Truck GPS Data for Freight Performance Measurement and Planning: Applications, Issues, and Opportunities

presented to
Florida Model Task Force, Freight Committee

presented by
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Project Objectives

• Project Objectives
  – Investigate the use of ATRI-FPM data for freight performance measurement and planning in Florida.
  – Use the data for the following applications
    • Derive freight performance measures (speeds) for Florida’s highways
    • Convert the GPS data into a database of truck trips
    • Derive truck-trip OD flow tables for the Florida Statewide Model
  – Other
    • Assess the data – its coverage of freight truck traffic in Florida
    • Exploratory analysis of the use of data for different applications
  – Note: All the work was done using data from year 2010
Freight Performance Measurement

• On Florida’s SIS highways

Average speeds on Florida’s SIS highways

– ATRI data used to measure average truck speeds on the entire SIS network

– Speeds measured for different time-of-day periods for each 1-mile segment on the SIS network (half-mile segments in urban regions)
  • AM peak
  • PM peak
  • Mid day
  • Off peak
  • Daily average

– Speeds measured based on 3 months of data in year 2010
PM Peak Period Speeds on Florida’s SIS Highways
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**Convert GPS Data into Truck Trips**

- Algorithms to convert raw GPS data into a truck trips database
- Two types of algorithms for two types of data
  - Algorithm for data with spot speeds
  - Algorithm for data without spot speeds
- Both algorithms attempt to identify valid stops (Origins & Destinations)
  - Not all stops are valid pick-up/delivery stops
  - Stops of smaller duration (e.g., < 5mins) likely to be traffic stops
  - Not all stops of larger duration are pick-up/delivery stops
    - Gas-station stops
    - Stops due to insignificant movements (e.g., within a large warehouse)
    - Rest stops (e.g., for water, restroom, food)
    - Stops mandated by federal law on hours of service (HOS)
  - Not all stops of smaller duration are insignificant either!! especially in urban areas
The algorithms were refined based on a variety of validations
- Comparison of trip outputs with manual tracking of trucks on Google Earth
- Checking the validity of trip end locations in Google Earth
- Discussions with ATRI and FDOT

Sample validation results
- Plotted the origins and destinations of random sample of trips on Google Earth
- 10% origins and/or destinations were found to be either in rest stops, or on roadways or on empty lands

Summary of Trips Extracted From 4 Weeks of GPS Data

<table>
<thead>
<tr>
<th>1 week in March 2010</th>
<th># raw GPS Records</th>
<th>1.62 Million</th>
<th>From Data w/ Spot Speed</th>
<th>3.77 Million</th>
</tr>
</thead>
<tbody>
<tr>
<td># of trucks in the data</td>
<td>4,276</td>
<td>14,152</td>
<td></td>
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</tr>
<tr>
<td># trips extracted that start and/or end in FL</td>
<td>30,832</td>
<td>52,233</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average trip length (miles)</td>
<td>138 miles</td>
<td>228 miles</td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1 week in April 2010</th>
<th># raw GPS Records</th>
<th>1.66 Million</th>
<th>From Data w/ Spot Speed</th>
<th>2.55 Million</th>
</tr>
</thead>
<tbody>
<tr>
<td># of trucks in the data</td>
<td>4,333</td>
<td>18,801</td>
<td></td>
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<tr>
<td># trips extracted that start and/or end in FL</td>
<td>31,001</td>
<td>48,047</td>
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</tr>
<tr>
<td>Average trip length (miles)</td>
<td>143 miles</td>
<td>215 miles</td>
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</table>

<table>
<thead>
<tr>
<th>1 week in May 2010</th>
<th># raw GPS Records</th>
<th>1.72 Million</th>
<th>From Data w/ Spot Speed</th>
<th>3.16 Million</th>
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</thead>
<tbody>
<tr>
<td># of trucks in the data</td>
<td>4,297</td>
<td>17,069</td>
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<tr>
<td># trips extracted that start and/or end in FL</td>
<td>31,537</td>
<td>47,249</td>
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<tr>
<td>Average trip length (miles)</td>
<td>142 miles</td>
<td>218 miles</td>
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</table>

<table>
<thead>
<tr>
<th>1 week in June 2010</th>
<th># raw GPS Records</th>
<th>1.70 Million</th>
<th>From Data w/ Spot Speed</th>
<th>3.38 Million</th>
</tr>
</thead>
<tbody>
<tr>
<td># of trucks in the data</td>
<td>4,288</td>
<td>12,667</td>
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<tr>
<td># trips extracted that start and/or end in FL</td>
<td>32,462</td>
<td>45,258</td>
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<tr>
<td>Average trip length (miles)</td>
<td>136 miles</td>
<td>222 miles</td>
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</table>
Characteristics of Trips Extracted for 1 Week in May 2010

