

SIMULATION-BASED LAYOUT ANALYZE OF A TURKISH CONTAINER TERMINAL

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ABSTRACT

Due to the recent increase in global trade of finished consumer goods the worldwide container traffic has grown dramatically. As a result, new terminals opened and existing terminals face a much higher container turnover than before. In order to meet these challenges, one of the biggest container terminals in Turkey seeks to reconsider its terminal operations and to improve its overall logistics performance. This paper presents an Arena-based simulation model to analyze the terminal operations and to highlight directions for the future development of the terminal configuration and the operational management of the terminal. The simulation model allows to choose the demand of containers, selecting the layout type, number of vehicles and number of yard line for analyzing some pre-defined performance criteria such as average productivity, average resource utilization and average waiting time of the resources to identify potential bottlenecks of the operational areas, namely the quay cranes, the storage yard. Preliminary simulation results related to several tested scenarios are presented in the final section of the paper.

Key Words: Simulation, performance evaluation, container terminal

1. INTRODUCTION

Among all freight transportation systems container transportation has shown by far the highest growth rate in turnover during the last 40 years. The use of standardized containers to store goods of all kind has tremendously improved the efficiency with which shipments are handled. The business environments and challenges of ports, railroads, and trucking companies have dramatically changed as a result of this “container revolution”.

Containerized cargo movements have not only changed the way in which transportation modes operate, it has also changed the manner in which transportation modes interact with each other. The new demand with containerization is how to develop more efficient concepts for the interaction of transportation modes, i.e. combine ship, rail, and road haulage to forward freight from the origin to the final destination of a transportation order. This need for combined freight transportation systems has brought about innovative transportation facilities, equipment, and management practices dedicated to intermodal freight movement.

Specifically, issues of logistics control in seaport container terminals have brought about a wealth of publications in the scientific literature [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12]. Among the logistics control problems investigated, the overall performance analysis of container terminals, the evaluation of alternate configurations,

berth allocation, stowage planning, scheduling of the handling equipment, storage and stacking logistics, quay-side and landside transportation planning have been areas of primary interest.

In practice, numerous studies have been undertaken on the design and re-design of facilities and equipment and the development of logistics control software and information systems. Computer-based tools such as simulation offer the possibility to mimic the terminal operations and to evaluate the system performance under different operating conditions and to systematically vary these experimental parameters in order to study the entire system behavior. Recent advances in simulation modeling, enhanced software with increased ease-of-use, and more powerful micro-computers suggest that computerized simulation of container terminals can become more powerful for supporting decisions, e.g. on the facility layout and equipment selection. In addition, changes to existing traffic loads may be examined to assess throughput, adequacy of resources, and the need for additional space requirements.

This paper proposes an Arena-VBA based simulation model as an efficient tool for evaluating the performance of a container terminal. The model allows analyzing some pre-defined performance criteria such as average productivity, average resource utilization and average waiting time (e.g. of quay cranes waiting for a carrier) to identify potential bottlenecks in the operational areas (quay cranes, storage yard, or transportation) in container terminals. This model also used to check the behavior of the port under various layout types scenarios.

A Container Terminal in Istanbul has been selected as a sample terminal for our research. The related project has been fully supported by the Turkish Government and the terminal operator.

2. THE CONTAINER TERMINAL

The container terminal includes three berths totaling 3,215 feet of quay length with four rail-mounted quay cranes and one rubber-tired quay crane, and nine rubber-tired yard cranes in the storage area. Inside the terminal transport operations are carried out manually by 30 internal trucks. With these specifications, container terminal can be classified as a modern port facility, but it cannot be considered as an ACT (Automated Container Terminal).

Per year, 1700 Container vessels with a total theoretically loading capacity of 750,000 TEUs can be serviced in container terminal. Because the terminal is located in the town center, it doesn't have enough storage space and possibilities for expansion are very limited. Terminal has a total storage capacity of 11,000 TEUs – 290 acres of container storage yard divided into nine storage blocks, each with a capacity of over 1200 TEUs and four-high stacking capacity. Container terminal layout as the orientation of the storage yards is both vertical and parallel to the berths. The terminal is operated around the week with three eight-hour shifts a day.

