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29- 31 MARCH 2015**

**MODELING AND ANALYSIS OF CONTAINER TERMINAL
OPERATIONS CONTAINER TERMINAL MODELING AND ANALYSIS
USING DISCRETE EVENT SIMULATION**

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ABSTRACT:This paper introduces the application of discrete event simulation in container terminal modeling and analysis.

Keywords: container Terminal, operations research, discrete event simulation, Flexsim.

INTRODUCTION

A container terminal is a complex system with many subsystems, e.g. stacking area, cranes and vehicles, and a large number of decisions for each subsystem. Due to the interactions of these subsystems, there is a lot of stochastic influence and interdependencies within the decisions which make an optimized operation of a whole container terminal very complex and without technical and methodical support hard to handle. One optimal operated subsystem influences all other subsystems and therefore does not result in optimizing the whole system. To optimize the operations in an overall system with all its stochastic influence and interactions the methods of discrete event simulation are explained in this paper. This provides the opportunity to create an experimental model and identify the best recommended course of action.

WHAT IS FLEXSIM CT

- Flexsim is a powerful analysis tool that helps engineers and planners make intelligent decisions in the design and operation of a system. With Flexsim, user can build a 3-dimensional computer model of a real-life system, then study that system in either a shorter time frame or for less cost than with the actual system.
- As a “what-if” analysis tool, Flexsim provides quantitative feedback on a number of proposed solutions to help quickly narrow in on the optimum solution. With Flexsim’s realistic graphical animation and extensive performance reports, user can identify problems and evaluate alternative solutions in a short amount of time. By using Flexsim to model a system before it is built, or to test operating policies before they are actually implemented, many of the pitfalls that are often encountered in the startup of a new system would be avoided. Improvements that previously took months or years of trial-and-error experimentation to achieve, can now be attained in a matter of days and hours using Flexsim.

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- Flexsim Container Terminals (Flexsim CT) is a Flexsim library specifically designed for simulating container terminal operations.



Figure (1) Full animated Port

PURPOSES OF USING FLEXSIM CT

Simulation models built in Flexsim CT can be used to improve many facets of a container terminal operation. *In general, Flexsim helps in the goals to:*

- Increase throughput
- Improve equipment utilization
- Reduce waiting time and queue sizes
- Reduce bottlenecks
- Demonstrate new tool design capabilities
- Balance workload allocating resources efficiently
- Study alternate investment ideas
- Train operators in overall system behavior and job related performance

More specifically, with Flexsim CT, the following can be analyzed:

- Yard stacking and segregation strategies
- Yard layout and dispatching
- Gate logistics and capacity
- Quay crane allocation
- Traffic constraints
- Yard equipment allocation
- Hossler gang allocation
- Ship scheduling
- Berth assignment

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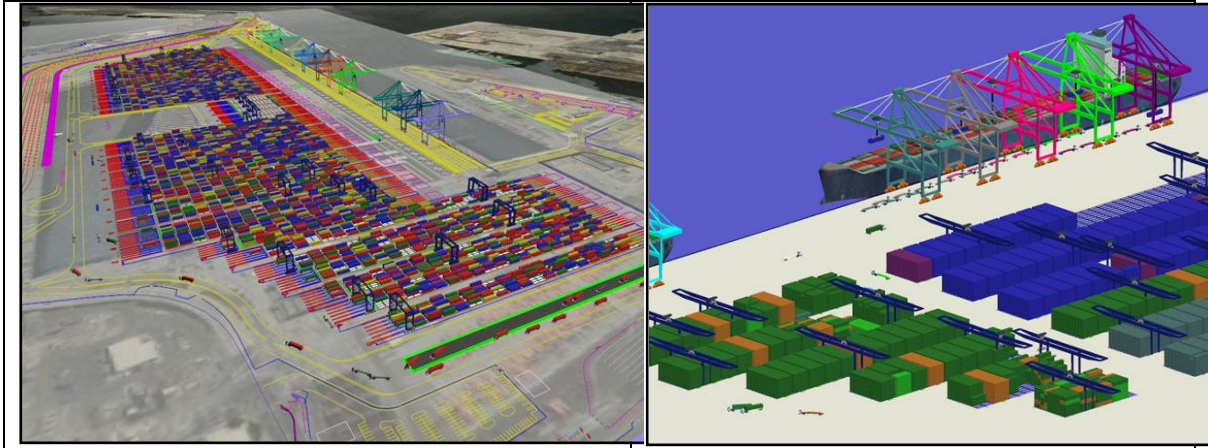


