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# The optimization of utilization of container terminal berth -the case of X container terminal Ltd(XCT)

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## ABSTRACT

This article is a study in the theory and practice of the current container terminal's berth utilization. It introduces the berth system and analyses the main calculation methods of berth utilization. Then it takes the berth utilization of X Container Terminal Company into selective analysis and depth study. Finally, it presents an optimizing strategy to the berth utilization of the company which is much to the point. It describes in detail in terms of the planning of ship's fixer schedule, optimized dispatching of the terminal resources and other factors. It provides a theoretical reference for the company to enhance berth utilization. It gives some suggestions to improve the berth utilization for X Container Terminal Company.

## KEYWORDS

Container terminal; Calculation; Berth utilization; Optimization; XCT.



## INTRODUCTION OF BERTH SYSTEM

The berths system of XCT divide into two parts. Length of part A (Berth3 to Berth7) is 1428.7 B(Berth9 to Berth10), which is bit smaller with length of 363 meters and depth of 9.4 meters, berth width of part B is 45.5 meters.

### Analysis of berth plan work flow

From viewpoint of management of berth plan, planners have to know vessels movement exactly and allocate resources appropriately, planners should assist shipping companies to control the shipping routes and avoid overdue work, from viewpoint of inner management, planners also should coordinate with other departments to meet the special request from customers. The berth plan work flow is shown in Figure 1.

### Information flow analysis of berth planning system

As the core management system of terminal operation, berth planning system is also the starting and ending point for operation. Before a vessel calling, the berth planning should be confirmed which could insure schedule of voyages are reasonable. If booking attains saturation, the company should reconsider to adjust schedule of voyages or choose other terminal to berth[1].