The volume of containers transported through Istanbul has increased over six times since 1998, with a throughput of over 4.5 million TEUs in 2007. Also Turkey's ports rank on the world market is consequently increased during these years. Despite this increase, the container terminal's market share in Turkey hasn't developed with the same ratio in 2007; terminals' market share of container trade in Turkey is 350,000 TEUs.

The container terminal does not have an efficient data collection system. Data collected from the terminal operations are manually entered into a data collection program at the end of each shift. Data from 2000 to 2007 include all necessary information for use in the simulation study of the terminal operations [13].

In addition, the following assumptions are used to make model more realistic.

- Although the terminal operates various trucks which are different in size, we assume that all trucks are of the same type.
- We assume that operating conditions of the terminal are not affected by weather conditions and do not differ between the working shifts. Also we assume that vessel arrivals to berths are unscheduled.
- One of the major problems in the terminal is the condition of the ground in the stacking area because rubber tired yard cranes often damage the surface of the transportation paths and the storage area. Thus, these cranes sometimes do not work properly. We considered this problem as an equipment failure.
- All scenarios are run with same input data.

The basic simulation model of the terminal was developed under these assumptions. Arena Input Analyzer 10.0 and SPSS 14.0 are used to analyze 84-months data. The simulation model is a tool capable of representing the reality with large precision in its results.

REFERENCES

- [1] Stenken, D., Voß, S., Stahlbock R. (2004), Container terminal operation and operations research – a classification and literature review, *OR Spectrum*, 26-2, 3-49.
- [2] Hartmann, S. (2004), Generating scenarios for simulation and optimization of container terminal logistics, *OR Spectrum*, 26-2, 171-192.
- [3] Günther, H.-O., Kim, K.-H., (2006) Container terminals and terminal operations, *OR Spectrum*, 28:437–445
- [4] Grunow, M., Günther, H.-O., Lehmann, M., (2006) Strategies for dispatching AGVs at automated seaport container terminals, *OR Spectrum*, 28:587–610
- [5] Murty, K. G., Wan, Y., Liu, J., Tseng, M. M., Leung, E., Lai, K., Chiu, H.W.C. (2005), Hong-kong International Terminals Gains Elastic Capacity Using a Data-Intensive Decision-Support System, *Infoms* 35-1: 61–75
- [6] Kozan, E. (1997) Comparison of analytical and simulation planning models of seaport container terminals. *Transportation Planning and Technology*, 20, 235–248.
- [7] Nam, K.-C., Kwak, K.-S., Yu, M.-S. (2002), Simulation study of container terminal performance, *Journal of Waterway, Port, Coastal and Ocean Engineering*, 128(3): 126–132.
- [8] Shabayek, A. A., Yeung, W. W. (2002), A simulation for the Kwai Chung container terminal in Hong Kong, *European Journal of Operational Research*, 40: 1–11
- [9] Kia, M., Shayan, E., Ghotb, F. (2002), Investigation of port capacity under a new approach by computer simulation. *Computers & Industrial Engineering* 42: 533–540.
- [10] Yun, W.Y., Choi, Y.S. (1999), A simulation model for container-terminal operation analysis using an object-oriented approach, *International Journal of Production Economics*, 59, 221–230.
- [11] Yun, W. Y., Choi, Y. S. (2003), Simulator for port container terminal using an object oriented approach, Working paper, Pusan National University.
- [12] van Hee, K. M., Wijbrands, R. J. (1988), Decision support system for container terminal Planning, *European Journal of Operational Research*, 34, 262–272.
- [13] Kulak, O., Polat, O., Guenther, H.-O. (2008) Performance evaluation of container terminal operations, *IT Based Planning and Control of Seaport Container Terminals and Transport Systems*, Bremen.