Port Productivity by Improving Shift Change Process

Mario Chong, Stephanie Dueñas Calderón,
Cristian Pérez Chacón and Pamela Suarez Ladines

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Chong, M. [1], Dueñas, S.[2], Pérez, C.[3] and Suárez, P. [1]

1: Facultad de Ingeniería, Universidad del Pacífico, Perú
2: Facultad de Ciencias e Ingeniería, Pontificia Universidad Católica del Perú, Perú
3: Facultad de Ingeniería, Universidad de Piura, Perú

Abstract

Nowadays, the increase of international trade is a fact that each maritime port must deal with, especially those used to exchange cargo containers. Without going so far, in South Pier of Callao (Peru), one of the main Container Terminal Port presents problems with a maritime service (Eurosal) in the time spent performing the loading and unloading processes. This document aims to provide an initiative to improve the productivity of the port, by a time and movements study, in order to increase the outputs of the process from a given set of inputs. To achieve an increase in productivity, we focus on the shift change process of Quayside Crane Operators, beginning an observation of the current scenario and mapping the process. Subsequently, we identify stages and activities that can be simplified or reduced, and we define a to-be process. Finally, we measure the tentative impact of the initiative on metrics such as movements, time and a tentative increase in revenue. Some of the relevant information about this document and the proposed initiative is the 12% reduction in the current work shift time, increasing container movements in 1.2% for the Eurosal service and this represents a monthly income of 20 thousand USD.

Keywords: Maritime Service, Quayside Crane, Shift Change, Productivity, Container Terminal Port.

1. Introduction

In the last ten years, international maritime trade has grown at an accelerated rate due to the increase in exports and imports goods in countries such as the United States, China and Latin America (World Trade Organization, 2018). Consequently, land customers demand faster maritime services in order to gain time in the international supply chain logistics. Container ports terminals worldwide, as a link in the logistic chain, have an important challenge to face with this international trade growth, looking for improving their productivity in order to fulfill the time arranged with maritime lines for load and discharge the number of containers established without any type of delays.

For instance, DP World is a container port terminal worldwide with 5.6 billion USD in sales and operations in over forty countries across six continents. In Latin American, it has four subsidiaries, which are stops of the Eurosal Maritime Service (Caucedo, Posorja, Callao and San Antonio) (DP World, n.d.). Recently, this service presents some issues, which delay between the time of arrival and departure through these four regional ports and this can be replicated to other Maritime Services.

Having significant delays in ports, generates a longer time in the duration of vessel transfer to the following destiny, impacting directly in the national economy because the goods do not arrive on time causing high losses, wasted merchandise and mistrust. With this current situation, three of us, as collaborators for one of the biggest Peruvian ports (DP World Callao), prepared this paper in order to transfer our knowledge and experience in efficiency projects with proposals that will improve the quay productivity. In particular, we focus on shift changes realized in Quayside Cranes (QC), which is the first and last stage during export and import maritime processes.

Our contribution will be enhancing the time invested in operation personnel shift changes providing a new scenario without stops in quay movements. With this initiative, movements will increase and vessel stay time will reduce, increasing incomes not only for DP World Callao but also for inland customers in a country that the international trades are 90% maritime way.

2. Literature review

The current industry, the development of new technologies and the growing interaction that exists between different countries has generated a greater exchange of goods. This has impacted the economy of each country and the development of ports to improve productivity. For example, Shanghai is one of the most important ports worldwide as it moves around 40.23 million TEUs per year (Mundo Marítimo, 2019) and economic development in recent years has been significant.

According to China's economic report, over the past 5 years, China's economy has grown between 6.5 and 7% per year and it is expected to grow by 6.4% during 2019 (Economic and Commercial Office of Spain in Beijing, 2010). This is due to many factors but one of the main ones is the increase in the capacity and productivity of its ports. Thus, during the last year, it had a trade surplus of 298,955 million USD, since compared to 2017, its exports grew by 11.4% and its imports by 18.6%, which translated into dollars, were 2'272,263 million USD and 1'973,308 million USD respectively (Economic and Commercial Office of Spain in Beijing, 2010).

Improving port productivity, known as "*how much output is obtained from a given set of inputs as such, it is typically expressed as an output-input ratio*" (Syverson, 2010), is paramount and has forced that emerging countries such as Latin American and the Caribbean be more competitive by breaking with the government's port monopolies (CEPAL, 2006). Consequently, new companies has invest in these ports in order to develop them. Nevertheless, to achieve this, it is necessary to assess the current situation through indicators. According to Wang et al, the efficiency of the port can be measured by an exhaustive quantifiable data analysis. Since the indicators give us quantitatively, the reality of what is happening, allow us to take actions, and decisions that can then be evaluated through them.