Figure (1) Screen Shots of Container Terminal

- **Flexsim** CT helps you find ways to move more containers more efficiently and at less cost. The power and beauty of Flexsim CT is that ideas for improving a process can be simulated, tested, and justified prior to implementing them in the actual system. The results of each simulation can be analyzed graphically through 3D animation, and through statistical reports and graphs, which are both excellent for communicating a model's purpose and results to technical and nontechnical audiences.
- Using Flexsim CT to study a process, end-users can confidently communicate their assumptions, findings, conclusions, and future actions to colleagues, bosses, or clients about how to improve container flow specifically and terminal operations generally. In addition to moving more containers more efficiently and at lower cost, organizations and individuals using simulation gain a greater insight into the system being studied, which consequently helps managers to predict and control a terminal's operations with greater reliability in the future.



Figure (3) CT Library

- Flexsim CT is the first available "off-the-shelf" simulation tool for container terminals. Through its simple drag-drop model-building methodology and its integrated 3D environment, Flexsim CT concentrates on making model-building easy, fast and intuitive.
- Flexsim CT provides real-time statistics collection of many key performance measures, including:

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- Berth productivity
- Ship queuing and wait times
- Crane utilization
- Truck queuing and wait times
- Yard content and container dwell times
- Yard equipment utilization
- Gate throughput and turn times

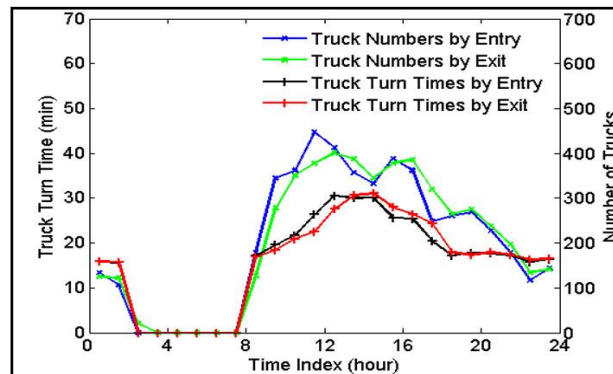
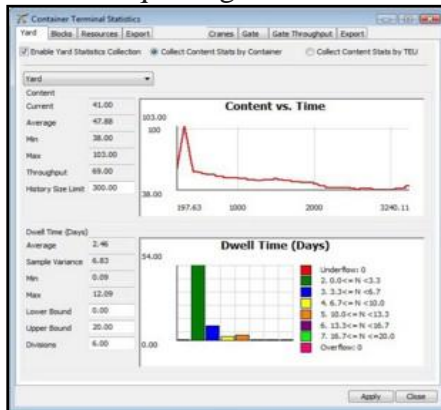


Figure (4) Flexsim CT Output Statistics

HOW FLEXSIM CT WORKS

- At any major port around the globe you'll find similarities that mark the basic structure of container terminals, the most important being that each deals in the traffic of containers. The port has a **berth** where ships arrive to unload and load containers. It may have a **gate** system where trucks arrive to pickup or drop-off containers and then return again to the **road**. It may also have a **rail yard** where trains arrive on the port's property to deliver and receive container cargo.
- Each sector - berth, rail, gate, yard - is a complex operation in and of itself. The berth receives a variety of ships on tight schedule and uses cranes and trucks to move containers on and off the ships. The rail receives a variety of trains, also on schedules, and uses rail-mounted gantry cranes, trucks and special yard blocks to service the trains. The gate is a portal for trucks arriving from the civilian road system. Those trucks are often processed (paper work and/or scans) before being routed to pickup or drop-off a container. The yard uses yard blocks (designated container storage areas), RTGs, top loaders and trucks to handle the constant container traffic. All of these supporting objects are available in the Container Terminal object library. To incorporate the full function of each sector, including arrival schedules and equipment assignments, each is defined through a planner - a set of menus that help the modeler set up the schedules and assignments.

