Volume & Turning Movements Project

Steering Committee Meeting #4

APRIL 13, 2017

Conference call number: 1-719-867-1571 and enter 725437# at the prompt
Housekeeping Items

- Please call Emily at 718-353-6938 for difficulties with the web or audio application.
- This is a **virtual meeting experience**
  - Please keep your phone muted until asking a question or speaking (press *6 to mute/unmute individual phone lines).
  - Please do not place call “on hold” as your hold music will be heard by the group.
- Speakers will answer questions at the end of their presentation.
- The audio from this meeting is being recorded.
- All materials & contact information will be available to participants after the webcast.
WELCOME!

Denise Markow, I-95 Corridor Coalition
Introductions

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Steven Jessberger
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### Attendees

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Thank you!
## Agenda

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<td>1 Project Tasks Status Update</td>
<td>Stan Young, NREL</td>
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<td>2 Technical Updates</td>
<td>Kaveh Sadabadi, UMD CATT Yi Hou, NREL</td>
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<td>3 Travel Monitoring Analysis System (TMAS)</td>
<td>Stan Young, NREL &amp;</td>
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<td>Denise Markow, I-95 Corridor Coalition</td>
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Status Update on Volume & Turning Movements from Probe Data Project

Stan Young, NREL

April 13, 2017
Volume & Turning Movements from Probe Data Project

- Coalition project funded through MCOM2 Grant
- Work being conducted in collaboration with the:
  - UMD CATT, Kaveh Sadabadi
  - NREL, Stan Young
  - Coalition, Denise Markow
  - INRIX (Rick Schuman), HERE(Terri Johnson), TomTom(Nick Cohn)
Background

• Network wide volume and turning movement data remains key missing dimensions for operational awareness and assessing transportation system performance

• Highway Performance Monitoring System (HPMS) data is currently state-of-the-practice in providing volume data, BUT it is limited and aggregated into hourly volumes for a typical day and may be significant lag in availability

• Turning movement data is only available in special studies

VISION

VOLUME ESTIMATE 24x7x365 ACROSS THE NETWORK
Project Goal

Accelerate the timeframe to a viable real-time volume and turning movement data feed anywhere on the network, and to make every effort to ensure that initial data products meet the I-95 Coalition members’ information needs for operations, performance measurement, and planning.
Objectives - Original

- Define a practical and logistical framework for the delivery of probe-based volume and turning movement data
- Understand, document, and share data requirement needs for a variety of DOT applications requiring such data
- Create a calibration and validation testbed to assist vendors’ initial development efforts.
- Provide representative data products, and set appropriate expectations for data fidelity, form, granularity, and usability
- Anticipating the need for an ongoing calibration network, estimate resources needed to maintain/operate a national calibration/validation testbed
Flow Chart - Initial

Calibration / Validation Testbed
UMD - NREL

INRIX
HERE
TomTom

Calibration Data
Validation Methods

- VTM products
- Validated
- Consistent formats
- Meets Coalition needs
As it Evolved / is Evolving Flow Chart

Calibration / Validation Testbed

UMD/NREL

INRIX / UMD

HERE

TomTom / NREL

Other (?)

Calibration Data (TMAS)

Validation Methods

UMD/NREL (?) → TTI

• VTM products
• Validated
• Consistent formats
• Meets Coalition needs
Status

- INRIX/UMD Data –
  - Expanding analysis to more locations
  - More data at procurement stage
- TomTom/NREL – Data is flowing, work has commenced
- HERE – still in process
- Calibration – FHWA TMAS
- Validation - In collaboration with TTI
Real-time / Historical

- Current work is primarily archive/historical based
  - Validation / Calibration / Vendor data are all historical
  - Current analysis has been planning/historical based

- Getting to real-time
  - Critical vendor data evolve to real-time API format
  - Calibration testbed in real-time API format (greater than yearly)
  - Historical analysis can simulate real-time by cordonning available data by time
Questions
Statewide Traffic Volume Estimation Using GPS Traces: INRIX Dataset - Maryland

