Freight Performance Analysis on I-94/I-90
From the Twin Cities to Chicago

Chen-Fu Liao
Minnesota Traffic Observatory
Department of Civil Engineering

Session 23: Freight and Rail Planning
April 27-28, 2010
St. Paul, Minnesota
Outline

• Objectives
• Data Summary
• Data Processing and Analysis
• Analysis Results
• Concluding Remarks
Objectives

- Use available truck AVL data from ATRI to analyze freight activity along I-94/I-90
- Compare variations of truck speed and travel time to identify potential freight bottleneck and forecast future freight demand
- Identify the needs of local highway infrastructure improvement to sustain growing freight demand
Data Summary

- FAF2 Data from FHWA
- 12 months (May 08 ~ Apr. 09) of Truck AVL/GPS Data from ATRI
- Highway Speed Data from MNDOT, Wisconsin DOT and IL State Toll Highway Authority

<table>
<thead>
<tr>
<th>Month</th>
<th># of Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 08</td>
<td>26365</td>
</tr>
<tr>
<td>Jun 08</td>
<td>54511</td>
</tr>
<tr>
<td>Jul 08</td>
<td>55657</td>
</tr>
<tr>
<td>Aug 08</td>
<td>53279</td>
</tr>
<tr>
<td>Sep 08</td>
<td>51920</td>
</tr>
<tr>
<td>Oct 08</td>
<td>54456</td>
</tr>
<tr>
<td>Nov 08</td>
<td>46529</td>
</tr>
<tr>
<td>Dec 08</td>
<td>47126</td>
</tr>
<tr>
<td>Jan 09</td>
<td>44708</td>
</tr>
<tr>
<td>Feb 09</td>
<td>42631</td>
</tr>
<tr>
<td>Mar 09</td>
<td>44158</td>
</tr>
<tr>
<td>Apr 09</td>
<td>57165</td>
</tr>
</tbody>
</table>
Data Processing Flow Chart

1. **Raw Truck GPS Data**
   - Locate Features
   - Create Route DB

2. **Segmentation Script**
   - Calculate Segment Speed
   - Generate Network Segment Speed
   - Segmented Truck Speed
   - Generate Truck Speed Statistics

3. **Data Quality Filtering**
   - Truck Stops and Stop Durations
   - Generate AVL Data on Route

4. **Generate Truck Speed Statistics**
Data Analysis

- Speed By Location
- Speed By Hour Of Day
- Speed and Volume at Location
- Performance Index
- Trip Destinations
- Truck vs. General Traffic
- Truck Stops & Durations
Average Truck Speed By Location

I-94/90 (TWIN CITIES CHICAGO)
Average Truck Speed of April 2009

I-94 (St. Paul-Chicago) - 2009/04 (6:00-9:00) - Mean

St. Paul  Tomah  Madison  Chicago

Mile

Speed (MPH)

Truck EB  Truck WB
Average Truck Speed STDEV of April 2009

I-94 (St. Paul-Chicago) - 2009/04 (6:00-9:00) - Std. Dev.

- Truck EB
- Truck WB

St. Paul, Tomah, Madison, Chicago, I-90 Toll Highway
Average Speed (EB)

Average Speed Eastbound

St. Paul  Tomah  Madison  Chicago

Mile

Speed MPH

I-90 Toll Highway

AVG_SPD_0508  AVG_SPD_0608  AVG_SPD_0708  AVG_SPD_0808  AVG_SPD_0908  AVG_SPD_1008  AVG_SPD_1108  AVG_SPD_1208  AVG_SPD_0009  AVG_SPD_0109  AVG_SPD_0209  AVG_SPD_0309  AVG_SPD_0409
Average Speed Westbound

Speed MPH

Mile

St. Paul
Tomah
Madison
Chicago

I-90 Toll Highway

Average Speed (WB)
Truck Speed and Volume Variation By Time of Day

I-94/90 (Twin Cities Chicago)
St. Paul, MN

Speed Distribution at MM18, EB

EB Mean=46.9, Median=57.7, N=33,610

Speed Distribution at MM18, WB

WB Mean=46.4, Median=54.6, N=33,788

I-94 at US52

Mean
Median
St. Paul, MN

I94 & US52
Performance Index

Reliability Measure

Buffer Time Index (BTI) = \( \frac{95\% \text{ TT} - \text{Avg. TT}}{\text{Avg. TT}} \)

Buffer Speed Index (BSI) = \( \frac{95\% \text{ Speed} - \text{Avg. Speed}}{\text{Avg. Speed}} \)

