Container Terminal Simulation with Flexsim CT

2007
Planning Example

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trucks/week</td>
<td>10,000</td>
</tr>
<tr>
<td>Trucks/day</td>
<td>1,428</td>
</tr>
<tr>
<td>Trucks/hour</td>
<td>60</td>
</tr>
<tr>
<td>Interarrival time</td>
<td>1 min</td>
</tr>
</tbody>
</table>

**Static Deterministic**
(Excel, Queuing Theory)

- Service time per lane: 3 min
- Productivity per lane: 20 trucks/h
- Required lanes: 3

**Dynamic Stochastic**
(Computer Simulation)

- Trucks never come one by one every minute
- Interarrival time changes every hour
- Demand has peaks and valleys

Only a small percent of the time service times are close to the average

How can you find the maximum queue size?
what about the waiting times?
Complex Systems

• Container terminals, like most real world systems, are too complex to allow realistic models to be evaluated analytically. These systems handle a huge amount of information from different independent processes which are stochastic and dynamic.

• With discrete-event simulation we can use a computer to evaluate a complex model numerically, and then gather data to estimate the performance of the real system under different scenarios.
Container Terminal Efficiency

(-) Ship Operation Time

(+) Quay Cranes Moves/Hour

(+) Trucks Cycles/Hour

Yard
Containers locations within the stack
Resources availability
Internal traffic
(+) Yard cranes moves/hour

Yard Planning, Resource Allocation and System Design
Existing Types of Simulation Projects

- Exclusive in-house projects:
  - 15 man years in development.
  - High development cost.
  - Used for a specific project.

- Small software tools to simulate only few aspects of the system.

- Consulting services (final user is not allowed to buy the software).

- 3D Animations (not really simulation).

None of the existing commercial packages from the big discrete-event simulation companies (Automod, Arena, Promodel, Witness, etc) are flexible enough for container terminals.
Project Participants (Steering Committee)

- **Flexsim – Developers (Utah)**
  - Anthony Johnson, anthonyj@flexsim.com
  - Cliff King, cliffk@flexsim.com
  - Roger Hullinger, rogerh@flexsim.com

- **SPRC - Port of Cartagena**
  - Mauricio Franco, mfranco@sprc.com.co

- **Maersk - APM Terminals (Pier 400 Terminal)**
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- **Port of Los Angeles**
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- **Moffat and Nichols (Long Beach, CA)**
  - Tracy Fidell, tfidell@moffatnichol.com
  - Robert Kaptein, rkaptein@moffatnichol.com
  - Ashebir Jacob, ajacob@moffatnichol.com
Simulator Features

- First commercial “off the shelf” container terminal simulator.
- Drag and drop objects, fast model construction (less than 6 hours).
- User friendly, 3D Graphics.
- Programmable, flexible, adaptable to any terminal.
- Statistically correct. Built-in ExpertFit and Optimiser (OptQuest).
- Open technology (sockets, odbc, c++, excel, xml).
Simulation Inputs: Terminal Infrastructure

- **Berth Layout**
- **Storage Blocks**
- **Cranes and Trucks**
  (travel speeds, productivity, MTBF, MTTR)
- **Gate Layout, Inner Roads and Traffic Constraints**
Simulation Inputs: Cargo Volumes

Detailed Vessel Movements and Cargo Dwell Time

Vessel Schedule and Berth/Crane Assignment

Truck Arrivals from Gate
Simulation Inputs: Operational Policies

Yard Cranes Assignment

<table>
<thead>
<tr>
<th>Block/Area</th>
<th>Operation</th>
<th>Container Type</th>
<th>Size</th>
<th>From</th>
<th>To</th>
<th>Ship</th>
<th>Segregation</th>
<th>Custom</th>
<th>Resource #</th>
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<tbody>
<tr>
<td>Block_EL</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RTG_T1</td>
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<tr>
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<td></td>
<td>RTG_T2</td>
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<tr>
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<td></td>
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<td>Block_EJ</td>
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<td>RTG_T3</td>
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</table>

Yard Stacking Filters and Segregation Policies

<table>
<thead>
<tr>
<th>Container Type</th>
<th>Size</th>
<th>From</th>
<th>To</th>
<th>Ship</th>
<th>Hatch</th>
<th>Block/Area/Table*</th>
<th>Placement Strategy</th>
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<tbody>
<tr>
<td>Impo</td>
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<td></td>
<td>AreaImpo</td>
<td>ImpoStrategy</td>
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<td>AreaExpoAndTransit</td>
<td>ExpoStrategy</td>
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<tr>
<td>Transit</td>
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<td>AreaExpoAndTransit</td>
<td>TransitStrategy</td>
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<td>Empty</td>
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<td></td>
<td></td>
<td></td>
<td>AreaEmpty</td>
<td>ExpoStrategy</td>
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Equipment Failures (MTBF, MTTR)

<table>
<thead>
<tr>
<th>Members</th>
<th>Functions</th>
<th>Breakdowns</th>
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</thead>
<tbody>
<tr>
<td>FT</td>
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<tr>
<td>MTBF</td>
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<td>RF</td>
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Housekeeping Jobs

Yard Stacking Strategies

<table>
<thead>
<tr>
<th>Name</th>
<th>Weighted - Imports</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Weight Values</th>
<th>Block</th>
<th>Easy</th>
<th>Cell</th>
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<tbody>
<tr>
<td>Segregated</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Empty</td>
<td>0.00</td>
<td>0.00</td>
<td>-200.00</td>
</tr>
<tr>
<td>Filling</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Number of Containers</td>
<td>0.00</td>
<td>0.00</td>
<td>-200.00</td>
</tr>
<tr>
<td>Stacking Trucks in Transit To</td>
<td>0.00</td>
<td>0.00</td>
<td>-200.00</td>
</tr>
<tr>
<td>Unstacking Trucks in Transit To</td>
<td>0.00</td>
<td>0.00</td>
<td>-600.00</td>
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<tr>
<td>Truck Travel Distance</td>
<td>0.00</td>
<td>0.00</td>
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</tr>
<tr>
<td>Covered Dwell Time (Days)</td>
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<tr>
<td>Yard Resource Travel Distance</td>
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</tr>
<tr>
<td>Yard Resource Task Queue Content</td>
<td>-200.00</td>
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</table>
Simulation Run in 3D Graphics for Face Validation
Simulator Outputs

- **Service Levels**
  - Productivities
  - Waiting Times
  - Queues

- **Resource Utilization**
  - Berth Occupation
  - Inventories
  - Capacities

- **Operational Costs**
  - Distances Travelled
  - Fuel Consumption
  - Yard Rehandles

- **Infrastructure**

- **Cargo Volumes**

- **Operational Policies**
Simulation Uses

- Increase throughput
- Improve equipment utilization
- Reduce waiting time and queue sizes
- Reduce bottlenecks
- Balance workload allocating resources efficiently
- Optimise prioritisation and dispatching logic for goods and services
- Study alternative investment ideas
- Justify capital expenditures
- Study cost reduction plans
- Demonstrate new tool design and capabilities
- Train operators in overall system behaviour and job related performance
- Process automation