Tracking Truck Flows for Drayage Efficiency Analysis

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Presentation Outline

1. Problem
2. Background
3. GPS Tracking
4. Data Collection
5. Data Analysis
6. Our Experience
7. Summary
Due to the growth of container volume at the Southern California Twin Ports, congestion has become a chronic problem.

Inefficient port drayage causes not only congestion but also high costs and pollution.

Solving this issue can bring healthier environment, lower costs of product and less traffic.

Solution requires a clear understanding of current state of drayage efficiency through detailed tracking.
Background

- The San Pedro Twin Ports are the largest port complex in the U.S. and 9th largest port in the world.
- The Port of Los Angeles has handled an average of 7.8-million 20-foot container units (TEUs) per year in the last 10 years.
- The port of Long Beach has handled an average of 6.4 million-TEUs over the last 10 years.
<table>
<thead>
<tr>
<th>Year</th>
<th>POLA</th>
<th>POLB</th>
<th>Total</th>
<th>Change from prior year</th>
<th>% changed</th>
</tr>
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<tbody>
<tr>
<td>2003</td>
<td>7.1</td>
<td>4.7</td>
<td>11.8</td>
<td>1.2</td>
<td>11%</td>
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<td>13.1</td>
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<td>11%</td>
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<td>2005</td>
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<td>2006</td>
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<td>15.8</td>
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<td>2007</td>
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<td>15.7</td>
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<td>-1%</td>
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<td>2008</td>
<td>7.8</td>
<td>6.5</td>
<td>14.3</td>
<td>-1.4</td>
<td>-9%</td>
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<tr>
<td>2009</td>
<td>6.7</td>
<td>5.1</td>
<td>11.8</td>
<td>-2.5</td>
<td>-17%</td>
</tr>
<tr>
<td>2010</td>
<td>7.8</td>
<td>6.3</td>
<td>14.1</td>
<td>2.3</td>
<td>19%</td>
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<tr>
<td>2011</td>
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<td>6.1</td>
<td>14.0</td>
<td>-0.1</td>
<td>-0.7%</td>
</tr>
<tr>
<td>2012</td>
<td>8.1</td>
<td>6.0</td>
<td>14.1</td>
<td>0.1</td>
<td>0.7%</td>
</tr>
<tr>
<td>2013</td>
<td>7.9</td>
<td>6.7</td>
<td>14.6</td>
<td>0.5</td>
<td>3.5%</td>
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<tr>
<td>2014</td>
<td>8.3</td>
<td>6.8</td>
<td>15.1</td>
<td>0.5</td>
<td>3.4%</td>
</tr>
<tr>
<td>2015</td>
<td>6.1</td>
<td>5.4</td>
<td>11.5</td>
<td>0.1 (YTD)</td>
<td>0.7%</td>
</tr>
</tbody>
</table>
GPS Tracking

- GPS tracking is a mature technology.
- Many commercial tracking products and services are available at reasonable costs.
- Tracking of container trucks using GPS is done by various stakeholders in the drayage industry (e.g., companies that provide drayage services, and the Harbor Trucking Association).
- GPS tracking collects data on where a truck has been and at what time, but does not provide info on what the truck is there for. Such info can be provided by the driver.
GPS Tracking

- We built a mobile application with simple user interface to collect these trip data.
Data Collection

• 5 drivers from a drayage company participated in the data collection.
• Collection spanned from 6/8/15 to 8/12/15.
• Work types of drivers:
  – 2 heavy-tag (truck can only run on heavy container corridor)
  – 1 delivery to rail
  – 1 Target delivery
  – 1 store delivery
Heavy Container Corridor
Rail Locations
Target Locations
Data Analysis

- We found a total of 2405 transactions.
- 12 terminals were covered.
- Arrival time at terminal is between 7:00 am and 20:30 pm
- 5 single transaction types:
  - Load Picked Up
  - Load Delivered
  - Empty Picked Up
  - Empty Delivered
  - No Transaction (job related to chassis, or no specific job performed)
- 4 Dual transaction types:
  - Load Delivered - Load Picked Up
  - Load Delivered - Empty Picked Up
  - Empty Delivered - Load Picked Up
  - Empty Delivered - Empty Picked Up
Data Analysis
Time Spent in Terminal

- **Turn time = Queue time + Transaction time**
  - Queue time is time between entering terminal and gate-in
  - Transaction time is time between gate-in and exit of terminal

- **Average turn time is 87 minutes, longer than several previous studies on single terminal**
  (40 min. by Lam et al., 38-61 min. by Giuliano et al., 72 min. by Monaco & Grobar)
Data Analysis
Time Spent in Terminal by Arrival Time
Data Analysis
Time Spent in Terminal by Arrival Time

Source: J.D. Haverman, 2014. Data for July 13-June 14, extracted from Harbor Trucking Assoc. Website
Data Analysis
Time Spent in Terminal by Transaction

