CAPACITY PLANNING ANALISYS FOR SERVICE STEEL PRODUCTS HARBOR

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ABSTRACT
The problem of calculating future capacity of a projected port involves several uncertainties, which means that it is not possible to find a single formula that considers the interaction of the different variables affecting the port's operational performance, particularly considering that many of these variables are related to stochastic distributions and restrictions in shared resources. Only a simulation model can consider all the variables and produce a reliable projection of the port's future behavior. It is very important to precisely estimate the figures because the demurrage costs grows exponentially as the port's occupancy moves toward 100%, which directly affects the project's feasibility.

Keywords: harbour, simulation, steel, investments

1. INTRODUCTION

1.1. Objectives

The objective of this project is to be able to compare different investment options for the projected port –yet to be built– at ArcelorMittal Tubarao, a port that will receive coal and dispatch steel products. The project is focused in evaluating the capacity of different possible combinations of equipment and facilities in order to reach the desired operating capacity with the minimum investment, considering different market scenarios.

As Silva (1999) stated, the port must be able to seamlessly organize and maintain continuous flows, becoming more efficient while processing bigger flows of merchandize in less time, lowering the costs where possible. In order to move the high volume loads required, modern ports have implemented computers and automatic systems to select the best transporting strategies –beyond overhead crane managing–, which, followed by only one person, can attain the results of hundreds of cargo loaders, diminishing drastically the cost of services, and quickening the operations.

Besides this analysis, it should be taken into account that the Brazilian ports suffer the indifference of the responsible parts towards the expansion of the exporting market, the modernization of ports, the (unnecessary high) costs of cabotage or their lack of interest in the naval industry, as mentioned by Oliveira (2000)

Another important limitation are the inefficiencies and high operational costs created by applying traditional but outdated costing and evaluation techniques, which embroil the predictions about the system. Thus very important decisions are the result of outdated estimative policies which results in improper cost estimation, which severely modify the project apparent feasibility.

This work attempts to develop a method to optimize the investment decisions, taking into account the scenario limitations, aiming for the critical processes involved. Making use of model simulation techniques is possible to validate different scenarios and alternatives in order to be able to detect the highest operational effectiveness while reducing the needed investment and minimizing the operational costs. This method solves the problem of locating the berths, cranes, overhead cranes, conveyor belts and other high cost critical equipment.

1.2. Problem Definition

According to Guan and Cheung (2004) the problem of allocating berths for the ships to arrive will be considered as a resource allocating problem.

As Moon (2000) defined, the problem consists in determine the location and berthing time of each arriving ship. Therefore the planning consists in assigning each free berth to one arriving ship before its effective arrival to the berth itself.

According to Brown, Cormican e Lawphongpanich (1997), requests of berth changing, delays and advanced arrivals routinely happen and should be taken into account, since they will cause frequent revisions of the approved plan.

Due to this high frequency of occurrence, a careful berthing allocation plan is necessary in order to avoid incurring in penalties miscalculations and delays (BROWN et al., 1994).

A typical port, constituted by berths, must be able to host multiple ships at the same moment (GUAN; CHEUNG, 2004). When there are no berths available, the ship must wait its turn behind the docking bar. The port entering can only be made through the only channel access which can only be used by a ship at a time (either to arrive or depart). The priority is given to loaded arriving ships.

Guan e Cheung (2004) name the sum of waiting time and processing time (servicing time) of a ship as its “flowing time”

According to Moon (2000), each ship needs a specific area and time at the berth in order to unload and load the corresponding cargo. During this process, different variables must be taken into account, such as the ship type and its particular waiting time, the amount of the products to be loaded or unloaded, and the delay that any product may have.

Since the moment of arrival of any ship can be perfectly considered a random variable, it is not necessary to predict the precise arrival of each ship. IN the practice it is impossible to planify the precise time for each ship arrival.

At the beginning of each month , the system generates a number of ships corresponding to month´s shipping program; then a UNIFORM(0, 30) days delay is assigned to each ship.. Dividing the month in regular periods will not produce a realistic pattern; the selected approach generates a Poisson distribution for time between ships arrivals, which is reasonable considering the multiple factors affecting ships traveling time.

The second most important random factor of the port model is the servicing time, the time that the ship has to stay berthed. It is very important due to the long time it involves and the high variance it possesses. Factors such as equipment malfunction or availability, production delays, weather, truck availability, entrance channel availability and other random factors create a complex problem that can be easily implemented into the simulation model but that is impossible to predict from a plain pre-made formula.

Therefore this factor will also affect with its own randomness the waiting time of the arriving ships, creating a highly random port behavior. It is notable that due to these very same factors the randomness of the system increases dramatically when the port occupation approaches to the 100%

1.3. Modeling

This model was developed using the software ARENA 11.0. It includes operations of coal reception and handling –by conveyors– and steel products retrieval, loading and dispatching.

The model considers the possibility of operating with different configurations of unloading equipment, cranes, berths, and conveyors, as well as the ability to vary the capacities of each and every resource in order to be able to contrast diverse available situations.

