GPS Data to Monitor Truck Roadway Performance

Edward McCormack
University of Washington
2015 I-NUF
Presentation Overview

• Overview of GPS data for truck monitoring
• Upsides and downsides to using this data
• Different types of GPS data and applications
GPS Basics

- Use satellites maintained by Dept. of Defense
- 5 to 10 meter accuracy
- New Russian and EU GPS systems may change things (more accuracy and features)
GPS Data From Device

- GPS devices communicate **only**:
  - ID
  - Latitude and Longitude (coordinates)
  - Time and date stamp
  - Travel Heading
  - Speed
  - Number of satellites (accuracy)

- Using this data you can calculate:
  - **Spot (instantaneous) Speed** - truck speeds at one point at one time
  - **Space Mean Speeds** – travel time between known locations

- All other information is due to processing or add-on technology
GPS Truck Data

- Truck data is increasingly available as GPS devices become more common
- But the private sector owns most of the data
- Used for freight performance measures
- GPS data more relevant and important with MAP-21 requirements
Source of Most Truck GPS Data

• Commercial Fleet Management GPS systems
  – Vendors sell GPS services to trucking companies.
  – Used to track and dispatch trucks, monitor driver performance
  – Report using a wireless connection
  – Estimate is 30% of all trucks have these GPS
  – Freight performance measures are a secondary product of these business systems

• Cell phones also have GPS but hard to link to trucks
Upsides to Truck GPS Data

• Good source of performance information
• Only consistent, widespread source of truck mobility information
• Accurate positional data
• GPS trucks are ideal traffic probes (traffic performance information)
• Expanding capabilities - growing number of better GPS devices with more frequent output
Downsides – Privacy

• Due to privacy protection you often do not know a truck’s:
  – size
  – class
  – cargo
  – if empty or full

• You either obtain less useful, aggregated data or have to develop mechanism to protect privacy

• May involve lawyers
Downsides - Data Errors

- Any raw GPS data requires error checking and cleaning:
  - Bad satellite reads
  - Tunnels
  - Urban canyons
Downsides – Processing

- Need to develop automatic tools to process (geocode) large datasets
- Centerline location problems
  - Which road is that truck on?
Downside – Collected as Business Data

- Maybe the biggest limitation – you can only get GPS data that is from devices installed for trucking efficiency.
- The GPS data we obtain is collected for business reasons - not for planning, performance measures, etc.
- The GPS data does not represent all trucks. I.e. the GPS data is not a statistical sample of all trucks on a road.
GPS Data Usability for Public Agencies

• Aggregation makes GPS easier to acquire and use but limits your usability

• Three elements at play
  – Protecting Privacy:
    • More aggregated - fewer privacy concerns
  – Retaining Value
    • More aggregated – less competition with vendor’s revenue source
  – Processing effort
    • More aggregated – fewer freight measures possible but less processing required
Examples of Different GPS Applications

• Look at GPS data used for freight measures for three different projects:
  1. NPMRDS
  2. WSDOT’s Freight Performance Measures Program
  3. Norway’s Truck Analytical Tests

• Different levels of processing, privacy concerns, costs, and applications
Example 1. NPMRDS

- USDOT’s National Performance Management Research (NPMRDS) Data Set
- Coverage every 5 minutes for national highway system
- Data is truck travel time by pre-determined segments
- Data set available free to DOTs and MPOs
- Number of trucks (n) is unknown (so limited to high volume roadways)
- **Highly Aggregated - Segment Level Point Data**
- Measures based on **Spot Speeds**
NPMRDS

- Aggregated so the GPS raw output does not need to be geocoded
- (The segment level output data still need to be cleaned and processed to be useful)
- Vendor processing is a “black box”
- Vendor (HERE) can still sell other products based on the data
- No privacy concerns
- Segment level data which can be used for:
  1. Roadway speeds
  2. Reliability measures
Output from NPMRDS
Output from NPMRDS