Average Turn Time (minutes) vs Transaction Type
Data Analysis
Time Spent in Terminal by Transaction

Average turn time, from longest to shortest

- For single transactions:
  - Load picked up
  - Empty delivered
  - Empty picked up
  - Load delivered

- For dual transactions:
  - Empty delivered – load pickup up
  - Load delivered – load picked up
  - Load delivered – empty picked up
  - Empty delivered – empty picked up

- No Transaction includes chassis information but we exclude them due to inconsistency.
# Data Analysis

## Travel between Locations

<table>
<thead>
<tr>
<th></th>
<th>Average Time</th>
<th>Average Distance</th>
<th>Average Speed</th>
<th>Min Speed</th>
<th>Max Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy</td>
<td>22.74</td>
<td>7.35</td>
<td>19.40</td>
<td>3.40</td>
<td>33.30</td>
</tr>
<tr>
<td>Rail</td>
<td>17.72</td>
<td>6.42</td>
<td>21.74</td>
<td>4.00</td>
<td>43.46</td>
</tr>
<tr>
<td>Target</td>
<td>20.91</td>
<td>7.91</td>
<td>22.70</td>
<td>7.11</td>
<td>39.97</td>
</tr>
<tr>
<td>Store Delivery</td>
<td>57.84</td>
<td>33.74</td>
<td>35.00</td>
<td>12.05</td>
<td>55.41</td>
</tr>
</tbody>
</table>
Data Analysis
Productive vs Non-productive Travel

- Travel is considered productive when a truck is moving with a container.
- We consider a travel non-productive if it is not an initial or final leg, and the transaction prior to the travel is delivery of a container.
- Target delivery has the highest non-productive rate.
- Each driver is estimated to have wasted at least 57 miles per day in non-productive travel.
# Data Analysis

## Productive vs Non-productive Travel

<table>
<thead>
<tr>
<th>Work Type</th>
<th>Productive Travel</th>
<th>Non-productive Travel</th>
<th>Non-productive %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store Delivery</td>
<td>4808.7</td>
<td>655.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Heavy Tag</td>
<td>1172.2</td>
<td>258.7</td>
<td>18.1</td>
</tr>
<tr>
<td>Rail</td>
<td>1931.9</td>
<td>996.1</td>
<td>35.2</td>
</tr>
<tr>
<td>Target</td>
<td>839.8</td>
<td>722.5</td>
<td>46.3</td>
</tr>
<tr>
<td>Total</td>
<td>8652.6</td>
<td>2632.3</td>
<td>23.3</td>
</tr>
</tbody>
</table>

- **Highest**: Target
- **2\(^{nd}\)**: Rail
Data Analysis
Cumulative Travels within Terminals

- Truckers tend to drive more in larger terminals.
  - The longest distance in APM, which is the largest terminal in the Twin Ports.
  - The shortest distance in PIER C BERTH C60-C62, which is the smallest.
- However, Yusen Terminal, the 3rd smallest, has the 2nd longest distance.
- If distance driven is large relative to a terminal size, it might be an indication of some issues, such as poor terminal design or system.
Data Analysis
Cumulative Travels within Terminals
Our Experience

- Driver input errors found in collected data due to
  - Misunderstanding of procedure
  - Careless operations
  - Treat it at low priority
- Fixing errors and cleaning up data is time consuming, and sometimes not possible without collaborative data.
- Hence collection of event information should be automated.
Our Experience

- Some GPS locations are incorrect in areas where signal is weak. This can be solved by an algorithm, such as the Kalman filter, or lots of data.

- For our data analysis need, not sufficient data after breakdown by arrival times, transactions, work types, etc. Longer tracking that requires driver input incurs too much overheads, hence hard to obtain willing participation.
Our Experience

- The cigarette lighters in almost all trucks are always on due to the backup batteries. Hence our plan to use them to trigger the start/stop of our mobile application failed.

- Resolution:
  - Have truck driver start/stop application manually (another source of errors due to missing data).
  - Alternatively, allow the application to stay on at all time and useless data filtered out prior to analysis.
Summary

- Average turn time is higher than previous studies on single terminal. Need to identify underlying reasons.
- Long queue time for 6:00 pm arrivals may be due to free entry after 6:00 pm under PierPass.
- Trucks mostly move under the traffic. More so for travels in the heavy container corridor and the Wilmington/Carson areas.
Summary

- Target delivery and Delivery to Rail have high percentage of non-productive travels. Possibly because these deliveries are either needed one-way or too special purpose.

- More data is needed to enable meaningful statistics after the breakdown into different categories. However, willingness for long-term driver participation can only be expected if tracking does not require driver input. Use weight sensors to detect container could be a solution.
Future Work

• Can build our own device instead of using mobile devices
• Can have a mechanism to send data when a wireless connection is detected. No need LTE services from ISPs.
• Track air pollution rate and real-time traffic data.
Thank you!

Questions?