In that sense, we have to consider a standard international indicator such as the average of TEU handled per crane per hour (Ford, 2015). In particular, the main measure is "*BPMH (Berth moves per hour), which focuses on the total number of containers that all cranes moved on/off a particular vessel each hour*, which also refers to the efficient use of the total labor force required for the operation to move the containers across the quay wall" (Port Technology, 2015).

Furthermore, it is important to review the current process to apply improvements. For instance, in the port of Ningbo - Zhoushan, demand exceeded productivity so there was an urgency to improve it. In this way, a group of researchers from the University of Nottingham Ningbo China decided to help and found that a bottleneck was generated in the circulation of trucks due to the synchronization of cranes. The main problem was that the automated solution did not include all the cases so some trucks were moving without freight. Then, this group create an intelligent system applying algorithms and developing mathematical models to optimize truck´s routes. This improved productivity by reducing in 10% inactivity time of cranes and distances. In consequence, this had an environmental impact by reducing pollution (Asociación Peruana de Agentes Marítimos, 2019).

Therefore, any improvement that can reduce time or increase the amount of movements will be translated into an increase in capacity, agility in the operation (Mooney, n.d.) and a greater benefit for the ship, port, customers and country (Hall, O'Brien, & Woudsma, 2013).

3. Methods and procedures

We follow the Permanent Program to Improve Productivity methodology (Ortiz & Fernández, 2008), as it guides companies to increase productivity by waste reduction and process measurement. First, we define a team responsible for the initiative. In DP World Callao is named Process Improvement Team (PIT), which works together with operation and senior management staff. Then we prioritize the problems that have a direct impact on operational productivity and decide to improve the high time on shift change process in quayside cranes (Figure 1).

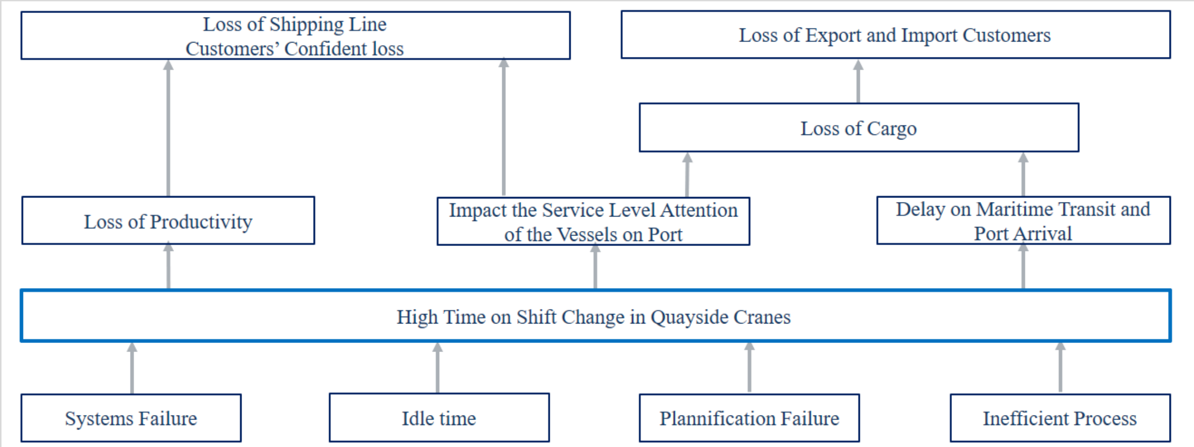

Figure 1. Problem Treen Analysis
Elaborated by the authors

We map the as-is process and apply a study of times and movements on each shift change (07:00, 15:00, 23:00) by QC from May to August 2019. Next, we analyze the process following a Lean Manufacturing perspective (Gonzáles, 2015), and design a strategy solution using the Single-Minute Exchange of Die tool (Gonzáles, 2015), in order to eliminate idle time (Meyers, 2000). For it, we identify the internal activities (done with the machine stopped) and external (done without stopping the machine) and propose an optimal sequence of activities for the shift change process. Finally, we estimate the process time improvement and calculate the impact in USD.

