE**

| 1 Crane | | | | | | | |
|---|---|---|---|---|---|---|---|
| μ | λ | Po | % Utilitation | Lq | Wq | Total Horas | Load |
| 9 | 1 | 0,89 | 11% | 0,01 | 0,01 | 0,83 | 3,00 |
| 9 | 2 | 0,78 | 22% | 0,06 | 0,03 | 1,90 | 11,84 |
| 9 | 3 | 0,67 | 33% | 0,17 | 0,06 | 3,33 | 17,76 |
| 9 | 4 | 0,56 | 44% | 0,36 | 0,09 | 5,33 | 23,68 |
| 9 | 5 | 0,44 | 56% | 0,69 | 0,14 | 8,33 | 29,60 |
| 9 | 6 | 0,33 | 67% | 1,33 | 0,22 | 13,33 | 35,52 |
| 9 | 7 | 0,22 | 78% | 2,72 | 0,39 | 23,33 | 41,44 |
| 9 | 8 | 0,11 | 89% | 7,11 | 0,89 | 53,33 | 47,36 |
| 9 | 9 | 0,05 | 95% | 18,05 | 2,01 | 65,00 | 50,00 |

Table 6:Variation of Various Queue characteristics with Change in Arrival Rate
Contaniers Number System by limitation **CRAFT** admision **One CRANE**

| 1 Crane | | | | | | | |
|---|---|---|---|---|---|---|---|
| μ | λ | Po | % Utilitation | Lq | Wq | Total Horas | Load |
| 10 | 1 | 0,91 | 9% | 0,01 | 0,01 | 0,55 | 2,20 |
| 10 | 2 | 0,80 | 20% | 0,05 | 0,03 | 1,50 | 7,20 |
| 10 | 3 | 0,70 | 30% | 0,13 | 0,04 | 2,57 | 12,20 |
| 10 | 4 | 0,60 | 40% | 0,27 | 0,07 | 4,00 | 17,20 |
| 10 | 5 | 0,50 | 50% | 0,50 | 0,10 | 6,00 | 22,20 |
| 10 | 6 | 0,40 | 60% | 0,90 | 0,15 | 9,00 | 27,20 |
| 10 | 7 | 0,30 | 70% | 1,63 | 0,23 | 14,00 | 32,20 |
| 10 | 8 | 0,20 | 80% | 3,20 | 0,40 | 24,00 | 37,20 |
| 10 | 9 | 0,10 | 90% | 8,10 | 0,90 | 54,00 | 42,20 |
| 10 | 10 | 0,05 | 95% | 18,05 | 1,81 | 58,00 | 50,00 |

Table 7:Variation of Various Queue characteristics with Change in Arrival Rate
Contaniers Number System by limitation **BERTH** admision **Two CRANE**

| 2 Crane | | | | | | | |
|---|---|---|---|---|---|---|---|
| μ | λ | Po | % Utilitation | Lq | Wq | Total | Load |
| 12 | 1 | 0,92 | 8% | 0,00 | 0,0003 | 0,02 | 0,02 |
| 12 | 2 | 0,84 | 17% | 0,00 | 0,0012 | 0,07 | 0,09 |
| 12 | 3 | 0,76 | 25% | 0,01 | 0,0026 | 0,15 | 0,24 |
| 12 | 4 | 0,68 | 33% | 0,02 | 0,0045 | 0,27 | 0,51 |
| 12 | 5 | 0,61 | 42% | 0,04 | 0,0071 | 0,42 | 0,94 |
| 12 | 6 | 0,55 | 50% | 0,06 | 0,0101 | 0,61 | 1,54 |
| 12 | 7 | 0,48 | 58% | 0,10 | 0,0137 | 0,82 | 2,36 |
| 12 | 8 | 0,43 | 67% | 0,14 | 0,0179 | 1,07 | 3,44 |
| 12 | 9 | 0,38 | 75% | 0,20 | 0,0226 | 1,36 | 4,79 |
| 12 | 10 | 0,33 | 83% | 0,28 | 0,0281 | 1,69 | 6,48 |
| 12 | 11 | 0,29 | 92% | 0,38 | 0,0344 | 2,06 | 8,55 |
| 12 | 12 | 0,25 | 100% | 0,50 | 0,0417 | 2,50 | 50,00 |

Table 8:Variation of Various Queue characteristics with Change in Arrival Rate
Contaniers Number System by Real performance **BERTH** Capacity **Two CRANE**

| 2 Crane | | | | | | | |
|---|---|---|---|---|---|---|---|
| μ | λ | Po | % Utilitation | Lq | Wq | Total | Load |
| 5 | 1 | 0,80 | 20% | 0,00 | 0,0040 | 0,24 | 10,00 |
| 5 | 2 | 0,63 | 40% | 0,03 | 0,0156 | 0,94 | 20,00 |
| 5 | 3 | 0,47 | 60% | 0,10 | 0,0347 | 2,08 | 30,00 |
| 5 | 4 | 0,35 | 80% | 0,25 | 0,0620 | 3,72 | 40,00 |
| 5 | 5 | 0,25 | 100% | 0,50 | 0,1000 | 6,00 | 50,00 |