• Trip Length distribution
  – For trips extracted from 1 week of data
    (without spot speeds) in May 2010

• Trip Length distribution
  – For trips extracted from 1 week of data
    (with spot speeds) in May 2010
• Cross tabulation between Trip Length and Trip Duration
  – For trips extracted from 1 week of data (with spot speeds) in May 2010

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<tbody>
<tr>
<td>% of Total</td>
<td>7.08%</td>
<td>6.51%</td>
<td>10.95%</td>
<td>6.22%</td>
<td>3.98%</td>
<td>5.14%</td>
<td>10.68%</td>
<td>6.94%</td>
<td>7.20%</td>
<td>7.74%</td>
<td>5.49%</td>
<td>7.77%</td>
<td>4.08%</td>
<td>9.75%</td>
<td>100.00%</td>
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</tbody>
</table>

Note: Trip Speed computation does not consider intermediate stops longer than 45 minutes
These distributions are for only those trips that started and/or ended in Florida.
**Convert GPS Data into Truck Trips**

- **Next steps**
  - Generate OD tables from all the trips derived from the raw datasets
    - For the Florida Statewide Model
    - For different model regions within Florida
  - Analyze other trip characteristics
    - Time of day profiles
    - Weekday vs. weekend trips
- **Issues**
  - Inference of trip ends can benefit from detailed land-use information
  - Which trucks carry freight vs. which are non-freight commercial vehicles?
  - How to separate intra-urban CMV movements from inter-regional freight movements?
  - The generated OD tables will not represent all the truck flows in the state. The data represents a sample of truck flows, but not all truck flows.

**Project Objectives**

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  - Investigate the use of ATRI-FPM data for freight performance measurement and planning in Florida.
  - Use the data for the following applications
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    - Algorithms to convert GPS data into truck trip flows
    - Derive truck-trip OD tables for the Florida Statewide Model
  - **Other**
    - Assess the data, and its coverage in Florida
    - Exploratory analysis of the use of data for different applications
How Much/What Freight-Truck Traffic in Florida is Covered by the ATRI Data?

• Visual illustration of network and geographical coverage of the ATRI data (produced by ATRI)

• What proportion of freight truck flows in Florida are captured in the ATRI data?

• FDOT Telemetric Traffic Monitoring Stations (TTMS count stations)
• Compared the truck counts from ATRI data with FDOT TTMS counts (assumed to be ground truth) for one week period (May 9-15, 2010)

• Procedure
  – Among all the trips derived from the raw GPS data, select only those trips that that started and/or ended in Florida
  – For each trip, the number of times it crosses each TTMS site was counted using the network analyst tool in ArcGIS
  – The resulting total truck traffic counts (crossing TTMS sites) from ATRI data were validated against manually counting (using the raw data) of the number of times trucks were crossing a few counting stations
  – The ATRI truck traffic counts were compared to the truck traffic counts from the TTMS vehicle classification counts (at each counting station)

• Results (see next slides)
• Percentage of Heavy Truck Counts from TTMS Data represented by ATRI’s GPS Data at TTMS Count Stations in FL (for 160 count stations)

<table>
<thead>
<tr>
<th>Percentage of heavy truck counts represented by ATRI’s GPS data</th>
<th>Number of TTMS Stations for total GPS data (class 8-13)</th>
<th>Number of TTMS Stations for total GPS data (class 9-13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&lt; 5%</td>
<td>58</td>
<td>13</td>
</tr>
<tr>
<td>5 - 10%</td>
<td>41</td>
<td>34</td>
</tr>
<tr>
<td>10 - 20%</td>
<td>56</td>
<td>71</td>
</tr>
<tr>
<td>20 - 50%</td>
<td>4</td>
<td>32</td>
</tr>
<tr>
<td>&gt;50%</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>160</td>
<td>160</td>
</tr>
</tbody>
</table>