Congestion Measure

Travel Time Index (TTI) = \( \frac{\text{Peak Travel Time}}{\text{Free Flow Travel Time}} \)
Buffer Time Index (BTI) of Apr. 2009

\[ \text{BTI} = \frac{95\% \text{ TT} - \text{Avg. TT}}{\text{Avg. TT}} \]

I-90 Toll Highway

St. Paul  Tomah  Madison  Chicago
BTI by Hour of Day at US52 (MM18)

$$\text{BTI} = \frac{95\% \text{ TT} - \text{Avg. TT}}{\text{Avg. TT}}$$
BTI by Hour of Day at MM393

Buffer Time Index Nearby O'Hare (MM393), APR. 09

\[ \text{BTI} = \frac{95\% \text{ TT} - \text{Avg. TT}}{\text{Avg. TT}} \]

Hour of Day

Buffer Index

Eastbound

Westbound
Travel Time Index (TTI) of Jan. 2009

Travel Time Index (TTI) = \frac{\text{Peak Travel Time}}{\text{Free Flow Travel Time}}
Travel Time Index (TTI) of Jan. 2009

Travel Time Index (TTI) = \[
\frac{\text{Peak Travel Time}}{\text{Free Flow Travel Time}}
\]
Trip Destinations Analysis

I-94/90 (TWIN CITIES □
CHICAGO)
Distribution of Trip Destinations
Truck vs. General Traffic

I-94 (TWIN CITIES-HUDSON, WI)
I-94 Annual Average Speed (EB)

Average Free Flow Speed Obtained from Mn/DOT
I-94 Annual Median Speed (EB)

I-94 EB Annual Median Speed (St. Paul - Hudson)

All Traffic Free Flow Speed

Posted Speed Limit 65 MPH

Truck

Average Free Flow Speed Obtained from Mn/DOT
I-94 Annual Average Speed (WB)

I-94 WB Annual Average Speed (St. Paul - Hudson)

Average Free Flow Speed Obtained from Mn/DOT
I-94 Annual Median Speed (WB)

I-94 WB Annual Median Speed (St. Paul - Hudson)

All Traffic Free Flow Speed

Posted Speed Limit 65 MPH

Truck

Average Free Flow Speed Obtained from Mn/DOT
Truck vs. General Traffic

I-90 (S. BELOIT – O’HARE)
General Traffic Speed (Segment Speed) Derived from Illinois Toll Highway Authority Inter-Plaza Travel Time
I-90 Annual Average Speed (WB)

General Traffic Speed (Segment Speed) Derived from Illinois Toll Highway Authority Inter-Plaza Travel Time
Truck Stops

I-94/90 (TWIN CITIES - CHICAGO)
EB Truck Stops (Apr. 2009)

Truck Speed < 5MPH and Travel Distance < 100 meters, N=72,543
WB Truck Stops (Apr. 2009)

Truck Speed < 5MPH and Travel Distance < 100 meters, N=74,405
Truck Stops from *TruckMaster*
Truck Stop Durations

I-94/90 (TWIN CITIES - CHICAGO)
Traffic Volume

I-90 (S. BELOIT- CHICAGO)
I-90 EB Truck Volume (Tier 4)

Average Daily Truck Volume (EB)

- South Beloit
- Elgin Road
- Marengo-Hampshire
- River Road

Mile

Truck Volume

April 2009 (Apr 09)
January 2009 (Jan 09)
October 2008 (Oct 08)
July 2008 (Jul 08)
I-90 WB Truck Volume (Tier 4)
Summary

- FPM data can be used to measure performance over time and by location
- Truck travel time reliability and level of congestion
- Truck volume variation and impact
- Performance Index (BTI, TTI)
- Truck Destinations
- Truck Stops and Rest Durations
Possible Causes of Bottlenecks

- Top 30 freight bottlenecks occurred at highway interchange (ATRI Report)
- Roadway geometry (grade, sight distance)
- Capacity (number of lanes), Toll booths
- Required lane of travel for trucks
- Speed limit and free flow speed
- Volume ratio of truck vs. general traffic
- Weather and Others
Potential Applications

- Truck travel time reliability and impact of congestion on cost of freight
- Identify truck stop facility needs
- Speed gap between general traffic and truck influenced by traffic volume
- Need national standard to report freight performance measures regularly
- Use FPM data for freight study in metro area
Acknowledgements

- USDOT, FHWA
- Minnesota DOT and ATRI
- Illinois State Toll Highway Authority
- CTS, University of Minnesota (UMN)
- Minnesota Traffic Observatory (MTO), Department of Civil Engineering, UMN
Freight Performance Analysis
Using Archived Truck AVL/GPS data

Thank You!