4. Experimental/numerical setting

Taking DP World Callao as the port of our study, we give some details collected from our process mapping:

1. It has two quays, which are able to receive vessels up to 7th generation. Approximately, 16 vessels berth each week.
2. DP World Callao has seven quayside cranes in order to attend the movements accorded for each vessel. In addition, operations personnel works in three shifts: morning (from 7:00 to 15:00), afternoon (from 15:00 to 23:00) and night (23:00 to 7:00).
3. The main international metric used to measure the productivity is BMPH (Berth Moves per Hour). On average the BMPH from January to July (2019) for the Eurosal Service (the one with issues identified) is 67.18.
4. After some visits to the operational zone, we release the actual shift changes process in quayside cranes with time invested in each activity.

The average time between the last movement-outgoing operator did and the first movement-incoming operator did is 17.5 minutes, during the test. The current process is shown in the following visual tools (Figure 2 and Table 1).

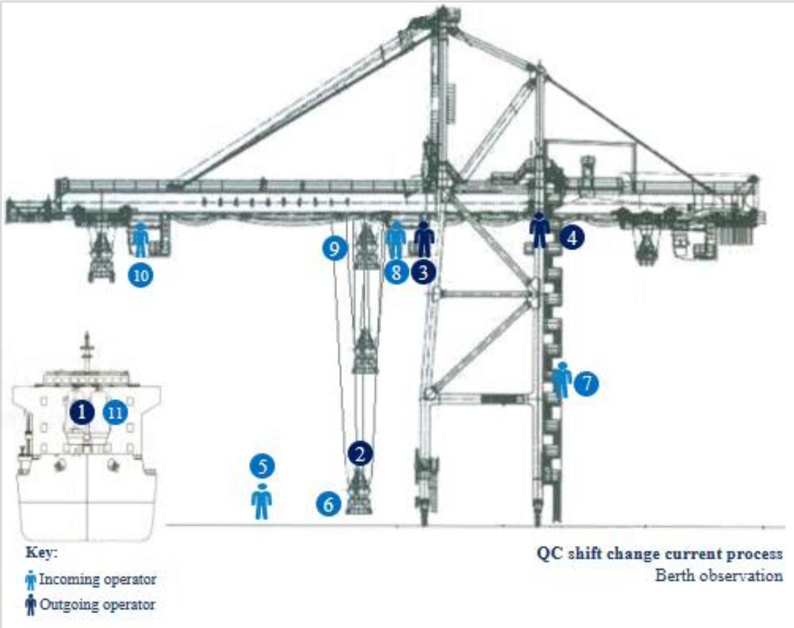

Figure 2. QC Shift Change Current Process
Elaborated by the authors

Stages	Minutes																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Last movement communication	■																
2. Trolley in parking position and Spreader Hoist down		■															
3. Post-operational cabin inspection			■	■													
4. Operator goes down to berth					■												
5. Entry shift operator walking to the QC						■	■	■									
6. Entry operator realize pre-operational flippers inspection									■	■	■						
7. Operator goes up to the cabin												■					
8. Entry operator realize pre-operational cabin inspection													■	■			
9. Entry operator hoists up the Spreader															■		
10. Tallie comunicates the activities to do																■	
11. First movement starts																	■

Table 1. QC Shift Change Time – Current Task and Minutes
Elaborated by the authors

5. Results and Discussion

By analyzing the as-is process, we identify opportunities focused on the shift changes time reduction by the simplification of activities changing them from serial to parallel steps. The proposal process is the following Figure 3:

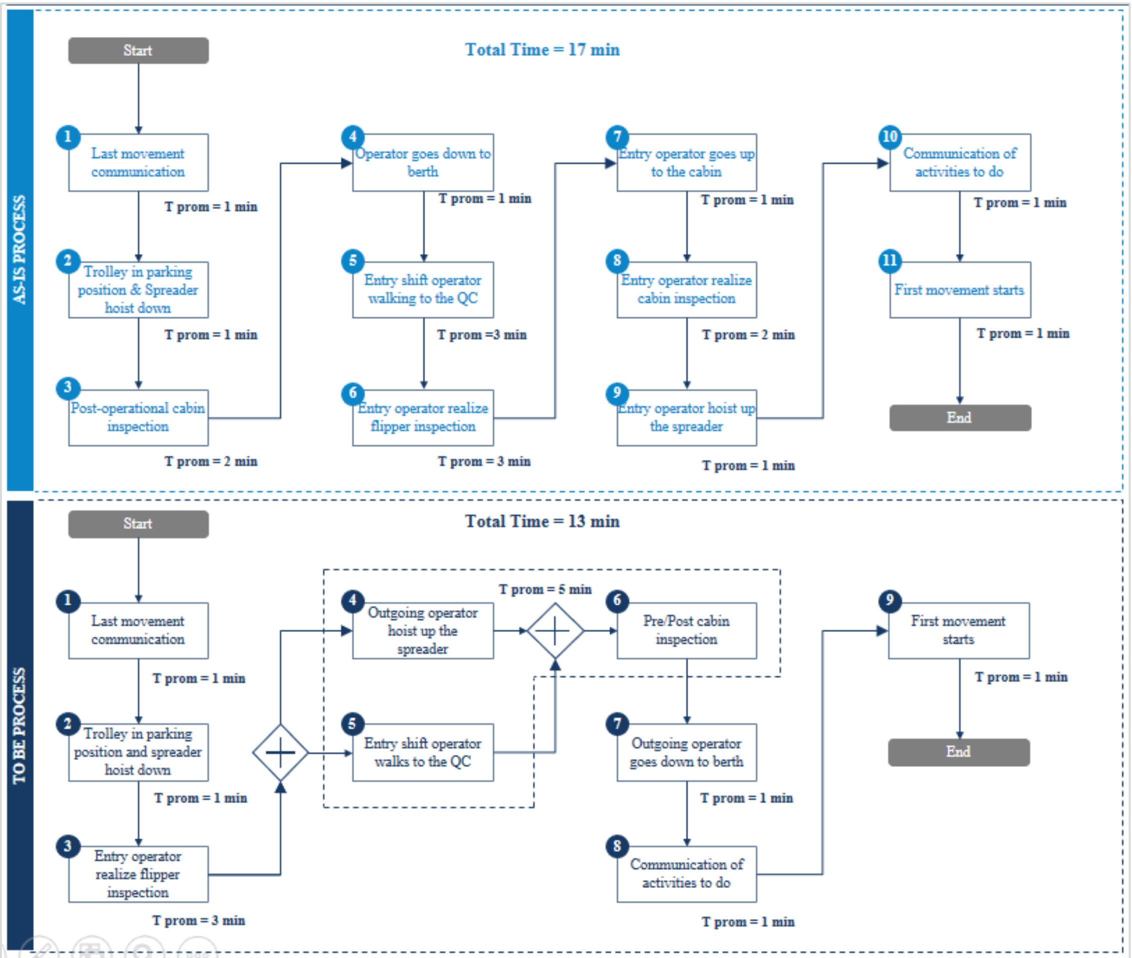

Figure 3. As-is and to-be comparison
Elaborated by the authors

Next, we describe the step by step of the to-be quay shift change process, with the time invested in each stage (Figure 4 and Table 2).

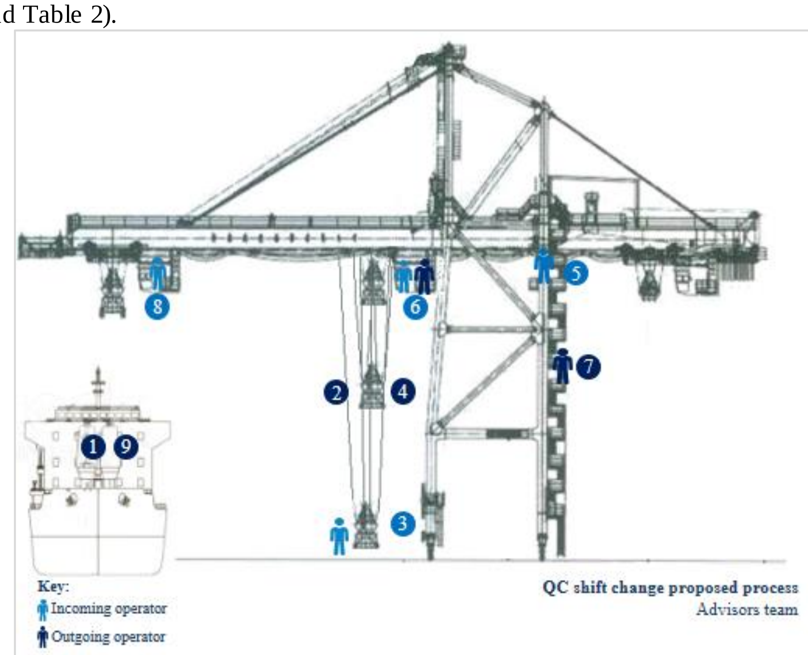

Figure 4. QC Shift Change Proposed Process
Elaborated by the authors

	Minutes												
Stages	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1. Last movement communication	■												
2. Trolley in parking position and Spreader Hoist down		■											
3. Pre-operational flippers inspection			■	■	■								
4. Outgoing operator hoists up the Spreader						■							
5. Entry shift operator walks to the QC						■	■	■					
6. Pre/Post operational cabin inspection (Both Operators - Hot Seat)								■	■	■			
7. Outgoing operator goes down to berth											■		
8. Tallie comunicates the activities to do												■	
9. First movement starts													■

Table 2. QC Shift Change Time – Proposed Task and Minutes
Elaborated by the authors

Finally, to strengthen the data analysis, we measure the average shift change time from May to August 2019, considering each work shift and quayside crane in order to calculate the impact of a time simplification between 1 and 5.5 minutes (Table 3).