Travel time reliability in the Mid America Freight Coalition Regions, Web Map Web Map by TOPS_Lab
Output from NPMRDS

Figure A-10: Annual Weekday Truck Delay on Southbound I-5
Example 2. WSDOT Freight Performance Measurement Program

- Raw GPS data from one vendor
- Data follows 7,000 individual trucks
- GPS output must be geocoded and cleaned
- Privacy needs to be addressed by scrambled truck ID and NDAs
- **Disaggregated - coordinate level probe (re-identified) data**
- Measures based on **spot speeds** and **space-mean-speed**
2. WSDOT Freight Performance Measurement Program

- Vendor did not have competition for the business use of data – buying data new revenue stream
- Probe data which can be used for:
  1. roadway speeds
  2. reliability measures
  3. user selected roadway segmentation
  4. measure on any roadway with large enough sample size
  5. corridor travel times
  6. origin and destination studies
WSDOT - One Day of GPS Data
Verify GPS Spot Speeds with Roadway Loop Data
Explore Reliability for Trucks

**AM Peak**
Speed distribution for SB I-5 (between 220th SW and 236th SW)

**PM Peak**
Speed distribution for SB I-5 (between 220th SW and 236th SW)

Left diagram shows a highway segment that is unreliable in the AM peak. Right diagram shows that trucks reliably travel at 50 to 65 miles per hour in the PM peak on the same segment.
Severe truck bottleneck in Central Puget Sound: I-5 northbound

- Location: I-5 northbound between S. Lander St. and S. Nevada St
- Length: 1.0 mile
- Daily Truck Volume: 18,000
- Average truck travel speed: 35 mph
- Percentage of travel speed below 60 mph: 56%
- Travel Reliability:

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>Unreliable</td>
</tr>
<tr>
<td>Midday</td>
<td>Unreliable</td>
</tr>
<tr>
<td>PM</td>
<td>Unreliable</td>
</tr>
<tr>
<td>Night</td>
<td>Reliably Fast</td>
</tr>
</tbody>
</table>
Interactive Freight Maps

Washington State Department of Transportation

Map Controls

Layers | Legend | Basemap | Tools

% of Trucks Traveling below 60% of Posted Speed

% of Trucks Traveling below 60% of Posted Speed (Increasing Milepost Direction)
- 81% - 100%
- 61% - 80%
- 41% - 60%
- 21% - 40%
- 0% - 20%

% of Trucks Traveling below 60% of Posted Speed (Decreasing Milepost Direction)
- 81% - 100%
- 61% - 80%
- 41% - 60%
- 21% - 40%
- 0% - 20%

WSDOT Freight and Goods

WSDOT Freight and Goods Transportation System (FGTS)
- T-1 Freight Corridors
- T-2 Freight Corridors
- T-3 Freight Corridors
3. Norwegian GPS Data Program

- Several programs completed and planned
- Privacy important but addressed because companies voluntarily supply the data
- Required complicated data processing
- Disaggregated, coordinate level, probe data + added vehicles/engine info
- Measures based on **spot speeds, space-mean-speed**, and **vehicle characteristics**
Norwegian Program

- Tests of truck GPS data linked to on-boards system
- Raw GPS data plus vehicle and engine parameters for each vehicle’s on-board computer
- Largest national freight transport company considering provide GPS data for all vehicles (3000+) and trailers
- Linkage to manifest data?
Norwegian Program

- Probe data which can be used for:
  1. roadway speeds
  2. reliability measures
  3. user selected roadway segmentation
  4. measure on any roadway with large enough sample size
  5. corridor travel times
  6. origin and destination studies
    +
  7. Air emission studies
  8. Green impact calculation tools
  9. Commodity movements
  10. Measures linked to vehicle classifications
  11. ???


