Applications of Vehicle Probe Data for Performance Measurement

Baltimore Regional Transportation Board
October 25, 2016

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Center for Advanced Transportation Technology
• Probe data background
• Applications in performance measurement
  – Freeways: Maryland Mobility Report
  – Arterials: Maryland Mobility Report
  – Weather Impact and Recovery
  – Work Zones
• Newly Acquired O-D Data & Applications
### Background - The World is Changing

<table>
<thead>
<tr>
<th>Year</th>
<th>World Population</th>
<th>Connected Devices</th>
<th>Connected Devices Per Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>6.3 Billion</td>
<td>500 Million</td>
<td>0.08</td>
</tr>
<tr>
<td>2010</td>
<td>6.9 Billion</td>
<td>12.5 Billion</td>
<td>1.81</td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
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</tbody>
</table>

More connected devices than people!
INRIX provides Internet services and mobile apps pertaining to road traffic and driver services (speeds, travel times, traffic counts).

INRIX collects terabytes of data from over 250 million mobile phones, cars, trucks, vans and other fleet vehicles via GPS.

INRIX sold 4 months of trip O/D data to Maryland SHA:
- 20 million trips, which include 1.4 billion waypoints
- 112 GB of data
Background – Historical Significance of “Big Data”
Background: Vehicle Probe Data

- Private data vendors collect and fuse data from several sources, including GPS probes
- Data is reported every minute on Traffic Message Channels (TMC)
Background: Incoming raw GPS data
(Source: INRIX)
Background: Validation effort

Through July 2015

- 11 states
- 55 evaluation reports
- 57 deployments, 829 days sensors on the road
- 1282 centerline mile (994 mile freeway, 288 mile arterial)
- 95,706 hour worth of ground truth data resulting from 13 million Bluetooth observations

<table>
<thead>
<tr>
<th>State</th>
<th>Validation rounds</th>
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<tbody>
<tr>
<td>CT</td>
<td>1</td>
</tr>
<tr>
<td>DE</td>
<td>6</td>
</tr>
<tr>
<td>FL</td>
<td>1</td>
</tr>
<tr>
<td>GA</td>
<td>1</td>
</tr>
<tr>
<td>MD</td>
<td>9</td>
</tr>
<tr>
<td>NC</td>
<td>6</td>
</tr>
<tr>
<td>NJ</td>
<td>13</td>
</tr>
<tr>
<td>PA</td>
<td>8</td>
</tr>
<tr>
<td>RI</td>
<td>1</td>
</tr>
<tr>
<td>SC</td>
<td>1</td>
</tr>
<tr>
<td>VA</td>
<td>10</td>
</tr>
</tbody>
</table>

Reports are available on: http://www.i95coalition.org/projects/vehicle-probe-project/
Background: Graphical output

- Bluetooth Data in Blue
- Wide SEM Band
- VPP Data in Red
- Narrow SEM Band
- Outliers marked with Black
Mobility Reporting: National and State Level

• National
  – Urban Mobility Report (TTI)
  – Since 2010 based on probe speed data

• States
  – Washington (WSDOT)
    • The Gray Notebook
  – Maryland (SHA)
    • Mobility Report (Since 2012)
  – Indiana (IDOT)
  – ...
Mobility Reporting: Performance Measurement

- Congestion: Travel Time Index (TTI)
  - Refers to the ratio of expected (average) travel time to the (minimum) free flow travel time of the segment
- Uncongested (TTI<1.15)
- Light (1.15<TTI<1.3)
- Moderate (1.3<TTI<2.0)
- Severe (TTI>2.0)
Mobility Reporting:
Performance Measurement

• Reliability: Planning Time Index (PTI)
  – Refers to the ratio of extreme (95th percentile) travel time to the (minimum) free flow travel time
• Reliable (PTI<1.5)
• Moderately Reliable (1.5<TTI<2.5)
• Unreliable (PTI>2.5)
Mobility Reporting: Corridor Level Example

2014 Maryland State Highway Mobility Report

495 Capital Beltway

Trends*

<table>
<thead>
<tr>
<th>Travel Time Index*</th>
<th>AM Peak</th>
<th>PM Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Planning Time Index*  

<table>
<thead>
<tr>
<th>Average Delay</th>
<th>AM Peak</th>
<th>PM Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Speed Profiles*

Daily Variability*

Top Bottlenecks*

<table>
<thead>
<tr>
<th>Year</th>
<th>Rank</th>
<th>Location</th>
<th>Location Description</th>
<th>Direction</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
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Notes

- Peak hours are considered as 6-9am and 3-6pm.
- Travel Time Index (TTI) is the ratio of the average travel time during the peak hour to the time required under free flow.
- Planning Time Index (PTI) is the ratio of the worst case travel time (95th percentile) during peak hour to the free flow time.
- Days entries are represented by week-day.
- TTI and PTI are expressed in percentage of free flow.
- Variability of worst-case travel experience along facility for each day of year, shown as a plot of PTI by day of week and month, showing seasonal and weekly trends.
- Top 10 bottlenecks on the facility, ranked by PTI factor.
- Impact factor is a combination of total number of bottlenecks occurrence by their average duration and by their average length.
Mobility Reporting:
Samples of Arterial Corridor Performance