Different types of ships where defined varying the capacities, load compositions and resources needed to unload. Different demand scenarios can be modeled modifying the arrival frequencies of the types of ships and the desired dispatching schedule.

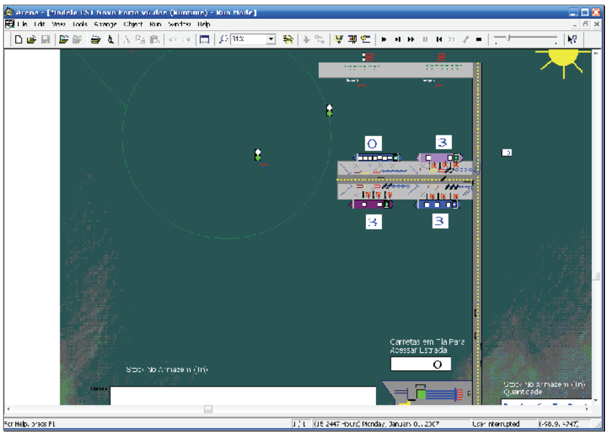

Figure 1: Screenshot of the model while running

1.4. Systems description

This system is composed by two sub-systems almost independent: The Coal System, and The Products System.

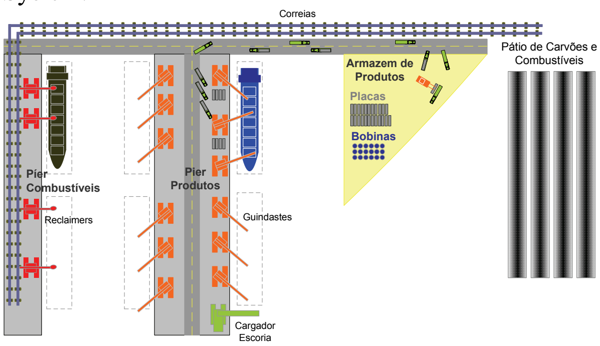

Figure 2: Harbor Layout

1.4.1. The Coal System

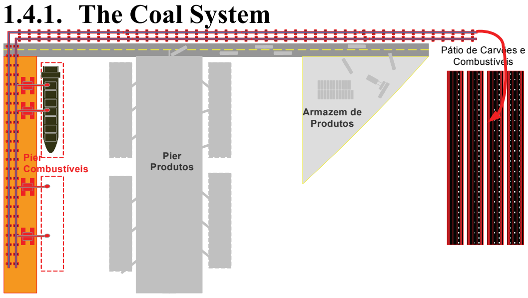

Figure 3: Coal System Layout

The project defines a harbors dedicated to receiving coal. These harbors can only be configured with one or two berths.

Unloading equipment will extract the coal from the ship and discharge it on a system of conveyors that will move away it into the storing area. Special restrictions exist in order to avoid mixing different kinds of coal, since they will be sharing conveyors.

Up to three unloading equipments may attend a single ship, but if needed, unloading equipment may simultaneously attend two ships at the time.

1.4.2. The Products System

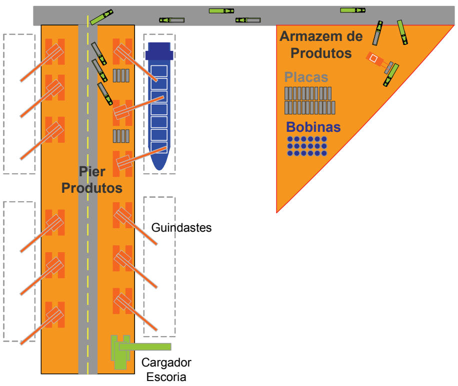

Figure 4: Layout of Products System

This system is composed by two connected harbors and a two-way route to the land. The number of berths may be easily set to one, two, tree or four, while any number of cranes may be assigned.

Several kinds of products will be loaded by cranes: slabs, coils, and other steel products. Cranes can move slabs in groups of two or tree, but have to move individually each coil.

Products will be transported by trucks from the storage area to the corresponding berth so the crane loads the ship with its cargo.

Cranes also have to carefully situate each product in the ship, demanding time. Each truck will have to wait until a proper crane is available, generating a queue for each berth.

Up to three cranes may simultaneously attend a single ship, if available. Cranes may be shared by different ships, since each crane can move to another ship as soon as it finishes its last task (which may or may not finish the ship's task queue).

It is critical to verify the interferences among the different trucks moving both ways, avoiding collisions and checking if the road's capacity is enough.

2. CASE STUDY

Since CST shares its port with other companies, as the port occupancy grows, the operational costs will increase exponentially, turning port operations extremely expensive. As CST is involved in an ambitious expansion plan, this will require the construction of a completely new port, which will operate at the required volume while maintaining competitive costs.

2.1. Scenario Definitions

Possible future scenarios were defined varying the frequency of each type of ship and balancing the steel products outcome with the coal that the new scenario involves.