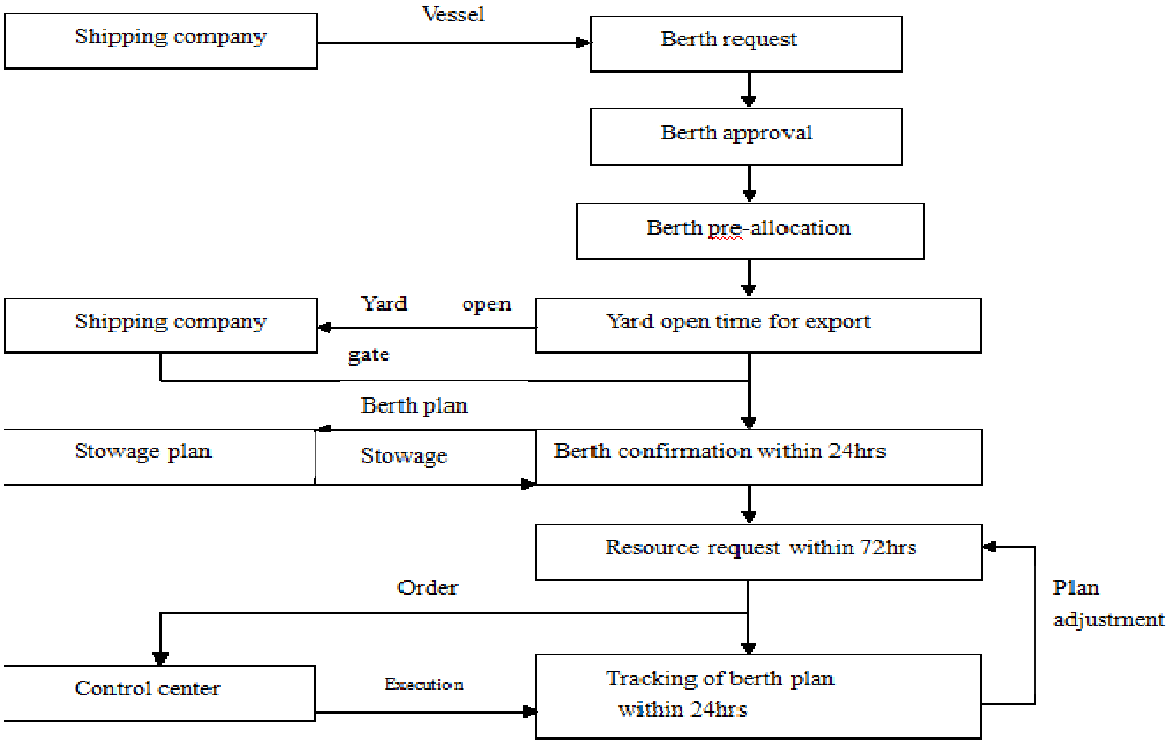


**Figure 1 : Berth plan work flow**

Therefore, berth planning should forecast if its resources could meet customers' needs. The shipping company should forecast vessels information before 72 hours, otherwise, vessels may have no place to berth or other resources to utilize. It is of great importance of reasonable berth planning for investment situation of terminal resources, involving human resources, equipment and other requirements of special operation. Berth planning is the ending point of terminal operation when it comes to rate of fulfillment. After vessels Departure, the berth planner should communication with shipping company, central control and resources allocation department about the implementation quality. The berth planner could adjust and/or optimize the next time berthing according to suggestion. Thus, berth planning is the brain for the entire terminal operation. In order to greatly enhance quality of terminal operation and utilization of terminal resources, berth planner should work out reasonable and scientific schedule of berthing and resources allocation based on the analysis of varies information.

### Introduction of berth productivity of XCT

For container terminal, berth productivity mainly concludes productivity/QC and productivity/vessel, both indexes will affect the berth time of vessels, which will affect the berth utilization as well. The productivity/QC in Figure 2 and productivity/vessel in Figure 3 of XCT are shown below.

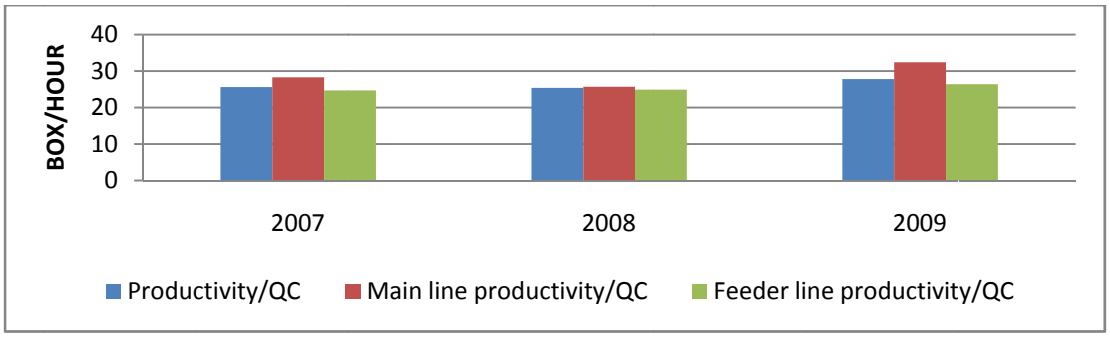


**Figure 2 : Index of Productivity/QC**

Productivity/QC is the quantity of boxes loading/discharging by each quayside crane in 1 hour. Due to low technology standard of QC of XCT, average productivity/QC is 25 boxes/hour, which is an average rate, and there is not much space for improvement.

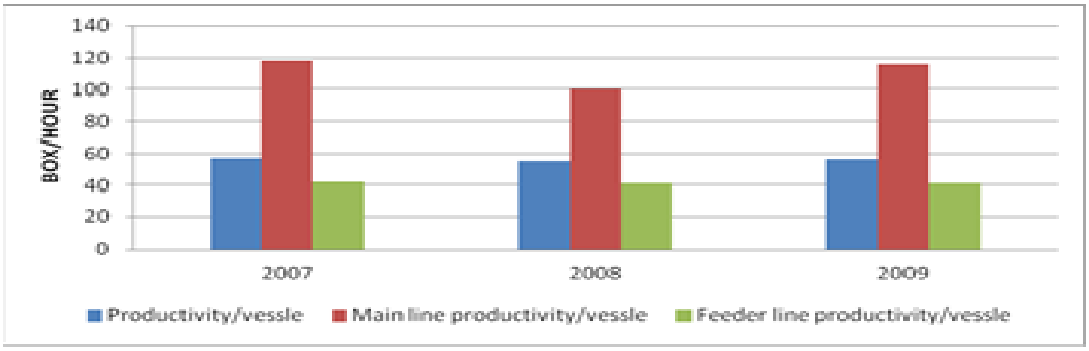


**Figure 3 : Index of productivity/vessel**

Productivity/vessel is the quantity of boxes loading/discharging by each vessel in 1 hour, which reflects terminal service standard and will affect vessel berth time. Productivity/vessel is the index paid most attention by terminals. Normally, loading/discharging amount, ratio of empty/full containers and quantity of cranes in use will have influence on productivity/vessel, which is reflected in Figure 3 that the indexes of main liner services and feeder services are so different. Productivity/vessel in XCT is 50 boxes/hour, which is little bit lower than other new container terminals.

