Research in Transportation Business & Management 19 (2016) 118–131

Contents lists available at ScienceDirect

Research in Transportation Business & Management

Insightful observations on trailer queues at landside container terminal gates: What generates congestion at the gates?

Ichio Motono [a,*], Masahiko Furuichi [b], Tamotsu Ninomiya [c], Satoshi Suzuki [d], Masako Fuse [e]

[a] Graduate School of Management, Kyoto University, Cabinet Office of Japan, Japan
[b] Graduate School of Management, Kyoto University, Japan
[c] Project Planning Dep., Hakata Port Terminal Co., Ltd., Japan
[d] Nagoya United Terminal System Development Group, Nagoya Harbor Transportation Association, Japan
[e] Science & Engineering Systems Division, ITOCHU Techno-Solutions Corporation, Japan

ARTICLE INFO

Article history:
Received 16 September 2015
Received in revised form 26 March 2016
Accepted 4 April 2016
Available online 23 April 2016

Keywords:
Container terminal
Congestion
Landside traffic
Queueing model

ABSTRACT

Many ports attempt to ease landside congestion in a terminal by increasing the gate lanes and/or flattening arrival trailer traffic peaks. Their approaches are based on assumptions that all the arrival trailers carry the appropriate documents which allows them to enter a terminal smoothly. However, our research reveals that landside congestion is caused partly by those Trailers which carry Improper Documents (IDTs). Both Nagoya and Hakata ports in Japan succeeded in reducing congestion by eliminating the IDTs using different approaches. Our survey indicated that the IDTs accounted for 12.7% of all the arrival trailers at Nagoya port and approximately 10% at Hakata port. More importantly, the gate service time was longer for the IDTs, which greatly affected terminal gate capacity. For instance, at a screening center at Nagoya port, it took 204.5 s on average for the IDTs but only 165.4 s for Proper Document Trailers (PDTs). A multi-server queueing model is developed. The simulation results show that a trailer's travel time can be considerably reduced if the IDTs are eliminated. The paper numerically demonstrates that the proposed measures for eliminating IDTs are effective for easing the congestion and thus are useful for ports suffering from landside congestion.

1. Introduction

Most newly delivered containerships, of which capacities are approximately 20,000 TEUs, have been deployed on the longest-distant routes, e.g. the Far East-North Europe trade routes. The introduction of larger containerships means that more containers are being loaded/discharged at the same time, which has exacerbated terminal congestion. As a result, containerships often have to wait for port entry offshore. To compensate for the lost time, they must increase sailing speeds on the routes to their next destinations, imposing additional costs to shipping lines as well as shippers. To make things worse, the larger container ships cause higher peaks in the container terminal operations, with wide-ranging impacts (OECD/ITF, 2015). Moreover, the larger containerships on the longer-distance routes tend to cascade down to the medium-distance routes. Similarly, the medium-size containerships on the medium-distance routes tend to cascade down to the shorter-distance routes, and so on. Accordingly, higher peaks at the container terminals, which cause landside congestion, may take place at any container port in the world regardless of whether their throughputs are large or small (Furuichi & Shibasaki, 2015). Therefore, port authorities and/or public sectors have been introducing countermeasures to alleviate landside terminal congestion.

Hakata port made various efforts to ease landside congestion by increasing the number of gate lanes and straddle carriers as well as adopting other measures but those efforts eventually ended in failure. Then the port carefully observed gate service behavior at the terminal gates, and found that the IDTs significantly worsened the gate capacity. Finally, the port introduced an IT system to realize a voluntary normalization system of trailer driver's behavior which provides the arrival trailer drivers with the landside congestion status information, and established a rule that trailer drivers must register their trailer IDs and container information one day before gate entry. These countermeasures succeeded in effectively reducing landside congestion. On the other hand, Nagoya Port established a Screening Center System (SCS) upstream of the terminals as a compulsory pre-gate system to increase terminal capacity (Suzuki, 2012). This system was originally introduced because they were suffering from a shortage of terminal yard area, however, the SCS unexpectedly contributed to a considerable reduction in the landside congestion. While the approaches taken by each port were completely different from one another, the authors realized that eliminating the IDTs may be a key to reduce the landside congestion.

Consequently, the authors examined the adverse effect of the IDTs on the terminal gate capacity and discussed how to effectively eliminate the IDTs. The authors begin with a literature review on landside congestion

* Corresponding author at: 1-6-1 Nagata-cho, Chiyoda-ku, Tokyo 100-8914, Japan.
E-mail address: tamagomoto@outlook.jp (I. Motono).

http://dx.doi.org/10.1016/j.rtbm.2016.04.001
2210-5395/

and then introduce countermeasures in Section 2. Methodology of the research is outlined in Section 3. Two case studies on Hakata and Nagoya ports where congestion was successfully reduced are presented in Sections 4 and 5 respectively. A numerical analysis on landside traffic is also conducted. Finally, a summary of the findings are presented in the last section.

2. Literature review on various causes of landside congestion

In this section, the authors review the landside congestion measures taken at various ports in the world. Landside congestion is defined as a state where trailers take additional waiting time in the queue either at the destination terminal gate or on the access road to the gate. The authors use the queuing theory as a conceptual framework to systematically outline the congestion measures. The theory is useful for not only evaluating the effectiveness of congestion measures but also explaining the causes of congestion. In the queuing theory, utilization rate denoted by ρ in the following equation is the key index to determine the magnitude of congestion.

$$\rho = \frac{\lambda}{s\mu}$$

λ	the average trailer arrival rate (trailers/s).
μ	the average gate service rate (trailers/s).
s	the number of gate lanes.
ρ	the utilization rate (%).