			Jan	Feb	Mar
Product Ships					
Ship Type	Product Type	Shipment (Tn)			
P1	Slabs	55000	1	1	
P2	Slabs	40000	3	3	
P3	Coil	20000	5	5	
P4	Coil	10000	19	20	
P5	Various	18000	2	2	
P6	Slag	50000	1	1	
Coal Ships					
Ship Type	Variety of Coals	Shipment (Tn)			
C1	1	30000	1	0	
C2	1	55000	1	1	
C3	1	75000	1	2	
C4	2	75000	2	2	
C5	3	75000	1	1	
C6	4	75000	0	0	

Figure5: Definition of Demand Scenario

Demand was defined on a monthly basis, considering variations of production level during the year. The arrival frequency of each type of ship was created generating a number of ships corresponding to each month, and assigning to each ship a random delay time of UNIFORM (0,30) days; resulting in a Poisson pattern of arrivals.

2.2. Investment Alternatives Definitions

Several variables, involving mayor investments, were used to define alternatives, each one requires a different level of investment, as well as different combinations of assets may be performed using the same budget.

Coal system

- Number of berths
- Number of Stacker Equipment
- Type and capacity of Stacker Equipment
- Conveyors capacity

Products System

- Number of berths
- Number of cranes
- Capacity of cranes
- Space available for trucks waiting at harbor
- Time to relocate crane in other berth
- Time to load truck at warehouse
- Number of trucks available

It was difficult to calculate the best combination of assets to reach the required capacity, due to multiple and dynamic bottlenecks in the system.

Different combination of assets will result in bottlenecks at different points in different moments. Only the simulation can find the expected performance under each combination of assets and considering different scenarios

Each alternative involves a different combination of assets, that is, more of one type of asset and less of the other type. For Instance: We can build a bigger channel allowing two ships circulating at the same time, and build less berths. Total ship time in harbor (time in berth + time waiting)

	Scen. 1	Scen. 2	Scen. N
Capacity of Access Channel	1	2	2
Number of Berths	6	4	2
Number of Cranes	4	6	3
Capacity of Cranes (ton/h)	1200	1000	1500
Crane Equipments Reliability	95%	95%	97%
Number of Stacker Equipment	1	2	3
Capacity of Unload Eq. (n/h)	1000	1500	2500
Number of Conveyors	1	2	2
Capacity of Conveyors (ton/h)	1800	900	2000

Several combinations may sum the same level of investment, but may differ in their expected performance.

By linear calculations of capacity balance it is impossible to reach results in terms of Demurrage costs, etc.

Testing about 20 scenarios, it was possible to find many scenarios acceptable in terms of: Reaching Operational Capacity, reduced costs of Demurrage, acceptable Supply Reliability and acceptable Service level to Client´s Ships.

More important, we could test the design under different demand scenarios and select those (about 4) showing a robust behavior under a wide range of situations, and select those that allow us to minimize the investment.

3. CONCLUSIONS

Investments alternatives may vary by at ranges of US$ millions, according to the decision of acquiring more equipments or cranes, or the amount of berths to be built, etc.

The model may be possible to reach the same capacity, involving substantially different amount of investments; that means it was possible to optimize the required investment.

Additionally, alternatives apparently good in certain scenarios may be inadequate to other common scenarios.

The model allowed CST to find the investments alternatives that reach the expected capacity, while maintaining demurrage costs limited in all scenarios, and minimizing the required investment as well.

3.1. Profit Analysis

The usage of the model may save CST unnecessary equipment investments and prevent choosing an alternative which may generate excessive demurrage costs in certain scenarios.

4. LITERATURE REVIEW

As previously said, most of the studies focus on strategic and tactical problems related to container operations, while avoiding researches about specific problems of berth allocation.

Kim e Moon (2003) use integer linear programming (ILP) in order to solve the problem using LINDO®. The computational time it took to solve each situation increased noticeably while considering more than 7 berths and the planning horizon was beyond 72 hours. Thus the conclusion that it was impossible to solve the problem through integer lineal programming was reached, and a Simulated Annealing algorithm was suggested to solve berth assignments optimization problems.

Lim (1998) modeled the problem as a restricted version of a bi-dimensional storing problem, shown succinctly trough a graph. In his solution proposal, he considered a fix berthing time, managing the ship berthing locations. At the Park and Kim (2003) research, a crane and berth managing program is proposed.

Imai, Nishimura e Papadimitriou (2001) considered the problem of berth allocation for commercial ports. In first place, it considers the problem as a static berth allocation problem (SBAP), which can be formulated as a integer three-dimensional attribution, assuming that every ship is already waiting at the port while the berthing plan is defined. Afterwards, attempts to consider the problem as a dynamic berth allocation problem (DBAP), which assumes that it is known when each ship arrives, and they only approach the port when the corresponding berth is available.

Imai, Nagaiwa and Tat (1994) suggested an algorithm that minimizes the sum of the waiting times of the ships at the port, also minimizing the insatisfaction in terms of berthing order. The berth allocation problem initially defined as a nonlinear multicriterial integer problem is redefined as a simple attributions problem. One of the latest works of Imai, Nishimura e Papadimitriou (2005) uses some assumptions taken from Imai, Nishimura e Papadimitriou (2001), considering that the manipulation time of the ship depends on where it is berthed.

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