Empty Container Stacking Operations: Case Study of an Empty Container Depot In Valparaiso Chile

Felipe Hidalgo, Diego Aranda, Jimena Pascual, Erhan Karakaya, Alice E. Smith and Rosa Guadalupe Gonzalez Ramirez

1. Introduction

International trade has been a key factor in the development of world economies, increasing the need for efficient supply chains to distribute products and services in global markets (Rodrigue and Notteboom, 2009). "*Although the responsiveness of trade to the Gross Domestic Product (GDP) growth has been moderate over the recent years, demand for maritime transport services and seaborne trade volumes continue to be shaped by global economic growth and the need to carry merchandise trade*" (UNCTAD, 2015). In this regard, inland transport of cargo and empty container handling plays a key role on the efficiency of global supply chains, particularly at strategic facilities such as port terminals, intermodal rail stations, warehouses or custom storage areas as well as empty container depots.

In this work, we present an analysis of the current handling operations at an Empty Container Depot (ECD) that provides services for different shipping lines that operate with the port of Valparaíso. The depot is located in the inter-port area of Placilla (in Valparaíso suburbs), where several depots and custom storage areas are located to provide cargo handling and other related services. The port of Valparaiso is the second largest port in Chile in terms of containerized cargo per year (measured in Twenty feet Equivalent Units, TEUs), and is ranked 17th in the Latin America and Caribbean region according to ECLAC (TEUs transferred in 2015[1]).

The aim of the analysis presented is to determine the current performance of operational policies related to the stacking of empty containers at the yard to derive recommendations for improved stacking policies and, potentially, yard layout re-design. It is important to mention that stacking operations at this empty container depot are strongly influenced by the marketing strategy of the depot and the contracts in place with shipping lines. These contracts include a non-fee storage period, which creates a demand for a FIFO (First In, First Out) policy for the dispatching of empty containers. This characteristic differs with respect to the operations at yards of a Port Container Terminal. For this reason, our work presents a novel contribution by analyzing a different application of stacking policies.

2. Literature Review

Several authors have studied logistics problems related to handling operations at multimodal container terminals, mainly focusing at seaport operations (Steenken et al., 2004; Stahlbock and Voβ, 2008; Bierwirth and Meissel, 2010; 2015). Particularly, Carlo et al., (2014) provide an overview and research directions for port storage yard operations. They distinguish between the following main decision problems that arise in the storage yard operations: (1) yard design, (2) storage space assignment for containers, (3) dispatching and routing of material handling equipment to serve container storage and retrieval processes, and (4) optimizing the remarshalling of containers.

[1] http://www.cepal.org/es/infografias/ranking-puertos-top-20-america-latina-caribe-2015

At the tactical and operational level, container stacking policies and the storage space allocation problem (including the pre-marshaling problem and the blocks-relocation problem) have been extensively addressed in the literature (Kim and Kim, 1999; Kang et al., 2006; Lee and Hsu 2007; Park et al., 2011; Chen and Lu, 2012). At the strategic level, yard design problems have been also addressed in the literature but not as extensively as container stacking strategies and policies. Yard design is an influential factor in the productivity of container handling operations (Kim et al., 2008), thus requiring strategic decisions in yard layout and outline, and in the number and placement of aisles (surrounding container blocks). Several authors have focused on the analysis of layout design and strategic decisions related to equipment acquisition at port terminals (Wiese et al., 2011; Ranau, 2011; Lee and Kim, 2013; Kemme, 2012; Wiese et al., 2013; Taner et al., 2014).

3. Empty Containers Handling Operations: Analysis of Current Situation

The Placilla depot was chosen because it is typical of such depots and they provided full information access. The depot is divided into two main areas: reefer and dry. In this paper, we will consider only the operations of the dry-container area. However, our approach and much of our analysis, is applicable to reefer-container operations as well. Figure 1 presents an overview of the ECD, where we can observe the dry and reefer areas, as well as the gate access where external trucks enter and exit the ECD and for picking up (gate-out processes) and delivering (gate-in process) containers.

As indicated in the figure, there is an inspection zone located at the main street where all arriving containers are inspected. For the inspection process, containers are segregated by type (40’ or 20’) and classified into Operational or Damaged. There is a maintenance area where containers are repaired; and an area for cleaning containers, as well as an area for repairing equipment. The wide streets allow for *reachstacker* cranes (or *toplifter* cranes) to operate and handle either type of containers (20´or 40´), except for street No.1. Street No. 1 is one way and used by gate-in trucks to access the dry container inspection zone. The back street is used as the access lane for gate-out trucks retrieving a container from a particular block, and as exit lane for all trucks. Different sections are organized into container blocks, each assigned to a particular customer according to size and class. Each block has a capacity of eight containers deep and up to seven containers high.

Figure 1: Layout of the Empty Container Depot.

4. Problem Description and Simulation Model

The aspects we will consider are the layout design of the depot in terms of the dimensions of the stacking areas, the assignment of block space for each customer of the depot (both shipping lines and leasing companies), the traffic flow of trucks, and stacking and retrieving policies. For this, we propose the use of a discrete-event simulation model with a related database to evaluate different policies and configurations. The performance measures to be considered are expected truck waiting times, yard crane utilization and truck turnaround times. An aspect taken into account is that different customers need their containers to be stacked in assigned and exclusive blocks, and that their contractual terms differ.

To represent the operations at the depot, data was collected from three sources. First, we considered a study already performed by the ECD to gather arrival process data. Second, we collected our own field data on different process times, and, third, the depot provided access to data in their ERP database.

Using this information, we set the simulation scenario thus. We consider operating hours from 8:00 AM to 6:30 PM. For high demand scenarios, the work shift is extended to operate during the night (24 hour operations) but only for dispatching processes. During lunch, service capacity is reduced by half (1:30 – 3:30 PM). The four toplifters operate on a FIFO request order. Housekeeping operations (where containers are remarshalled to improve retrieval) are done during idle times. The service of trucks arriving to the depot is FIFO with the exception of massive runs, generally associated with repositioning operations of a shipping line. Each block of the yard is assigned to a single customer and containers are segregated according to the condition class. (Two classes can be mixed in the same block if there is high demand at the yard.) Damaged containers that have been authorized for maintenance or repair service are moved at 8:00 AM to the maintenance area, and at 19:00 hours those containers that were repaired are taken back to the yard and stacked at appropriate locations.

As a first step we have been working on the integration of the simulation model with a database. The two main databases used correspond to those used by the ECD. One contains the current state of the system (the precise location of all containers) and the other contains a history of all gate-in and gate-out operations. The simulation interacts with the database to update the state of the system and to perform calculations regarding container movements to retrieve a unit or to remarshal and reorganize a block.

We are currently working on the experimental design in order to derive recommendations in terms of the layout design, stacking/retrieval rules, resource allocation and other variables of interest that may help improve the operations of the depot.

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