

THE USE OF SIMULATION TO CALCULATE THE LABOR REQUIREMENTS IN AN INTERMODAL RAIL TERMINAL

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ABSTRACT

An intermodal rail terminal is a facility where the transfer of cargo occurs between truck and rail. The operations within these terminals involve many resources and operating rules. The ability of a terminal to respond to activity peaks that occur as a result of train arrivals and departures is critical. In order to explore how operations can be improved given the dynamics of resource and demand interactions, a simulation model was developed to assist in understanding and exploring areas where throughput can be improved. The model was constructed such that capacity issues could be explored incrementally. The first focus was for understanding if efficient deployment of labor resources could provide desired throughput.

1 INTRODUCTION

A major US rail operator needed to gain a more thorough understanding of the capacity constraints of one of its major West Coast intermodal facilities. The terminal of interest is very important and has the largest volume of any of their facilities. At the same time, the terminal also experiences the least throughput of any of their facilities. The rail operator needed a tool to help them understand why the terminal was not performing to expected levels. They had been using experience, spreadsheets, or “white board” analysis as their means of making decisions. A more dynamic and quantitative tool was desired to gain a more thorough understanding of the capacity constraints.

There are a variety of terminal layout, resource, and operational issues that can impact throughput and capacity: rail crane allocation, yard crew size to support each crane, travel time between container storage locations, etc. The simulation model that was built for this project included the ability to look at these and other major terminal capacity influences.

The focus of the model and the first area of investigation was the labor deployment to support rail crane lifting

activities. It was desired to understand if the capacity problems of the terminal could be solved by more efficient management of labor and crane resources. After the “best” throughput has been achieved through the management of resources, the model can then be used to explore other terminal constraints—such as container parking block locations or track resource availability. This paper describes how the model was designed and used to calculate the “manpower threshold”—the point where additional staffing will no longer increase productivity.

2 TERMINOLOGY

An overview of the typical activities that occur in the intermodal rail terminal is provided as a reference. The facility that was modeled included the following major resources:

- Containers(Units): The basic unit flowing through a terminal is a shipping container. Containers are also referred to as units.
- Strip Tracks: Terminal tracks where loading and unloading of containers to/from railcars occurs.
- Rail Mounted Cranes (RMC): Cranes that traverse along the strip tracks and either load or unload containers to/from the railcars.
- Yard Vehicles (or Hostlers): Yard trucks that are capable of moving containers loaded on chassis from the strip tracks to container storage blocks and vice versa.
- Over the Road Vehicles (OTRs): Street legal vehicles that are arriving at the terminal to deliver or pickup containers on chassis.
- Container Storage Blocks: Parking lot areas where containers on chassis are stored until loaded onto a train or removed by an OTR. Each container storage block is typically assigned to a particular destination, customer, or other criteria. The terminal that was simulated almost exclu-

sively stores containers on chassis—very little ground stacking is used.

3 MODEL OBJECTIVES

The primary goal of this study was to provide an understanding of the current capacity at a major West Coast intermodal rail terminal. The model created was a planning level model that can serve to identify problem areas as well as provide measures that can be used to justify capital improvement expenditures. To accomplish this, the model represented the critical activities in the terminal and provided relevant metrics.

The user would like to be able to perform analysis on an ongoing basis and required that demand, resource quantities, and terminal layouts be configurable. The ability to configure different scenarios without extensive simulation training is important. A simulation modeling “system” that includes a easy-to-use user interface was required for the rail operator to perform both input and output report management.

4 TECHNICAL APPROACH

One of the first steps in formulating the model was to consider the level of abstraction to represent system operations. A general description of the technical approach and level of detail used for the simulation effort is provided in this section.

4.1 Modeling System Architecture

The flexibility of the simulation effort was a primary concern—especially as it was desired to reapply this model at other terminals or explore additional operations on an ongoing basis. Custom software was developed by Automation Associates, Inc. to integrate the inputs, outputs, and simulation engine into a single tool. The software downloads the input data, launches the model, and loads output reports with a single mouse click. Scenario management is also provided so that input and outputs are available for comparison during the project.

To ensure the flexibility and the usability of the modeling system, the following architecture was used.