Analysis Performed by:
Przemyslaw Sekula & Nikola Markovic

Presented by:
Kaveh Sadabadi

VTM Steering Committee Meeting
April 13, 2017
Today’s Presentation

• Background & State of the practice
• Objectives
• INRIX dataset
• Regression analysis
• Results
• Next steps
• Q & A
• Federal requirements for performance measurement/reporting (MAP-21)
• Accurate **speed** and **volume** data is needed (e.g., vehicle-hour delay)
  – Speed data is available through vehicle probes (e.g., VPP, NPMRDS)
  – Volume data is not there yet!
• State agencies have limited access to traffic count measurements
  – Maryland has 85 Automatic Traffic Recorder (ATR) stations
  – This covers only 2% of road segments in the state
State of Practice

• Annual estimates
  – Highway Performance Monitoring System (HPMS)
    • https://www.fhwa.dot.gov/policyinformation/hpms.cfm
  – Annual Average Daily Traffic (AADT)
    • https://www.fhwa.dot.gov/policyinformation/hpms/shapefiles.cfm
    • Latest data: 2015
• Archived measurements
  – Travel Monitoring Analysis System (TMAS)
  – Hourly traffic counts at all permanent traffic monitoring sites
• Current practice
  – Use (mainly) speed data to build hourly traffic distributions (profiles)
  – Use profiles to distribute AADT to hourly traffic volumes
  – A comparison with actual volumes shows significant inaccuracies ($R^2 = 0.5$)
Objectives

• Given the following:
  – Probe volumes (processed from GPS traces of a subset of vehicles),
  – Other archived data (speeds, road geometry, weather, etc.), and
  – ATR counts
• Can we build a model to accurately estimate statewide volumes?
INRIX Dataset

- 4 months of INRIX data during 2015 (February, June, July, October)
  - 20 million trips, 1.4 billion waypoints
  - 112 GB of data
  - Waypoints are typically 1 sec apart

Providers and vehicle classes

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Waypoint Snapping and Map Matching

• Two step process
  – Snapping
  – Map matching
• OpenStreetMap tools used
• Needed a lot of fine-tuning
• 18.7 million out of 19.7 million trips (95%)
• As a result on average, we got twice as many probe volumes at ATR stations
• Average hourly penetration rates
  – Range 0.17%-2.25%
  – Median 1.58%
• Average probe volumes
  – Range: 1.5-92.6
  – Median: 31.9

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Other Data & Correlations

- Speed data from RITIS
- Road characteristics
  - Type of the road (IS, US, MD),
  - Number of lanes,
  - Speed limit,
  - Directions separated
- Weather data
  - Temperature, humidity, pressure, visibility, wind speed, precipitation
- Temporal characteristics
  - Hour of day, day of week, federal holiday

Yellow/magenta: +/- correlation
Regression Analysis

- Multi-layer Artificial Neural Network (ANN)
  - Built in TensorFlow™
  - Deeper networks are used
  - Trained over 211K coefficients
  - Tested both local GPU and AWS for training

- 35 ATR stations were selected for analysis
  - At each iteration
    - 34 stations are used for training (170,000 data points)
    - 1 station is used for evaluation (5000 data points)
  - Repeat this 35 times and report test results for all 35 locations

- Note that other ATR stations are excluded from analysis due to a combination of reporting excessive missing numbers and road type

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Results

- Error measures
  - $R^2$
    - Range: 0.61-0.94
    - Median: 0.82
  - Mean Absolute Percent Error (MAPE)
    - Range: 14%-48%
    - Median: 22%
  - Error to Capacity Ratio (ECR)
    - Median: 8%
Contribution of GPS Trace Data

• Calibrate models including and excluding probe volumes and compare performance
  – 22% if probe volumes are included (8% w.r.t. road capacities)
  – 50% if probe volumes are excluded
  – 30% if only probe volumes are included