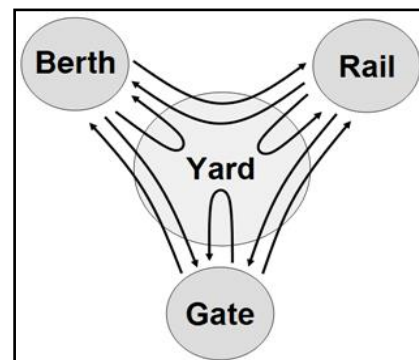


Figure (5) CT Structure

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- The flow items in Flexsim CT are the containers. Containers are introduced into the model by ships (berth), or trains (rail) or trucks (gate) and are similarly removed from the model by ships or trains or trucks. A container may arrive by a ship and exit by a truck. It may arrive by a truck and exit by a train. It may arrive by a ship and also exit by a ship. Any combination is possible where one sector acts as the source and another (or the same) sector acts as the sink.
- All of these systems utilize the **yard area** where the containers are "buffered" while waiting to be routed to the next system. It acts as the central hub since every container must visit the yard before moving to its destination. Containers are buffered in the yard for a given dwell time which may last for moments or for several days.

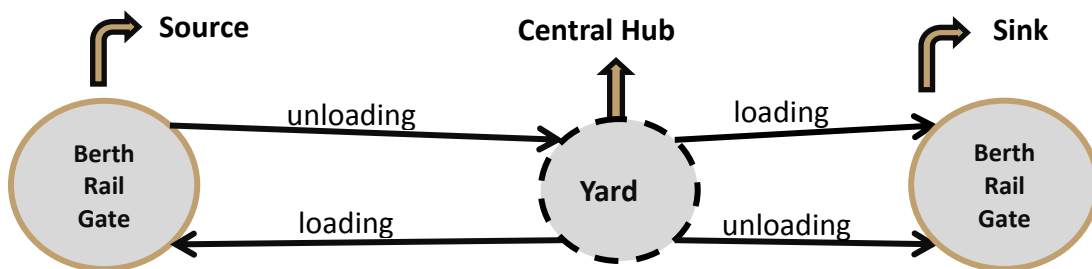


Figure (6) Yard Area Flexsim Simulation Model

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- Flexsim CT models each of these four major systems of the container terminal as well as the supporting structures and equipment needed for each. It also employs the power of abstraction to allow a modeler to focus on one key area of the port only, such as just the shipping-side operation. Whether modeling a full container terminal, or only a sector or two.
- For example, perhaps only the ship side operation is needed to be examined along with the yard content. The gate and rail operations aren't necessary so they are abstracted by Flexsim CT.

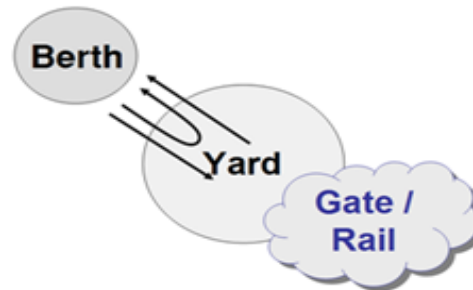


Figure (7)2 Berth + Yard

- Or maybe simulating the berth only without even worrying about the yard is required. This scenario can be modeled as well. Any portion of the container terminal can be abstracted.

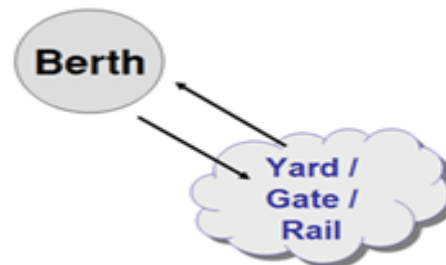


Figure (8) Berth Only

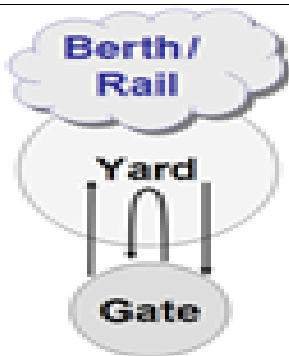


Figure (9) Gate Only



Figure (10) Berth + Gate + Yard

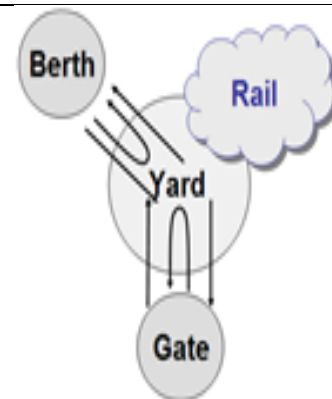


Figure (11) Gate + Yard

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BUILDING SIMPLE MODEL

The following link to download the evaluation version of Flexsim CT:
<http://www.flexterm.com/index.php/download-2/>

MODEL DESCRIPTION

- A very small terminal has one berth to dock ships.
- One ship comes to call every week, and the terminal owns a single crane to work the ship.
- Containers are imports and exports and placed in a single block in the yard.
- The containers remain in the yard for 2 days and then leave the model as if picked up by a truck arriving at the gate.