A customized user-interface using Microsoft® Excel was used such that the following types of inputs can be easily entered:

- Manpower/staffing Schedule
- Train schedule
- Crane/hostler operational rules, crew assignments, etc.
- Strip track assignments

Rockwell Software’s Arena ® was used as the simulation engine. Logic modeled included: hostler team opera-

tions, crane loading/unloading operations, hostler container selection logic, and train demand generation.

The same customized user-interface using Microsoft Excel for the inputs was also used to organize the following outputs:

- Crane/hostler/labor utilization graphs
- Container storage block capacity graphs
- Capacity report summaries
- Unit handling reports

4.2 Train Demand Generation

The demand pattern at the simulated facility changes dramatically during the course of a week. Inbound demand typically peaks at the beginning of the week, while outbound demand peaks at the end of the week (including the weekend). The model needs to run for at least 7 days to account for this. An example of the changes in demand over a week are illustrated in Figure 1.

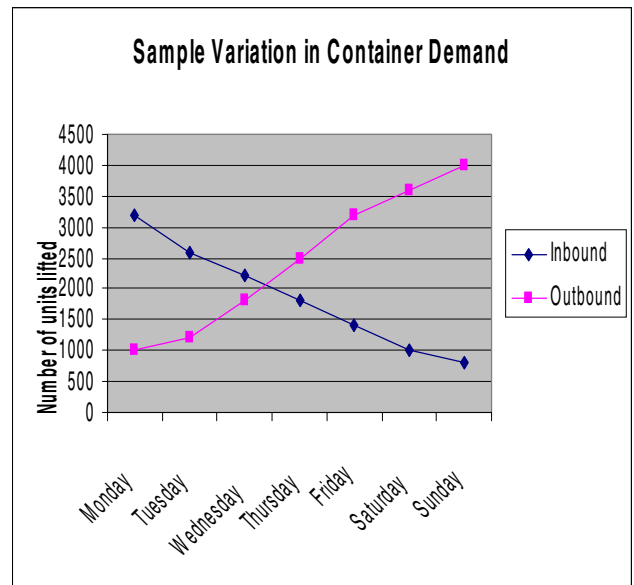


Figure 1: Typical Weekly Demand Profile

Two key drivers of facility performance are the sequence of train work activity over a weekly period and the number of units to be loaded or unloaded on those trains. Understanding this demand profile is necessary to make accurate inferences about the labor utilization and yard capacity.

The model uses an actual train schedule to generate the sequence of inbound and outbound trains. The user can easily change the characteristics of any train in the schedule in the Microsoft Excel worksheet:

- Train class
- Origin/destination information

- Work type (inbound/outbound)
- Scheduled arrival time (for inbound trains)
- Scheduled cutoff, release, and departure times (for outbound trains).

4.2.1 Track Segment Assignment

For the initial model creation, a detailed scheduling algorithm that can dynamically schedule train blocks to tracks is not included. The user specifies which train is placed exactly on what tracks within the terminal. Long trains are often split into “blocks” when placed onto tracks. The ability to schedule partial trains to separate tracks is allowable.

4.2.2 Inbound vs. Outbound Trains

Trains are assumed to arrive and depart on time. To focus on labor usage, the baseline model assumes that there are always tracks available at the desired times, such that strip track capacity is not an issue.

An inbound train block will arrive at the scheduled time and then be placed on the track segment assigned to it. Once the train block is assigned to the track, teams of cranes and hostlers will be dispatched to begin unloading that train block.

An outbound train has a different set of timing parameters, as follows:

- Set time: time when sufficient units are available to begin loading work on that train block.
- Cutoff time: Last allowable time that an outbound unit is allowed through the OTR gate. Units arriving after the cutoff time must go to the next outbound train.
- Release time: Target time when the train is scheduled to be fully loaded.
- Depart time: Time when the train physically leaves the track.

When the model reaches the set time for a particular outbound train block, it will be placed on its assigned track segment. Teams of cranes and hostlers will then be dispatched to begin loading work on that train block. It is assumed that there is an infinite supply of empty cars available for outbound moves. The model does not include the switching moves associated with bringing in empty cars.

4.3 Parking Lot Selection

A critical factor for understanding the true capacity of the terminal is the container storage layout—in terms of both physical location and number of spaces available. If a desired lot becomes full, a hostler may have to drive a longer distance to store a unit; this additional delay time takes away from productive work.

