Big Data Analysis to Measure Delays of Canadian Domestic and Cross-Border Truck Trips

Kevin Gingerich and Hanna Maoh
University of Windsor

Freight Day VI Symposium
Hosted by the University of Toronto Transportation Research Institute - Centre for Urban Freight Analysis
Wednesday March 1, 2017
Agenda

• Introduction

• Data Overview
  • GPS Data
  • Converting raw data into observable trips

• Trip delays
  • Measuring delay as a function of the total trip (instead of just single location events)
  • Identifying cross-border delays
  • Separating expected / unexpected delays
• Big Data for transportation can be categorized as follows (ITF, 2015):

• **Opportunistic sensing**
  - Collected for one purpose, used for another
  - Such as GPS data from trucks

• **Purposed sensing**
  - Collected for the purpose it is designed for
  - Such as fixed detectors, etc.

• **Crowd sensing**
  - Using content sharing platforms such as facebook, twitter, etc. to understand individuals and their travel patterns

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Data

• In this presentation, we use a dataset of **GPS pings** observing truck movements across Canada and the continental U.S.

Data Statistics
For a one month period occurring in July, 2013
30,000 Canadian owned trucks
Owned by 580 carriers

• Each GPS ping provides the location of a truck at a particular point in time

<table>
<thead>
<tr>
<th>Carrier ID</th>
<th>Truck ID</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Day</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1042</td>
<td>554</td>
<td>48.47848</td>
<td>-114.14864</td>
<td>20130302</td>
<td>145845</td>
</tr>
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<td>1042</td>
<td>589</td>
<td>52.54987</td>
<td>-108.13242</td>
<td>20130309</td>
<td>224532</td>
</tr>
<tr>
<td>1165</td>
<td>1147</td>
<td>47.34894</td>
<td>-109.78547</td>
<td>20130328</td>
<td>062234</td>
</tr>
</tbody>
</table>

_Data shown here is artificial_
Stop Events

• As part of the data processing, the purpose of a stop event is estimated as either:

1. **Primary stop** – Vehicle is stopped to transfer goods
2. **Secondary stop** – Vehicle is stopped for other purposes such as fuel refills, driver break, etc.

• The **primary stops** are used as end points to define **trips**
  • 221,800 trips derived for the one month period
Trip Zones

- The trips are aggregated (for both origins and destinations) by zones at the census division level (in Canada) and MSA or county level (in the U.S.)

- The focus of this study is on trips travelling between zones (inter-zonal)
Trip Delays

• Part 1: Border delays
Border Locations

- Border wait times are analyzed at three border crossings:
  - Blue Water Bridge
  - Ambassador Bridge
  - Peace Bridge
Border Crossing Trips by Origin Frequency
## Border Crossing Statistics (minutes)

<table>
<thead>
<tr>
<th></th>
<th>Ambassador Bridge</th>
<th>Blue Water Bridge</th>
<th>Peace Bridge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CAN bound</td>
<td>USA bound</td>
<td>CAN bound</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>3.35</td>
<td>4.61</td>
<td></td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>13.6</td>
<td>14.3</td>
<td>11.3</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>17.6</td>
<td>18.9</td>
<td>16.8</td>
</tr>
<tr>
<td><strong>95 Percentile</strong></td>
<td>42.3</td>
<td>48.3</td>
<td>48.7</td>
</tr>
</tbody>
</table>
Border Crossing Distributions

• Crossing time distribution – Ambassador Bridge
Canada Bound Border Delays

- We can determine the delay as a proportion of the total travel time since we know:
  1. the delay at the bridge
  2. the total travel time
U.S. Bound Border Delays

Border delay as a proportion of the trip travel time

Total trips

<table>
<thead>
<tr>
<th>Border delay as a proportion (%)</th>
<th>AMB</th>
<th>BWB</th>
<th>PCB</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5%</td>
<td>89%</td>
<td>78%</td>
<td>70%</td>
</tr>
<tr>
<td>5-10%</td>
<td>7%</td>
<td>14%</td>
<td>19%</td>
</tr>
<tr>
<td>10-15%</td>
<td>2%</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>15-20%</td>
<td>1%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>&gt;20%</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Average Delay Proportion: 2.5% AMB, 3.6% BWB, 4.4% PCB
• Part 2: Expected / Unexpected Delays
Expected / Unexpected Delays

• To further analyze delays, **all trips** (not just int’l trips) were broken down into proportions of:
  1. Free flow travel (no delay)
  2. Expected delay
  3. Unexpected delay

• Calculations require **the trip travel time** and the **minimum/average** travel times for any trip between the origin-destination zones and during the specified time of day
Trip Delay Results

• Only origin destination (OD) zonal pairs with at least 40 trips were retained
  • Reducing the trip count from 221,807 to 83,654 trips belonging to 756 zonal pairs

• Average proportions include 75% for the free flow travel time (no delay); 19% for expected delays; 6% for unexpected delays

• Average total delays for each origin/destination zone were also calculated
  • Range of values from 10% to 34%
Average zone delays

Average Proportion of Delay
- No Value
- 10% - 15%
- 15% - 20%
- 20% - 25%
- 25% - 30%
- 30% - 35%

Highest avg. delay by zone:
1. Durham - 34.3%
2. Simcoe - 34.1%
3. Halton - 31.3%
4. Division No 13 - 30.9%
5. Fraser Valley - 30.8%
6. Toronto - 30.6%
Connected zones pairs

- While 2 western province locations exhibit high delays, they are based on a very small sample of origin-destination pairs.
By contrast, the Toronto zone has a large number of zonal pairs (32).
Trip delay and distance

• Delay and distance relationship suggests that short delays tend to have higher delays (as a proportion of the entire trip)

• The adjusted line is a better representation of the actual pattern
  • The increase in the original line is due to a different cut-off time for valid trips that are larger than 900 km
Acknowledgements

• We would like to thank Transport Canada, who loaned the GPS data used in this study
  • in addition to methodologic discussions provided by Louis-Paul Tardif and Andrew Carter

• We are also thankful to the financial contributions provided by NSERC
Thank you for watching!