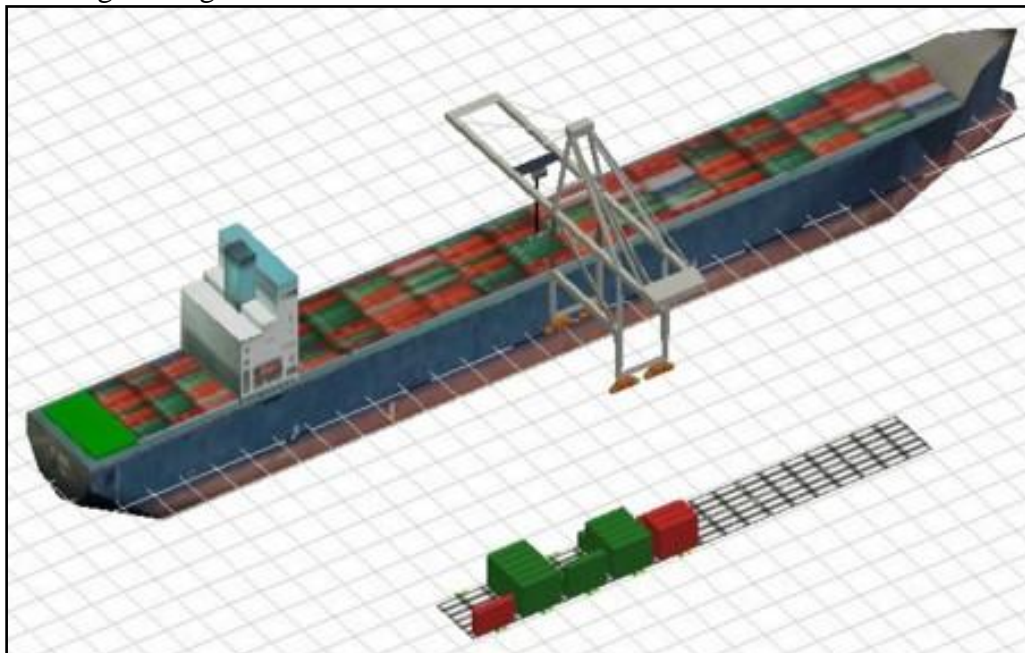


Figure (12) Model Screen Shot

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BERTH PLANNER

Berth Layout

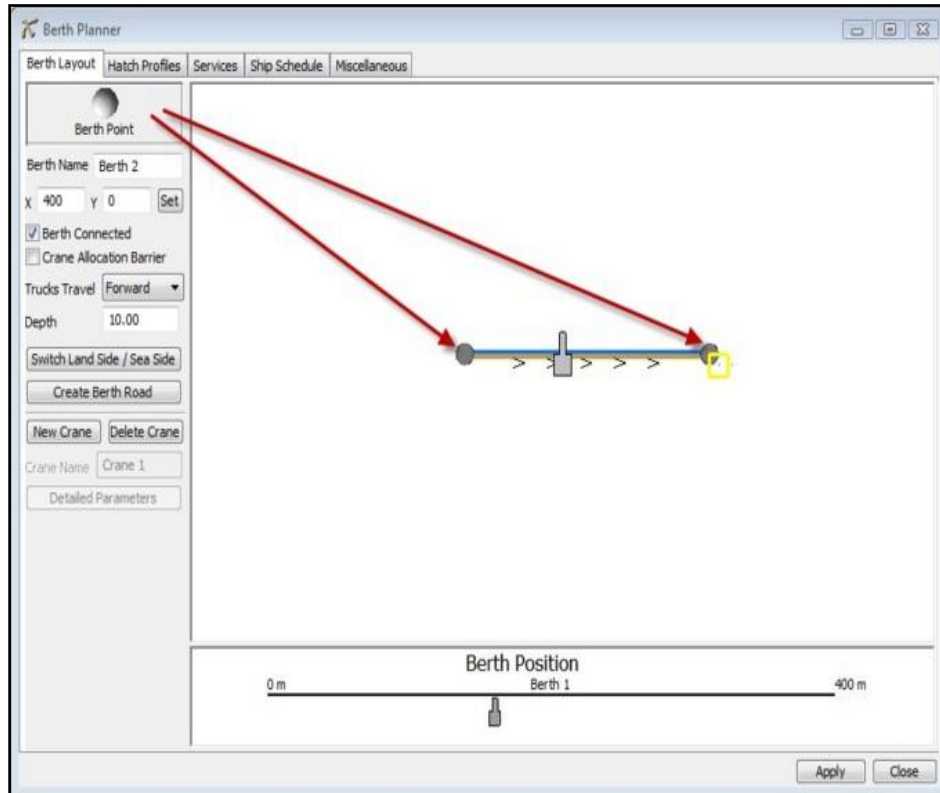


Figure (13) Berth Layout

- a. Drag BerthPlanner from library to grid
- b. Drag Berth Points to create layout
- c. Click "New Crane" to add cranes.

Hatch Profiles

- Describe the types and sizes of containers contained in a typical hatch.