The model allows for flexible assignment of the lot capacities in terms of number of available parking spaces. If the number of units parked in a given lot reaches capacity, a hostler will have to choose another lot according to a priority scheme.

The model includes a flexible user input to specify the relative priorities of various lots by unit type and destination. Separate priority lists are provided for inbound and outbound units. When storing inbound units, the lots are searched in priority order until one is found with available space.

When retrieving outbound units from the parking lots, the hostlers will check the highest priority lot first for units booked for that train. If a unit is not found, the second highest priority lot is examined, etc.

4.4 Crane and Hostler Operations

In actual terminal operations, cranes and hostlers are dispatched to work on different train blocks in the yard, based on a number of different criteria. For example, the dispatcher may assign a group of 10 hostlers to help unload one train block. As the unloading tasks are completed, the dispatcher may then decide to remove 5 of the hostlers to assist other cranes. The remaining 5 would continue working to finish up the original train block.

To simulate this decision making, the model includes a logical “dispatcher”. This logic dynamically assigns cranes and hostlers to work segments, and will keep track of the amount of work remaining on each train block, and the current status of the cranes and hostlers, and make decisions on how to assign tasks to the resources appropriately.

Cranes and hostlers are assigned to work on a train block based on a flexible algorithm. This algorithm accounts for the number/type of units multiplied by the expected time to load or unload the units, relative to the time remaining until the train’s scheduled departure time. The expected time to do the loading/unloading can be determined by randomly sampling where the units are coming from and determining the time required.

The model can run in both an “unconstrained” and “constrained” mode. In “unconstrained mode”, the model assumes that there are always cranes and hostlers available to complete work on a train block, and decides how many to dispatch solely based on the required processing time for that block. In “constrained” mode, the number of available cranes and hostlers can be specified, such that the dispatcher logic needs to take into account which vehicles are available. Both modes are interesting for analysis purposes.

4.4.1 Hostler Movement Logic

The model accurately calculates the delay time for a hostler to move from one physical location in the yard to another. To do this, the model uses a variable hostler driving speed and the physical distances between terminal loca-

tions to calculate the travel time. For hostlers retrieving an outbound unit from a lot, the model includes a variable “seek time” as a user input. This represents the additional time that a hostler may require to locate a specific unit.

4.4.2 Hostler Utilization Output

The model includes the capability to report how the hostler usage changes over the course of the work week. At the end of each simulated hour, the model produces an output of the average and maximum number of hostler busy during that hour. By examining this chart and comparing it to the input train schedule, it can be understood how the specific sequence of trains affects the staffing requirements.

4.4.3 Simplified Gate Activity

The parking capacity is significantly impacted by the dwell time of inbound units, and the arrival patterns of outbound units. A detailed gate model was considered to be out of scope for a model that focuses on crane and hostler labor requirements. To capture this effect, a simplified model of arriving and departing OTRs is included.

After inbound units are unloaded from a train and transferred to a parking lot, they will dwell for some time until departing via OTR. An input of dwell times is defined using a probability distribution. For each inbound unit, the model samples from this distribution to determine the dwell time.

For outbound units, a similar approach is used. An input distribution is provided such that the model can determine how much “earlier” a unit arrived into the terminal. This time is specified relative to the train’s cutoff time.

5 SUMMARY

A simulation model was developed and validated to support the analysis of labor deployment and other resource capacities at a major intermodal terminal. The railroad operator was able to validate the model against an actual daily train schedule by comparing the actual crane lifts performed versus the model output. The objective of this model was primarily for advanced planning and analysis purposes; however, as the rail operator started working with the model, they discovered that it can really help them with ongoing labor scheduling on a weekly basis. The next steps anticipated for this project are to provide a more robust user interface to allow for the model to be used on an operational level. Additionally, as this model is successfully used for the West Coast terminal, it is expected that it will be configured for other critical terminals in the network.

AUTHOR BIOGRAPHIES

BETH C. KULICK is Vice President of Automation Associates, Inc. She joined Automation Associates in 1988 as a Simulation Analyst and has created customized simulation models for a variety of industries. She received a M.S.I.E. from Texas A&M University and a B.S.M.E. from Purdue University. Her interests include creating advanced business analysis tools that are based upon simulation models. Her email is <bkulick@automationassociates.net> and her corporate web address is <<http://www.automationassociates.net>>.

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