## THE CALCULATION OF BERTH UTILIZATION OF XCT

There are many ways of calculation of BU, in this essay, I revise the formula of <Design Code of General Layout for Sea port(JIJ211-99)>, which has berth time and shore time in consideration. If the represents BU the formula[2] is as follows.

$$\rho = \frac{\sum(\text{length of vessel} * 120\% * \text{berth time})}{\text{length of shoreline} * \text{work time}} * 100\%$$

Shipping Length: Due to safety of berthing among vessels, 10% safety distance will be left within fore and aft of berthing vessel. Therefore, 1.2 times of vessel length should be as the actual data when analyze statistics in a terminal. Berthing Time: From the berthing time of mooring a first rope to uncoil the last rope excluding period caused by weather[3,4].

In this paper, I used the data of 4 successive weeks in May 2010 to calculate the BU of XCT. May is a typical month in Dalian, when the port operation would be interrupted by fog, which will reflect the real situation of XCT. Part A and part B are two separate berth systems, so we make calculation separately.

BU of Part A in May 2010:

$$\rho = \frac{\sum(\text{length of vessel} * 120\% * \text{berth time})}{\text{length of shoreline} * \text{work time}} * 100\% = 42.2\%$$

BU of Part B in May 2010:

$$\rho = \frac{\sum(\text{length of vessel} * 120\% * \text{berth time})}{\text{length of shoreline} * \text{work time}} * 100\% = 28.8\%$$

BU of part B is much lower than part A due to smaller berths and lower technology standard, the average BU of XCT is 33%. If we make the calculation by weeks, maximum BU of May is 42.9%, while minimum BU of May is 32.1%, where there is a gap of 10%. That is mainly because of poor weather condition which affected vessel schedule and caused channel control.

When analyzing the trend of BU in May 2010, due to poor weather condition and schedule reset which caused vessels crowded in port, BU changes dramatically week by week. This reflects the problem of BU in XCT, the trend of BU in May 2010 in Figure 4 is shown below.

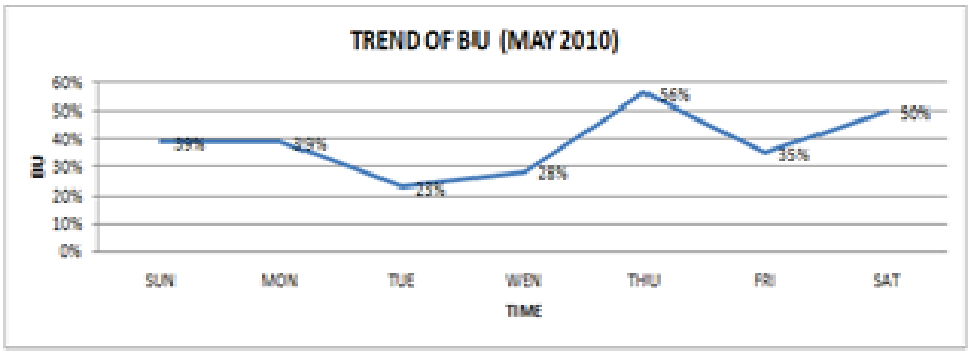


**Figure 4 : Trend of BU in May, 2010**

Chart of BU of XCT from January 2008 to July 2010 in Figure 5 is shown below.

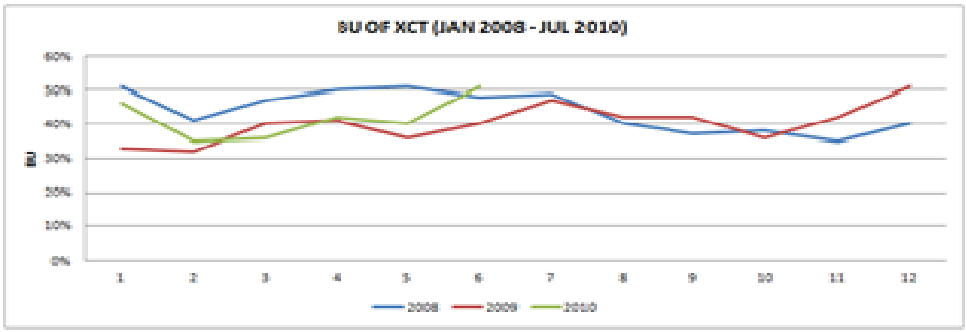


**Figure 5 : Trend of BU in 2008-2010**

From January 2008 to July 2010, BU of XCT decreased from 44% to 38%, maximum productivity/month reached 51%, while the minimum fell to 33%. The trend fluctuates due to financial crisis and service allocation. Decrease of BU reflects the shipping industry and market situation. BU in first half of 2008 is much higher than the second half, that's mainly because global financial crisis started in September 2008 and all the shipping companies cut the transportation capacity, which caused the liner services of XCT dropped a lot. In 2009, due to the recovery of global finance, shipping industry was becoming better and BU started to rise since the second half of 2009, maximum BU reached nearly 50%. There are not much difference between BU 2009 and BU 2010[5]. So, during the three years, due to financial crisis, scale of XCT liner services, market volume of containers were affected a lot, which can be reflected by low BU, it was a waste of port facilities and there is a big potential for BU of XCT to increase.