• Aggregate percentage coverage by facility type

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>No. of count stations</th>
<th>ATRI truck counts</th>
<th>TTMS truck counts for Class 8-13</th>
<th>TTMS truck counts for Class 9-13</th>
<th>% coverage assuming ATRI data comprises trucks of class 8-13</th>
<th>% coverage assuming ATRI data comprises trucks of class 9-13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeways &amp; Expressways (1)</td>
<td>29</td>
<td>111,608</td>
<td>1,063,765</td>
<td>869,684</td>
<td>10.5%</td>
<td>12.8%</td>
</tr>
<tr>
<td>Divided Arterials (2)</td>
<td>64</td>
<td>30,472</td>
<td>333,791</td>
<td>205,534</td>
<td>9.1%</td>
<td>14.8%</td>
</tr>
<tr>
<td>Undivided Arterials (3)</td>
<td>52</td>
<td>6,969</td>
<td>101,066</td>
<td>53,987</td>
<td>6.9%</td>
<td>12.9%</td>
</tr>
<tr>
<td>Collectors (4)</td>
<td>8</td>
<td>5,127</td>
<td>42,164</td>
<td>32,704</td>
<td>12.2%</td>
<td>15.7%</td>
</tr>
<tr>
<td>Toll Facilities (9)</td>
<td>7</td>
<td>9,291</td>
<td>80,493</td>
<td>60,012</td>
<td>11.5%</td>
<td>15.5%</td>
</tr>
<tr>
<td>Total</td>
<td>160</td>
<td>163,467</td>
<td>1,621,279</td>
<td>1,221,921</td>
<td>10.1%</td>
<td>13.4%</td>
</tr>
</tbody>
</table>
• Summary
  – ATRI data shows about **13%** coverage of the truck traffic in Florida, if we assume the data comprises class 9-13 trucks

• Next steps
  – Similar analysis is being conducted for a week in 2012 to assess the increase in the truck traffic captured by the ATRI data
  – Origin-Destination (OD) Matrix Estimation methods for estimating the full OD tables of truck flows in Florida

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  – Other
    ✓ Assess the data, and its coverage of freight truck traffic in Florida
    • **Exploratory analysis of the use of data for different applications**
      – Analysis of truck flows from ports
      – Analysis of truck routes
Other Applications: Truck Flows From Ports

- Two illustrations
  - Analysis of trucks flows from Blount Island (Jacksonville)
  - Analysis of trucks flows from Port Everglades

- Procedure
  - Take all trucks that had a nexus with the port during a period in 2010,
  - Follow them from when they leave the port for a maximum of 11 hrs,
  - Terminate trips after exhibiting little to no movement for >2 hours.
  - NOTE: The analysis uses only part of ATRI’s truck GPS database

- Results in the next slides
12/10/2012

I-95 N
1,098 Trips
14.6%

US 1 N
295 Trips
3.9%

I-10 W
477 Trips
6.3%

SR 200 S
175 Trips
2.3%

Urban
3,485 Trips
46.4%

Blount Island

Other (NW)
251 Trips
3.3%

I-95 S
895 Trips
11.9%

Other (NE)
652 Trips
8.7%

Other (SW)
171 Trips
2.3%

Other (SE)
21 Trips
0.3%

Other
Total
7,520
Trips
7,520
Total

Blount Island
Other Applications: Analysis of Truck Routes

Research Task:
Characterize the movement of trucks before and after they cross the I-75 Ocala Counting Station, specifically focusing on trucks that utilize US 301.

Step One: Proof of Concept
Test using one week of data (April 26-May 2, 2010)

Legend
- Ocala Counting Station
- GPS Position Read
Southbound Analysis
Based on 1,568 Trips

The portion of the trip occurring before Ocala is shown in light blue.
The portion of the trip after Ocala is shown in dark blue.

Legend
- Ocala Counting Station
- Southbound Before Ocala Station
- Southbound After Ocala Station

Where did southbound trucks come from before passing Ocala on I-75?

Legend
- Ocala Counting Station
- Southbound Before Ocala Station

I-75: 33.6%
I-10: 15.4%
I-95: 1.9%
US 301: 0.6%
SR 24: 1.5%
US 301: 12.8%
SR 20: 1.3%
CR 318: 1.5%
US 27: 2.2%
Ocala Origin: 11.4%
Isolating ONLY trips that used US 301 southbound to get to I-75 southbound near Ocala

Southbound Analysis
196 Trips

Legend
- Ocala Counting Station
- Southbound Before Ocala Station - US 301 Only
- Southbound After Ocala Station - US 301 Only

Where did trucks come from that used US 301 southbound to get to I-75 southbound?

Legend
- Ocala Counting Station
- Southbound Before Ocala Station - US 301 Only
Where did trucks go to that used US 301 southbound to get to I-75 southbound?

I-75 100%
I-75 70.9%
I-75 40.9%
FL TPK 9.7%

I-275 21.9%
I-75 31.1%
I-75 21.4%
I-75 6.1%

Legend
- Ocala Counting Station
- Southbound After Ocala Station - US 301 Only

Thank you

Questions and Discussion