The utilization rate depends on three factors affecting congestion: λ, μ and s. The utilization rate fluctuates in a day because trailer arrival rate varies from hour to hour: ρ is high in peak hours and low in off-peak hours. Any kind of congestion is explained by high level of ρ in peak hours. The congestion becomes extremely severe when ρ is greater than 1. In that case, the queue length extends unboundedly and the congestion will not be cleared until subsequent hours. In order to prevent severe congestion, ρ must be kept less than 1 in all hours.

The congestion measures can be classified into three categories according to which factor the measure controls. The first category is to control the trailer arrival rate (representing λ) by; (a) dispersing the number of the arrival trailers by shifting to the other modes, (b) limiting the number of the hourly arrival trailers by the terminal appointment system (TAS), and (c) extending the gate hours. The second category is to increase the number of the gate lanes (representing s). Third category is to improve the gate service rate (μ) by; (a) shortening the gate service time by introducing IT system, and (b) eliminating the trailers carrying improper documents at the gate. The option (b) of the third category is what this paper is interested in.

2.1. Controlling the trailer arrival rate

2.1.1. Dispersing the number of the arrival trailers by shifting to the other modes

The option (a) of the first category is to reduce the number of the arrival trailers through shifting a certain number of the trailers to rail or inland/coastal water transport. For instance, 32 km-dedicated railway called Alameda Corridor was developed in 2002 to directly connect the ports of Los Angeles and Long Beach (LA/LB) with continental gateway terminal bypassing the downtown in Los Angeles. It cost US$2.4 billion and took 20 years (Alameda Corridor Transportation Authority, 2016). Betuwe line that connects Rotterdam port with Emmerich, western border of Germany, by 160 km-dedicated railway started its operation in 2007. It cost Euro4.7 billion and took 14 years since Dutch Congress approved the project (Koeste & Rouwendala, 2010; Innovation and Network Executive Agency, 2016). Besides the railway projects, a new terminal is being developed at outer harbor in Tokyo port to accommodate the increasing demand and disperse the trailer traffic to the off-shore away from the downtown in Tokyo. The terminal is scheduled to be open in 2017 and cost JPY113 billion. The access road directly linked with highway in 2012. It cost JPY264 billion and took more than twenty years (Port of Tokyo, 2016). These three examples indicate that physical development cannot be quick-impact measures even though they fundamentally ease the landside congestion. In addition, inland waterway as modal shift is only applicable option when a port is located near the potentially navigable canal or river without a huge investment.

2.1.2. Limiting the number of the hourly arrival trailers by TAS

The option (b) of the first category is the TAS, which assigns the number of the arrival trailer to the hourly slots and control the peak traffic. A typical TAS was introduced in the ports of California. A unique state regulation named Assembly Bill 2650 was introduced in California in 2003. It permitted the terminals to implement either the TAS or the peak pricing system to avoid the longer trailer queues. The bill also imposed a penalty to the terminal operators with US$250 per trailer if the trailers are idling more than 30 min in front of the terminal gates. Giuliano and O'Brien (2007) and Giuliano, Hayden, Dell'Aquila, and O'Brien (2008) evaluated the effects of the TAS in the ports of Los Angeles (8.16 million TEUs in 2105) and Long Beach (7.19 million TEUs in 2015). They concluded that no evidence was found that the TAS had reduced the queue lengths or the transaction times. The following reasons were presented why the TAS had resulted in failure. Firstly, nine (9) terminals among thirteen (13) in the ports adopted the TAS, of which operational frameworks were different. The trailer drivers were confused when making each appointment in the different operational frameworks. Secondly, priority gates were not prepared to make the arrival trailers who made an advance-appointment smoothly come to the gates. Thirdly, the ports of LA/LB did not accept appointments less than 24 h before their arrival, whereas the trailer drivers could not inform the exact arrival time unless they were approaching just before the gate. Fourthly, an appointment was made not for a container but for a trailer driver, which accordingly caused overbookings or no-shows. The said situation made the trailer drivers difficult join the TAS program.

On the other hand, the port of Oakland (2.39million TEUs in 2014) in California took a different approach. An appointment was made not for a trailer driver but for a container, to avoid no-shows and overbookings. The port accepted an appointment even 15 min before their arrival. The port also introduced the gate automation system. Consequently, the program achieved labor cost reduction by 65% at the terminals (Morais & Lord, 2006).

Botany port (2.29 million TEUs in FY2014) in Sydney, Australia had developed the TAS system (Cox, Mahoney, & Smart, 2009; Davies, 2009, 2013), which was originally introduced at both DP World terminal and Patrick terminal in 1990s. There had been controversial discussions among the terminal operators and the users since the introduction of the TAS. New South Wales state government launched a mediation effort over the dispute. The terminal operators stressed the effect of the TAS, however, the trailer drivers and the forwarders complained the negative impact of the TAS. They alleged that unclear slot allocation by the terminal operators and oppressive penalty to the trailer's late gate arrival. Finally, the Sydney Port Corporation (SPC) as the port authority of the Botany port proposed a new framework that imposes penalty on both the trailer drivers and the terminal operators. The trailer drivers are charged for their late or early gate arrivals and no show at the gates. The terminal operators are charged for their turnaround time delay in a yard as well. The trailers were also equipped with RFIDs to record their movement. The cost of monitoring the movement was compensated by newly introduced port wharfage fee AUS$10 per TEU for both import and export containers. The SPC also had prepared the trailer parking slot near the terminals in order that the trailers are able to adjust early arrival at the gate and avoid late arrival at the gate. The program had