## ANALYSIS OF BERTH UTILIZATION OF XCT

**BU still has huge rise space**

Average BU of XCT is between 30 to 40%, which means the terminal facilities are not fully used, especially for the result of May (33%), there is still huge space for improvement.

**BU fluctuated too much, which led to unbalance in resource utilization**

From Monday to Sunday, BU fluctuates too much, maximum BU is 56% on Thursday, while during Tuesday and Wednesday, BU falls to bottom at 20%, and average BU on weekend is 50%, which will cause resource used unbalanced. At

first, extra employees are needed on weekend, which means labor cost should rise due to overtime payment; on the other hand, low BU on Tuesday and Wednesday means there's a big waste of the facilities and labor resources[6].

**Irregular schedule and vessel crowded in port caused severe berth waiting**

Another reason of lower BU of XCT is because the schedules to Dalian of most shipping companies are on weekend. There are 44 services calling XCT a week, over 40% are on weekend, which leads to severe berth waiting. There were 46 voyages waiting for berths available in May 2010, which was about 17.5% of total voyages a month, and total waiting time was 598 hours which was about 23.2% of total berth time. About 40% berth time in weekend was for berth waiting. So how to reduce waiting time and raise the utilization of facilities and labor resources, is one of the top problems to be concerned on port management.

**Long berth waiting time affected berth of follow-up vessels**

Average berth time is 9.8 hours, which means services of XCT can meet the requirement of shipping companies, but during May 2010, there were about 100 voyages that had over 10 hours berth time, which was 38% of the total voyages. Some VIP services, North Korea services and feeder services, that had special requirements, were among these voyages. These special requirements will lead to a rise of berth time, and the follow-up vessels will be affected as well.

## OPTIMIZATION STRATEGY OF CONTAINER BERTH UTILIZATION

The main point to optimize BU is to reduce both berth waiting time and operating time by setting up reasonable schedules of shipping companies, choosing the best berth plans and other ways to cut the non-operating time.

**Optimizing schedule of shipping companies**

Unreasonable schedule will lead to severe berth waiting, which obviously cause more berth time, and finally it will make the customers unsatisfied with our services. It is necessary for XCT to balance the schedules.

There are two ways to balance the schedules. On one hand, XCT should move the weekend services to working days, which can effectively solve the severe berth waiting on weekend. Of course, we need to consider the views of shipping companies, market situation and the needs of port operation. On the other hand, we need to strengthen controls of the services that cannot match their schedules. If the vessels couldn't call our port on time, they need to inform the port in 24 hours, which will give port more time for resource allocation. Once there are severe berth waiting or conflicts of berth plans, XCT needs to take port condition and benefits of shipping companies in consideration to avoid unnecessary waiting and waste of potential profit.

**Reasonable allocating port resources**

**Flexible berth plans to have port shoreline resource fully used**

Currently, flexible berth has become the main stream way of modern container terminal berth[7]. At the process of terminal designing, the length of the shoreline will be determined after the determination of the berth number. In operation, the ships could be longer or shorter than the designed length of the berth because of the variety of ship types and the large change of the ship length. Obviously, it is difficult to deal with a variety of changes of the ship length if only using a ship plan based on a fixed berth. The biggest drawback of the traditional fixed berth plan is the wasting of the shoreline length, the wasting of terminal resources reduces the operation efficiency of the container terminal, and extending the ship's time in port.

Fixed berth will lead to some of the cranes laying up, influence the whole operation efficiency of the container terminal, and result in unnecessary economic losses to the terminal[8]. Flexible berth will assign a certain shoreline length according to the ship length, and there will be no more fixed berth. When a ship is operating, the certain shoreline length and the area in front it will be equal to a berth, and there is no obvious distinction to the originally designed berth. This approach will allow the number of the mooring ships exceeds the original divided number of the fixed berth, will maximum the use ratio of shoreline length, thereby shortening the ship's time in port.