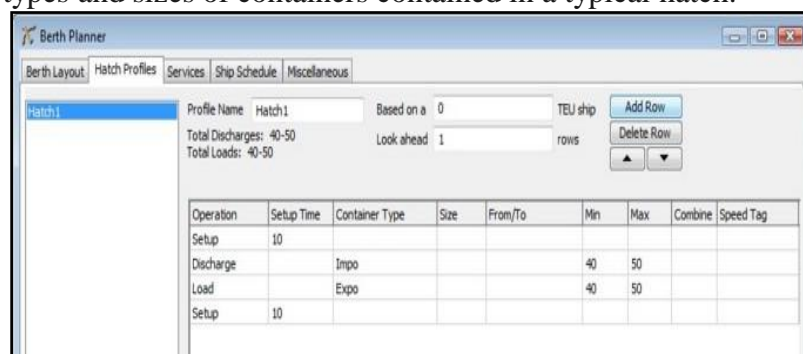


Figure (14) Hatch Profiles

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Services

- Describe ships data: sizes, typical, hatches, arrival time.

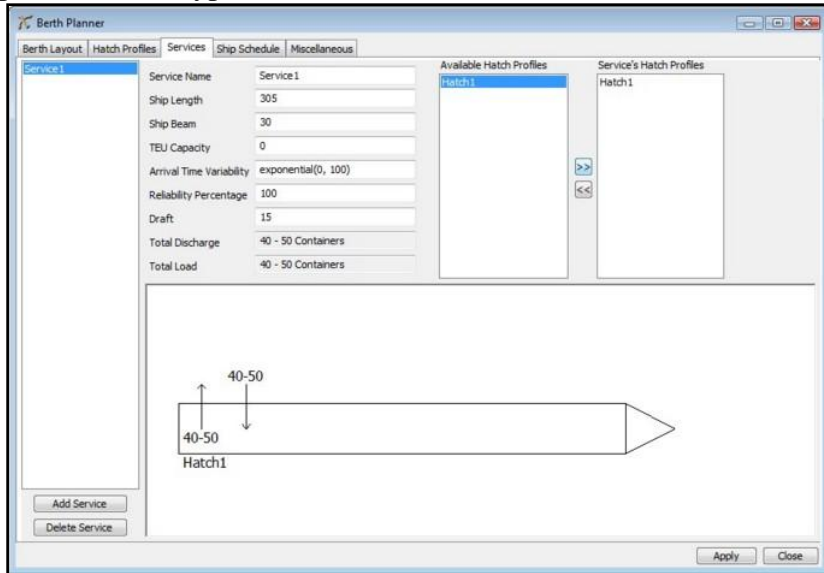


Figure (15) Services

Ship Schedule

- Drag ships to the schedule
- Vertical position = arrival time
- Horizontal position = location in berth