Shift Hour	As is	To be	Difference
7 AM	**00:19:13**	**00:16:18**	**00:02:56**
QC1	00:17:46	00:15:32	00:02:15
QC2	00:18:33	00:15:55	00:02:38
QC3	00:18:33	00:16:15	00:02:19
QC4	00:19:08	00:17:20	00:01:48
QC5	00:21:02	00:17:25	00:03:37
QC6	00:18:35	00:15:51	00:02:44
QC7	00:20:56	00:17:32	00:03:24
3 PM	**00:16:09**	**00:13:54**	**00:02:15**
QC1	00:13:20	00:13:01	00:00:19
QC2	00:14:39	00:13:14	00:01:25
QC3	00:14:38	00:13:10	00:01:28
QC4	00:16:58	00:15:00	00:01:58
QC5	00:17:47	00:15:42	00:02:04
QC6	00:16:56	00:15:54	00:01:02
QC7	00:18:29	00:15:20	00:03:09
11 PM	**00:17:09**	**00:14:12**	**00:02:58**
QC1	00:16:32	00:13:59	00:02:33
QC2	00:16:35	00:14:14	00:02:20
QC3	00:16:04	00:14:45	00:01:19
QC4	00:17:42	00:15:31	00:02:11
QC5	00:18:29	00:15:28	00:03:01
QC6	00:16:43	00:15:03	00:01:39
QC7	00:18:15	00:15:25	00:02:50
Average	**00:17:30**	**00:15:19**	**00:02:11**

Table 3. Average Time Reduction Impact
Elaborated by the authors

With this improvement, we reduce 2 minutes (on average) in the to-be process. Then, we calculate the impact in movements for Eurosal Maritime Service:

1. Monthly movements average for Eurosal Service is 15,500 mov/month.
2. The actual BMPH is 1.12 mov/min, spending 13,839 min/month.
3. Considering 3 shift changes per day and the continuous operation in DP World Callao (24/7), 180 min/month is added to the total time invested on Eurosal Service.
4. The new time will be on average 14,019 min/month with the same BMPH, the port will execute 15,702 mov/month, 1.2% more (202 mov/month).

The resume of the step by step is detailed in the following table. In addition, we include the profit gained with this initiative (Table 4):

Movements:			
	67 mov/hr =	1.12 mov/min	
Eurosal Movements and time invested per month:			
	15,500 mov/mth *	1 min/1.12 mov =	13,839 min/mth
Impovement metrics:			
	2 min/shift *	3 shift/day =	180 min/mth
Results:			
	14,019 min/mth *	1.12 mov/min =	15,702 mov/mth
Revenue:			
As is process -->	100 $/mov *	15,500 mov/mth =	1,550,000 $/mth
To Be process -->	100 $/mov *	15,702 mov/mth =	1,570,160 $/mth
		Impact -->	**20,160 $/mth**

Table 4. Impact on QC Shift Change Process
Elaborated by the authors

6. Conclusions and future research

It can be concluded that improving productivity in the port of Callao contributes to offer a better Eurosal service since time is reduced in 2 minutes and the quantity of container movements increased in 202 per month, which means 68.12 BMPH. Furthermore, the study of times taken during different days by QC and by shift changes helped us to obtain representative data that we could model to reach better times with our improvement proposal because we could reduce from 11 to 9 stages. We focused on the idle time identification in the most critical process for the port (loading and unloading), process analysis and changing from a linear process to a parallel one, in order to increase the number of movements. What is more, we confirm that small changes in standardized processes represent significant impact on company revenue; in this case, it was 20 thousand USD per month by reducing 12% of the time and increasing movements by 1.2%.

The replica of this proposed model, that does not demand a significant investment, could help other terminals to improve their productivity to ensure a unified international logistics chain, where all stakeholders involved (maritime lines, ports, direct customers and country development) can be benefited. Finally, our paper sent the basis for future research in similar matters, where new initiatives could be applied such as technology application, mechanic improvements, among others.

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