Dalian Container Terminal Company is actually formed two different sets of berth group, and limited the full sharing of the shoreline resources, coupled with the differences of 3-7# berth depth, 3-5# berth depth is -12 meters, while 6-7# berth depth is about -14 meters, this berth group should be constituted into two different groups in theory. However, due to the berthing of ships based mainly on small vessels, ship's draft by tide usually around -12 meters, though there is a difference between the 3-7# berth depth, we can still regard them as a berth group to use, only in extreme cases to take the problem of ship's draft into account. Because of the presence of the objective constraints for the berths of Dalian Container Terminal, it is necessary to take the frequency distribution of all the berthing ship's length into full analysis, to take the needs of flexible berth operations into maximum account, so as to ensure the most effective use of the shoreline.

**Optimizing operation sequence**

Once there are severe berth waiting, limited berth resources couldn't meet the request of the waiting vessels, so in that case, XCT has to optimize the operation sequence. There are couple of rules:

**FCFS: first come first served principle[9]**

This principle is commonly used in queuing principle, it can guarantee the equitable terminal services, and also the most likely to get customers to accept, but only if there is no special priority in the presence. As in Dalian Container Terminal, there are two kinds of priority, one is ocean main liner, the other is domestic boutique liner. So it is difficult for the

terminal to adequately maintain service fairness in practice, and this is a general principle, so the role for this principle in promoting berth utilization is limited.

**EDD: earliest due date**[10]

EDD means that the ships with urgency schedule will be given a priority operation. When part of the ships almost delayed to its fixed schedule, under the condition that terminal resources and other ships' schedule allowed, terminal can give priority to the needs of customers, and to meet customer needs.

**SPT: shortest processing time**

SPT means that the ship which have a shortest operation time will be given a priority operation. Under certain circumstances, such as the certain number of mooring ships, berth planning department should fully balance the loading and unloading container volume, ship schedule and other factors of the ships which are waiting to moor and the ships which will be arrived soon. Berth planning department also should estimate the total number of ships and the total operation time in a certain time, give priority to the ships with shortest operation time, minimize the number of waiting ships and waiting time.

There are some other principle, like SCR (smallest critical), MWKR (most work remaining), LWKR (least work remaining) and MOPNR (most operations remaining)[11]. Sometimes we can have the rules in combination, for example, 'SPT+MWKR', SPT can reduce the quantity of the vessels while MWKR can have the operation of different vessels finished nearly at the same time.

**Optimizing port facilities resource**

We need to have work efficiency of one vessel and total work efficiency of the port in consideration when optimizing facilities resources. There are two ways of optimization: operation balanced principle and operation centralized principle[12].

**Operation balanced principle**

First of all, key bay for operation, which means the bay with most boxes for loading/discharging and will affect the vessel's berth time and productivity/vessel, should be made. Then to make reasonable allocation of the facilities (trucks, gantry cranes), which can reduce the work time of key bay and maximize the productivity/crane.

**Operation centralized principle**

Operation centralized principle is to centralize the facilities to raise the productivity/vessel, usually port should take extra cost in consideration, which means in order to finish operation on time, reasonable extra cost can be taken to raise the productivity.

**Reducing non-operating time**

Non-operating time includes inspection time, facilities waiting time, baplie waiting time, facilities maintenance time, and waiting time due to poor weather condition, shift change, lunch break, etc. Normally facilities and baplie waiting time is not acceptable for port. But XCT is a professional container terminal with 20 years history, facilities maintenance is one of the top problems, which means port should strengthen the management of facilities. For other non-operating time, port should take reasonable methods to make the reduction and raise the work efficiency and service standard.

## CONCLUSIONS

From the existing theoretical and practical study, the research on the berth utilization of container terminals is not deep enough, though related calculation methods have mentioned about the berth utilization of container terminals in the existing "standard". But in practice, there is a big difference between the understanding and application of the calculation method of berth utilization, the combination of theory and practice is not good enough, but the berth utilization of a professional container terminal is a very important comprehensive index. In modern container terminal operation management, more terminals focus on the efficiency indicators, while ignoring the analysis of this comprehensive index. After the emergence of flexible berthing, the calculation of the berth utilization and berth through capacity should be paid more attention by all terminal managers. So, the author believes that future research should focus on the following two points:

The berth and shoreline utilization under flexible berthing way still needs to be deeply discussed. And it still needs a new perspective and approach to discuss the benefits which flexible berthing could bring to container terminals. At present, the true significance and role of the berth utilization which container terminal companies regard as is still lack of effective acknowledge. And how to make the Container Terminal Company to optimize its own service and management through a simple analytical model, still needs to be continuous discussed, so that the theory and practice of the terminal operations could be combined.

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