Comparative Simulation Study of Intermodal Yard Operations in Automated Container Terminal

TRB CMTS Conference
June 29th, 2010

Arnold and Mabel Beckman Center of the National Academies
Irvine, California

moffatt & nichol
creative people, practical solutions.
Presentation Outline

- Background
- Simulation of the two proposed intermodal yard layout
- Results and conclusions
Moffatt & Nichol

• A consultant firm providing many engineering services.

• Expertise in maritime related infrastructures included planning and designing

• Port planning group
  • Mainly container terminal planning and design
Comparative Simulation Study

Container Terminal Operation - Berth

Berth Area
Container Terminal Operation - Yard
Comparative Simulation Study

Container Terminal Operation - Gate
Comparative Simulation Study

Container Terminal Operation – Intermodal

Intermodal Yard
Comparative Simulation Study

**Project Background**

- US west coast automated container terminal
- 3 M+ TEU annual throughput capacity
- Large vessels
- Limited backland
- High percentage of Intermodal Yard (IY) throughput
Comparative Simulation Study

Proposed Option – Wheeled Buffer

[Diagram showing Wheeled Buffer, Working Tracks, and RMG Crane]
Alternative Option – *Grounded Buffer*
Comparative Simulation Study

**High Level Comparison of Two Options**

<table>
<thead>
<tr>
<th></th>
<th>Wheeled Buffer</th>
<th>Grounded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Cost</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Experience</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Flexibility</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Equipment</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>

Can proposed layouts finish given throughput?
Equipment requirement?
Which layout to recommend?
Operational Constraints

- Trains are double stacked
- 20’ containers go to the bottom tier
- One train assigned to two tracks
- Safety rule
  - Cranes cannot work on a train segment while wheel change is taking place
  - Cranes cannot move a container over a moving train engine
  - Cranes cannot move a container over workers or inspectors
Example Simulation Animation

- Simulation Demo of Container Terminal Operation
Simulation Logic Flow – One Train

Train arrives according to schedule → Two empty tracks available?

- Y: Each train assigned to two empty tracks
  - Y: Start strip-inspect-load process for each half train on tracks
    - Y: One track finishes strip-inspect-load process
      - Train departs
    - N: Wait until finish
  - N: Both half-trains finished?
    - Y: Wait until available
    - N: Two empty tracks available?

- N: Wait until available
  - Y: Both half-trains finished?
    - Y: Wait until available
    - N: Two empty tracks available?
Train Strip-Inspect-Load Process

1. Unlock Cones
2. Unload Top Tier
3. Remove Cones
4. Unload Bottom Tier
5. Inspection & Repair
6. Load Bottom Tier
7. Place Cones
8. Load Top Tier
9. Lock Cones and Begin Exit Sequence

A Well Car
Simulation Experiments

• Scenarios
  – Two layouts
  – Different working shift assumptions
  – Various equipment configurations
    • Number of RMGs
    • Number of trucks
## Comparative Simulation Study

### Example Simulation Outputs

<table>
<thead>
<tr>
<th>Wheeled Buffer Option Scenarios</th>
<th>Number of Working Shifts</th>
<th>Number of RMG's</th>
<th>Number of Trucks</th>
<th>Avg Train Turn Time (hr)</th>
<th>Max Train Turn Time (hr)</th>
<th>Avg Track Occupancy (%)</th>
<th>RMG Net Prod (mph)</th>
<th>RMG Utilization (%)</th>
<th>Truck Turn Time at Buffer (min)</th>
<th>Truck Utilization (%)</th>
<th>RMG Blocked Time (%)</th>
<th>Weekly Throughput (boxes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>44.8</td>
<td>58.3</td>
<td>100</td>
<td>23.4</td>
<td>0.71</td>
<td>4.09</td>
<td>99.46</td>
<td>1.8</td>
<td>8956</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td>10</td>
<td>9.7</td>
<td>10.4</td>
<td>34.7</td>
<td>35.9</td>
<td>0.71</td>
<td>3.76</td>
<td>88.9</td>
<td>0.7</td>
<td>12763</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td>15</td>
<td>8.9</td>
<td>9.5</td>
<td>31.8</td>
<td>38.1</td>
<td>0.66</td>
<td>3.78</td>
<td>67.3</td>
<td>0.3</td>
<td>12581</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>15</td>
<td>12.1</td>
<td>24.2</td>
<td>43.3</td>
<td>33.8</td>
<td>45.2</td>
<td>5.49</td>
<td>75.2</td>
<td>2</td>
<td>12788</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>20</td>
<td>10.2</td>
<td>13.5</td>
<td>36.4</td>
<td>36.6</td>
<td>41.6</td>
<td>3.7</td>
<td>68.2</td>
<td>0.6</td>
<td>12766</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>25</td>
<td>10.2</td>
<td>13.2</td>
<td>36.4</td>
<td>36.9</td>
<td>41.3</td>
<td>3.74</td>
<td>57.6</td>
<td>0.4</td>
<td>12766</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4</td>
<td>40</td>
<td>12.3</td>
<td>23.9</td>
<td>43.9</td>
<td>35.2</td>
<td>54.1</td>
<td>3.86</td>
<td>41.2</td>
<td>0.4</td>
<td>12788</td>
</tr>
</tbody>
</table>
### Recommended Equipment Configuration

<table>
<thead>
<tr>
<th></th>
<th>Num Track RMGs</th>
<th>Num Buffer RMGs</th>
<th>Num Trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wheeled Buffer</strong></td>
<td>5</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td><strong>Grounded Buffer</strong></td>
<td>4</td>
<td>6</td>
<td>25</td>
</tr>
</tbody>
</table>
Comparative Simulation Study

Conclusions

• Both layouts can finish the given throughput
  – Number of tracks
  – Buffer size

• Safety rules appears not incur significant delays

• Perpendicular layout is recommended
  – Less RMG’s & trucks
  – Less Space

• Simulation can help client make smart investment decisions in container terminal master planning
Thank you!

moffatt & nichol