Table 9:Variation of Various Queue characteristics with Change in Arrival Rate
Contaniers Number System by limitation **CRAFT** admision **Two CRANE**

| **2 Crane** | | | | | | | |
|---|---|---|---|---|---|---|---|
| μ | λ | Po | % Utilitation | Lq | Wq | Total | Load |
| 22 | 1 | 0,95 | 5% | 0,00 | 0,0000 | 0,00 | 2,26 |
| 22 | 2 | 0,91 | 9% | 0,00 | 0,0002 | 0,01 | 4,52 |
| 22 | 3 | 0,86 | 14% | 0,00 | 0,0004 | 0,03 | 6,78 |
| 22 | 4 | 0,82 | 18% | 0,00 | 0,0007 | 0,04 | 9,04 |
| 22 | 5 | 0,78 | 23% | 0,01 | 0,0012 | 0,07 | 11,30 |
| 22 | 6 | 0,74 | 27% | 0,01 | 0,0017 | 0,10 | 13,56 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 22 | 7 | 0,70 | 32% | 0,02 | 0,0023 | 0,14 | 15,82 |
| 22 | 8 | 0,66 | 36% | 0,02 | 0,0029 | 0,18 | 18,08 |
| 22 | 9 | 0,62 | 41% | 0,03 | 0,0037 | 0,22 | 20,34 |
| 22 | 10 | 0,58 | 45% | 0,05 | 0,0046 | 0,27 | 22,60 |
| 22 | 11 | 0,55 | 50% | 0,06 | 0,0055 | 0,33 | 24,86 |
| 22 | 12 | 0,51 | 55% | 0,08 | 0,0065 | 0,39 | 27,12 |
| 22 | 13 | 0,48 | 59% | 0,10 | 0,0077 | 0,46 | 29,38 |
| 22 | 14 | 0,45 | 64% | 0,12 | 0,0089 | 0,53 | 31,64 |
| 22 | 15 | 0,42 | 68% | 0,15 | 0,0102 | 0,61 | 33,90 |
| 22 | 16 | 0,39 | 73% | 0,19 | 0,0116 | 0,70 | 36,16 |
| 22 | 17 | 0,36 | 77% | 0,22 | 0,0131 | 0,79 | 38,42 |
| 22 | 18 | 0,34 | 82% | 0,27 | 0,0148 | 0,89 | 40,68 |
| 22 | 19 | 0,31 | 86% | 0,31 | 0,0165 | 0,99 | 42,94 |
| 22 | 20 | 0,29 | 91% | 0,37 | 0,0184 | 1,11 | 45,20 |
| 22 | 21 | 0,27 | 95% | 0,43 | 0,0205 | 1,23 | 50,00 |

Table 10:Variation of Various Queue characteristics with Change in Arrival Rate
Contaniers Number System by limitation **CRAFT** admision **Two CRANE**

| **2 Crane** | | | | | | | |
|---|---|---|---|---|---|---|---|
| μ | λ | Po | % Utilitation | Lq | Wq | Total | Load |
| 29 | 1 | 0,97 | 3% | 0,00 | 0,0000 | 2,73 | 1,59 |
| 29 | 2 | 0,93 | 7% | 0,00 | 0,0001 | 2,75 | 3,18 |
| 29 | 3 | 0,90 | 10% | 0,00 | 0,0002 | 2,78 | 4,77 |
| 29 | 4 | 0,86 | 14% | 0,00 | 0,0003 | 2,82 | 6,36 |
| 29 | 5 | 0,83 | 17% | 0,00 | 0,0005 | 2,87 | 7,95 |
| 29 | 6 | 0,80 | 21% | 0,00 | 0,0007 | 2,93 | 9,54 |
| 29 | 7 | 0,76 | 24% | 0,01 | 0,0010 | 3,00 | 11,13 |
| 29 | 8 | 0,73 | 28% | 0,01 | 0,0013 | 3,08 | 12,72 |
| 29 | 9 | 0,70 | 31% | 0,01 | 0,0016 | 3,17 | 14,31 |
| 29 | 10 | 0,67 | 34% | 0,02 | 0,0020 | 3,28 | 15,90 |
| 29 | 11 | 0,64 | 38% | 0,03 | 0,0024 | 3,39 | 17,49 |
| 29 | 12 | 0,61 | 41% | 0,03 | 0,0029 | 3,51 | 19,08 |
| 29 | 13 | 0,59 | 45% | 0,04 | 0,0034 | 3,65 | 20,67 |
| 29 | 14 | 0,56 | 48% | 0,05 | 0,0039 | 3,79 | 22,26 |
| 29 | 15 | 0,53 | 52% | 0,07 | 0,0045 | 3,79 | 23,85 |
| 29 | 16 | 0,51 | 55% | 0,08 | 0,0051 | 3,79 | 25,44 |
| 29 | 17 | 0,48 | 59% | 0,10 | 0,0057 | 3,79 | 27,03 |
| 29 | 18 | 0,46 | 62% | 0,12 | 0,0064 | 3,79 | 28,62 |
| 29 | 19 | 0,44 | 66% | 0,14 | 0,0071 | 3,79 | 30,21 |
| 29 | 20 | 0,41 | 69% | 0,16 | 0,0079 | 3,79 | 31,80 |
| 29 | 21 | 0,39 | 72% | 0,18 | 0,0087 | 4,79 | 33,39 |
| 29 | 22 | 0,37 | 76% | 0,21 | 0,0096 | 5,79 | 34,98 |
| 29 | 23 | 0,35 | 79% | 0,24 | 0,0105 | 6,79 | 36,57 |
| 29 | 24 | 0,33 | 83% | 0,28 | 0,0115 | 7,79 | 38,16 |
| 29 | 25 | 0,32 | 86% | 0,31 | 0,0125 | 8,79 | 39,75 |
| 29 | 26 | 0,30 | 90% | 0,35 | 0,0136 | 9,79 | 41,34 |
| 29 | 27 | 0,28 | 93% | 0,40 | 0,0147 | 9,79 | 42,93 |
| 29 | 28 | 0,27 | 97% | 0,45 | 0,0159 | 10,79 | 44,52 |
| 29 | 29 | 0,25 | 100% | 0,50 | 0,0172 | 11,79 | 50,00 |