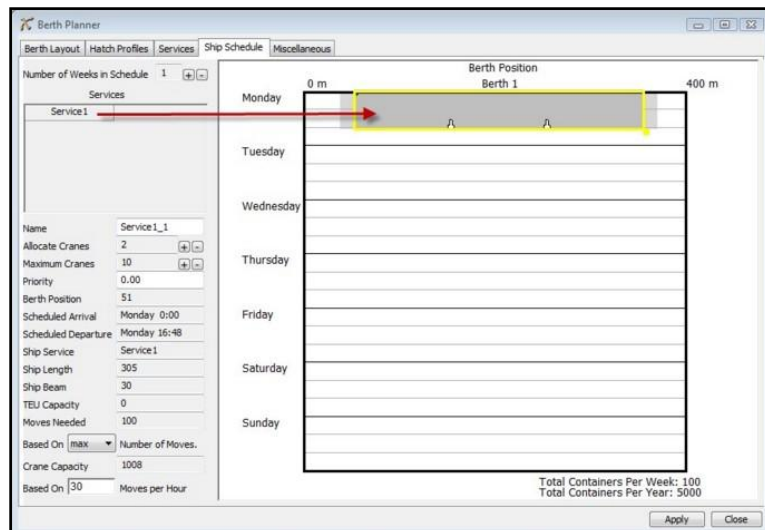


Figure (16) Ship Schedule

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YARD BLOCK

- Click and drag the block to the location of the yard want to place it.
- In the Block Assignments tab specify to store all containers in Block1.

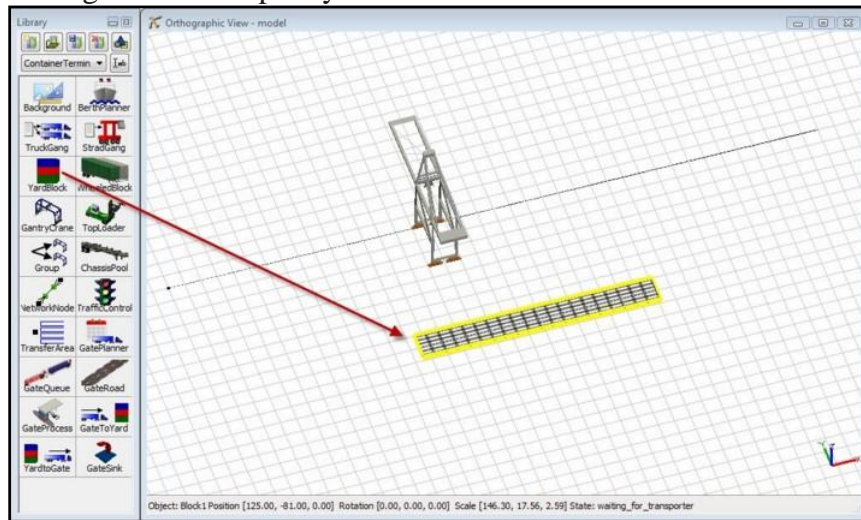


Figure (17) Yard Block

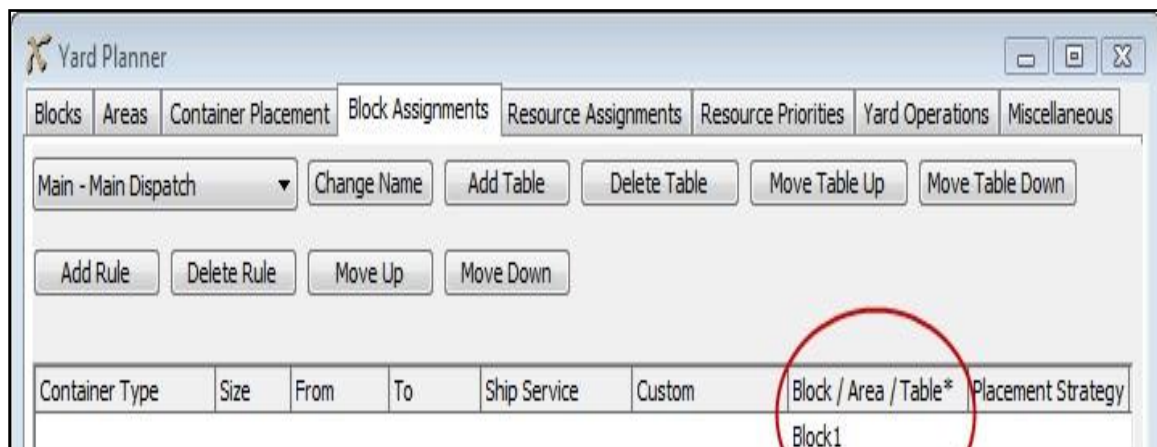


Figure (18) Block Assignment

CONCLUSIONS

- > Flexsimvery effective analysis tool that helps terminal managers and decision makerstakecritical decisions in all CT related operations by building 3D computerized models of a real-life CT, then study it in a shorter time and lower cost than actual CT.