**MD 32**
- **Limits:** MD 108 (Clarksville PIke) to MD 26 (Liberty Road)
- **Corridor Length:** 16.3 miles
- **Speed Limit:** 40 - 50 MPH
- **Travel Lanes:** (1 - 2) Northbound (1 - 2) Southbound
- **Signal Controlled Intersections:** 11
- **Grade Separated Interchanges:** 3
- **Major Cross Streets:** MD 108, Burnswoods Rd, MD 26, MD 144, MD 26

### Routes and Ridership

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Daily Ridership</th>
<th>2013 AADT</th>
<th>Trucks 2013</th>
<th>Peak Hour Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>N/A</td>
<td>20,000 - 20,000</td>
<td>7% - 11%</td>
<td>0%</td>
</tr>
</tbody>
</table>

**US 1**
- **Limits:** MD 410 to MD 150
- **Corridor Length:** 10.7 miles
- **Speed Limit:** 35 - 50 MPH
- **Travel Lanes:** (2 - 4) Northbound (2 - 4) Southbound
- **Signal Controlled Intersections:** 40
- **Grade Separated Interchanges:** 3
- **Major Cross Streets:** MD 410, MD 190, I-695, Rhode Island Ave, Rolling Rd, MD 312, Mukilte Rd, Cortez Rd, Cherry Lane

### Routes and Ridership

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<thead>
<tr>
<th>Year</th>
<th>Average Daily Ridership</th>
<th>2013 AADT</th>
<th>Trucks 2013</th>
<th>Peak Hour Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>N/A</td>
<td>10,000 - 10,000</td>
<td>3% - 7%</td>
<td>0.6% - 8.5%</td>
</tr>
</tbody>
</table>

**Segment Operations**

- **LOS D or Better**
- **LOS E**
- **LOS F**

<table>
<thead>
<tr>
<th>Level of Service</th>
<th>AM Peak Hour</th>
<th>PM Peak Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOS D or Better</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>LOS E</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LOS F</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**LOS 'E' Intersections**

**LOS 'F' Intersections**

**Color Key**

- **PTI** planning time index (95th percentile travel time / freeflow travel time)
- **TTI** travel time index (90th percentile travel time / freeflow travel time)
Mobility Reporting: Anticipated Arterial Probe Data Effectiveness

Likely to have accurate probe data

- AADT > 40000
- 2+ lanes
- <= 1 signals per mile
- Principal Arterials (HPMS)
- Fully or Partially captures >75% slowdowns

Possibly accurate probe data

- AADT 20K to 40K
- 2+ lanes
- <= 2 signals per mile
- Minor Arterials (HPMS)
- Should be tested

Unlikely probe data is accurate

- Low Volume, AADT < 20K
- >=2 signals per mile
- Major Collectors (HPMS)
- Not recommended

- Probe data quality most correlated to signal density
- Increased volume aids probe data, but does not overcome issues associated with signalized corridors
- Accuracy **ANTICIPATED** to improve with increased probe density and better processing
### Interval for Winter Road Restoration Time

<table>
<thead>
<tr>
<th></th>
<th>Beginning Time</th>
<th>Ending Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17:32</td>
<td>25:00</td>
<td>7:28</td>
</tr>
</tbody>
</table>
Mobility Performance: Work Zones

• Exposure
  – Volume
  – Site specific data

• Safety
  – Volume
  – Crash/incident data

• Mobility
  – Volume
  – Speed (probe data)
Sample Results

- Westbound I-70, East of Frederick – WZ3: Speeds
Mobility Performance: Work Zone PM Dashboard

Source: RITIS
Data Sample: Single Trip

Trip
- Unique Id
- O/D locations and times
- Pedestrian or vehicle
- Vehicle: fleet, consumer, mobile
- Vehicle: weight class 1-3

Waypoints
- Order: 0, 1, ..., n
- Latitude and longitude
- Time stamp (sec)
Waypoint locations (June 2015)

- Percentiles are based on a sample of 500 million waypoints from Feb and Oct
Trip Attributes

- MD-MD: 76%
- MD-External: 10%
- External-MD: 10%
- External-External: 4%

Vehicles: 99%
Pedestrians: 1%

- Fleet: 31%
- Consumer: 10%
- Mobile: 59%

- Weight C1: 33%
- Weight C2: 22%
- Weight C3: 45%

Bar Graph:
- Monday: 16%
- Tuesday: 17%
- Wednesday: 17%
- Thursday: 18%
- Friday: 18%
- Saturday: 9%
- Sunday: 5%

C1 ≤ 14,000 lb, C3 ≥ 26,000 lb
Trips within MD

Chord Diagram
- Trips with O/D in MD
- Trips with a waypoint outside MD are filtered out

Observations
- Most trips are within the same county
Trips along I-95

Blue/Red trajectories are North/South bound (70k trips during July)
Trips from Activity Zones

Comparison
- Peak
  7:00 am - 9:00 am
  4:00 pm - 6:00 pm
- Offpeak
Thank you!

For more information...

www.catt.umd.edu

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