Evaluation of Intermodal Marine Container Terminal Gates via Simulation

Jeffery Karafa & Mihalis M. Golias
Department of Civil Engineering & Intermodal Freight Transportation Institute
University of Memphis

53rd Annual Transportation Research Forum
Tampa Airport Westshore
Tampa, Florida
March 15-17, 2012
Introduction

• Container volumes are predicted to double over the next 10-15 years

• Volume increases must be met with physical expansion or increases in efficiency

Source: http://www.transportation1.org/tif3report/freight_cont.html
Introduction

- Congestion concerns are coupled with emissions concerns
- Diesel emissions are known to contain carcinogens
- Drayage activities are a major source of emissions at ports

Source: http://global-quote-now.net
Introduction

Drayage: “the movement of containers between a port terminal and an inland distribution point or rail terminal”²

- Drivers paid by the move
- Causes “peaking”, especially prior to gates opening in the morning

Source: http://crossglobegroup.com

Introduction

In-gate processing is another source of delay for drayage operations. In-gate processing includes:

• Identity verification
• Checking container availability
• Equipment inspection
• Dispatching yard equipment
• Typical delay is 4-5 min.

Source: http://www.ictsi.com
Introduction

Attempts to increase terminal gate efficiency include:

• Installing advanced technology
• Extending gate operation hours
• Appointment systems

Source: http://www.tideworks.com
Objective
Create a dynamic traffic simulation model capable of modeling drayage movements within an IMCT to measure the effectiveness of gate strategies. The simulation must be able to:

• run for **24 hours** to include **extended** gate hours scenario,

• measure **congestion** via delays & **travel** times,

• measure **emissions**.
Literature Review: Gate Strategies

1. Extended gate hours at Port of Los Angeles/Long Beach resulted in 20% shift of drayage demand to off-peak hours
   ▪ Assessed fees to peak-hour moves to offset costs

2. Extended gate hours briefly tried at terminals at the Port of Newark/Elizabeth resulted in no shift
   ▪ No shift to off-peak hours resulted

Literature Review: Gate Strategies

1. Port of New Orleans found appointment system improved traffic flow and increased terminal throughput

2. Port of Los Angeles/Long Beach found appointment system to be ineffective
   - Implemented alongside extended gate hours
   - System was imposed from outside

## Literature Review: Simulations

<table>
<thead>
<tr>
<th>Authors</th>
<th>Software</th>
<th>Port</th>
<th>Entrance Gates</th>
<th>Terminal Yard</th>
<th>Exit Gates</th>
<th>IMCT Road Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huynh &amp; Walton (2005)</td>
<td>Arena</td>
<td>Houston</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Fischer et al. (2006)</td>
<td>QuickTrip</td>
<td>LA/Long Beach</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Moini (2010)</td>
<td>Arena</td>
<td>generic</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Lee et al. (2011)</td>
<td>Paramics</td>
<td>Singapore</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Dougherty (2010)</td>
<td>Vissim</td>
<td>Newark/Elizabeth</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>
Vehicle Types

“Other”

Container Trucks

Chassis Trucks

Bobtail Trucks

Source: http://ehtrucking.com/

Source: http://www.autocreditfinancing.com/

Source: http://blog.logisticsgriffin.com
1. Newark Liberty Int’l Airport
2. I-95
3. I-78
4. Doremus Ave.
5. Port St.
6. PNCT Terminal
7. Maher Terminal
8. APM Terminal
9. Maher chassis depot
10. PNCT chassis depot
12. Newark Bay

Source: Google Earth
Simulation Considerations: Don’t Lose the Truck!!

- Multiple zones at each entrance
- Allows for the creation of waypoint routes
- Zone type allows vehicles to enter simulation at link speed
Simulation Considerations: Realistic Queue Formation

- Trucks do not utilize lanes without adjustment to behavioral logic
- Each terminal used a combination of:
  - Lane restrictions
  - Route choice rules
  - Nextlanes rules
Simulation Considerations: Delays at Gates

- Terminal gates were modeled using toll feature
  - Allowed for discrete uniform delays from 0-200 s.
  - Each terminal gate was set up as a series of 3 tolls to approximate normal distribution

- Mean delays:
  - Container 4.5 min.
  - Chassis 2.25 min.
  - Bobtail 1.125 min.
  - Appointment 50% reduction in delays
OD Development

- Used data made available by Dougherty (2010) and Spasovic (2009) was used to create OD
  
- Hourly entering/exiting demand
- Entrance demands for peak hours, split by entering/exiting & vehicle type
- Peak hour terminal demands
- Peak hour turn counts
OD Development

• Five appointment scenarios were created
  ▪ Each scenario increased the demand for the appointment lanes by 10%
  ▪ All scenarios had 30% of the lanes at the entrance and exit gates converted to appointment lanes

• The only appointment scenario that outperformed the base case was the scenario in which 30% of the demand was assigned to the appointment lanes
## Scenarios

1. **Base Scenario (2006)**
2. **Extended Hours (2006)**
3. **Appointment (2006)**

Each scenario was run for 15 iterations. The results are the average values.

4. **Base Scenario (2020)**
5. **Extended Hours (2020)**
6. **Appointment (2020)**

2020 scenarios were created by increasing the volumes of the ODs by 25%.
Travel Time: % of Base Case

2006

2020

Extended Hrs.

Apt. System

Hour

APM  Maher  PNCT

The Intermodal Freight Transportation Institute (IFTI)
Herff College of Engineering
Delays at Gates: % of Base Case

2006

2020
Time in terminal (incl. gates)

Extended Hrs.

Apt. System

2006

2020

Hour

6  7  8  9  10  11  12  13  14  15  16  17

Hour

6  7  8  9  10  11  12  13  14  15  16  17

APM  Maher  PNCT

Department of Civil Engineering

The Intermodal Freight Transportation Institute (IFTI)
Herff College of Engineering
Emissions

2006

<table>
<thead>
<tr>
<th>Year</th>
<th>CO</th>
<th>CO2</th>
<th>HC</th>
<th>NO</th>
<th>Fuel</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2020

<table>
<thead>
<tr>
<th>Year</th>
<th>CO</th>
<th>CO2</th>
<th>HC</th>
<th>NO</th>
<th>Fuel</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

• The results show that extended hours outperforms appointment lanes under heavy congestion.

• Results also indicate that a simulation that does not include the entire roadway network of an IMCT will miss interactions critical to assessing the viability of implementing gate strategies.
Evaluation of Intermodal Marine Container Terminal Gates via Simulation

Jeffery Karafa & Mihalis M. Golias
Department of Civil Engineering & Intermodal Freight Transportation Institute
University of Memphis

53rd Annual Transportation Research Forum
Tamps Airport Westshore
Tampa, Florida
March 15-17, 2012