Norwegian Output

**TABLE 27 TABLE OF SPEED LIMITS AND OBSERVED SPEEDS, KM/H**

<table>
<thead>
<tr>
<th>Speed limit</th>
<th>Mean observed speed</th>
<th>Standard Deviation</th>
<th>95% CI</th>
</tr>
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<tbody>
<tr>
<td>50</td>
<td>57.8</td>
<td>11.9</td>
<td>57.4 - 58.2</td>
</tr>
<tr>
<td>60</td>
<td>66.4</td>
<td>11.2</td>
<td>66.2 - 66.6</td>
</tr>
<tr>
<td>70</td>
<td>74.6</td>
<td>9.3</td>
<td>74.5 - 74.8</td>
</tr>
<tr>
<td>80</td>
<td>77.4</td>
<td>11.4</td>
<td>77.3 - 77.5</td>
</tr>
<tr>
<td>90</td>
<td>85.1</td>
<td>6.48</td>
<td>85.0 - 85.2</td>
</tr>
<tr>
<td>100</td>
<td>86.6</td>
<td>8.49</td>
<td>86.3 - 86.9</td>
</tr>
</tbody>
</table>

**TABLE 35 IMPACT OF FREIGHT DENSITY ON EMISSIONS**

<table>
<thead>
<tr>
<th>Number of vehicles</th>
<th>100%</th>
<th>50%</th>
<th>33%</th>
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</thead>
<tbody>
<tr>
<td>Vehicle load</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel consumption (g)</td>
<td>170292</td>
<td>264062</td>
<td>357066</td>
</tr>
<tr>
<td>NOx (g)</td>
<td>2971</td>
<td>4841</td>
<td>6700</td>
</tr>
<tr>
<td>CO (g)</td>
<td>49</td>
<td>101</td>
<td>152</td>
</tr>
<tr>
<td>PM (g)</td>
<td>11</td>
<td>22</td>
<td>32</td>
</tr>
<tr>
<td>THC (g)</td>
<td>7</td>
<td>13</td>
<td>19</td>
</tr>
</tbody>
</table>
GPS Truck Data Trade-Offs

Aggregated Data has:
- Minimal or no privacy concerns
- Does not conflict with vendor’s use of GPS data for revenue
- Processing concerns reduced but also a “black box”
- Spot speed data can only measure segment level speed and reliability (typically used for major roads)
- Less costly
GPS Data Trade Offs

**Disaggregated Data** has:

- Many potential privacy and business concerns
- A conflict with vendor’s use of GPS for revenue
- Both acquisition and processing costs but data can be modified to meet project needs
- Many freight performance and monitoring uses
- Spot speed, space-mean-speed, vehicle characteristics
In Conclusion – Truck GPS Data

• Unique source of truck performance information that has seen valuable applications
• For transportation agencies level of data aggregation matters
• Data has inherent limitations for planning purposes and performance measures because it collected for business reasons
• As GPS device capability and planning requirements grow so will applications
Ed McCormack
University of Washington
(206) 543-3348
edm@uw.edu
ATRI

• Identification of major national bottlenecks
GPS Data Application – NPMRDS

• Large national GPS database
• Covers National Highway Systems
• Free to DOTs and MPOs
• Data in 5 minute slices
• Many applications
• ATRI is the source
GPS Data Application - WSDOT

- Data from one vendor
- 3+ years of statewide data
- Used as part of a freight performance measures program
- Identify truck bottlenecks
- Look at the reliability of roadway segments
- Inform WSDOT’s project prioritization process
TRUCK SPEED WEEKDAY PM SPEED: 33 km/h
GPS Data Applications - Ontario

- GPS data relationship with one vendor
- Long-term program using data for planning and engineering
- Truck data used for:
  - historic traffic performance
  - congestion indices
  - border waits
  - safety studies
So To make GPS useful

These data:

– ID
– Latitude and Longitude (coordinates)
– Time and date stamp
– Travel Heading
– Speed
– Number of Satellites (accuracy)

Need to be converted to useful statistics