• GPS trace data and resulting probe volumes have a significant impact on the quality and accuracy of volume estimates
Further Performance Evaluations

- Time impact
  - Day vs. night
  - Peak vs. off-peak
- Volume impact
  - Low vs. moderate vs. high volume roads
- Highway type impact
  - Interstate vs. US vs. state highways

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MAPE: Mean Absolute Percentage Error
ECR: Error to Capacity Ratio

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Next Steps

• How different time granularities would impact model accuracy (60, 30, 15, 10, 5 minutes)
• Grouping ATR locations based on factors such as proximity, highway type and geometry to calibrate group-specific models
• Pick two state/regions for INRIX to provide GPS trace data and repeat the analysis
Questions

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University of Maryland

April 13, 2017
Real-time Volume Estimation – Denver Area

Yi Hou

April 13, 2017
Outline

• FHWA Travel Monitoring Analysis System (TMAS) data
• Weather data
• TomTom data
• Combined dataset for Denver
• Web app framework
• Future work
FHWA TMAS Data

- Station data
- Volume data
- Vehicle classification data

- State
- Station ID
- Direction
- Urban/Rural
- Number of lanes
- Road sign (Interstate, US, State)
- Road number
- Latitude
- Longitude
FHWA TMAS Data

- Station data
- Volume data
- Vehicle classification data

- Year
- Month
- Day
- Weekday
- Hour of day
- Hourly volume
FHWA TMAS Data

- Station data
- Volume data
- Vehicle classification data

- Year
- Month
- Day
- Weekday
- Hour of day
- Total hourly volume
- Motorcycle volume
- Passenger car volume
- Bus volume
- Truck volume
Weather Data

- Average temperature
- Visibility
- Wind
- Precipitation
- Snow
- Fog
- Rain
- Thunderstorm
TomTom Data

• Travel time
• Speed
• Probe vehicle count
• Speed limit
• Street name
• Segment ID
ATR Locations and Denver Road Network
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Web App Framework Prototype

https://yihou.shinyapps.io/volume/
Future Work

- Obtain TomTom travel time, speed, and probe count data
- Explore other data sources
- Build predictive models to estimate ubiquitous volume for Denver road network
- Extend the methodology to other US cities
- Build web based tools to view ubiquitous real-time volume
- National wide real-time traffic volume estimation
- National wide real-time freight volume estimation
- Extend the methodology for energy and GHG emission estimation
Thank You!

Questions?

www.nrel.gov
FHWA
Travel Monitoring Analysis System (TMAS – version 2.5)

Steven Jessberger – System Owner
FHWA – Office of Highway Policy Information
steven.jessberger@dot.gov
202-366-5052
TMAS compared to HPMS

• HPMS represents **spatial data** for all federal aid roadways in the US.

• TMAS represents **temporal data (24/7)** for all permanent traffic monitoring sites in the US.
Uploading Files to TMAS

• TMAS access is behind the FHWA UPACS website login and verification system
• ASCII text files per the Traffic Monitoring Guide (TMG) format https://www.fhwa.dot.gov/policyinformation/tmguide/
• Station files must be loaded and approved before any data files can be loaded
• Each TMAS state batch may contain one or more traffic counting sites of the same data type
• TMAS volume and station data is publically available for a historical series at: https://www.fhwa.dot.gov/policyinformation/tables/tmasdata/
TMAS TMG Formatted Data Files

• Station Data – where the site is located and attributes about the site, such as: direction, lanes, sensor type, lat/long, route number, LRS, ...

• Volume Data – hourly data, most often a full 24 hours, with no missing values (over 5,000 sites sent in each month with 24/7 data)

• Classification Data – mostly hourly, by vehicle type, for over 2,000 sites in the US. (can be in 5, 15 or 60 min. time increments)

• Weight Data – per vehicle record data with axle spacings and axle weights for over 600 sites in the US.

• Coming soon: nonmotorized, speed and PVF data (all following the 2016 TMG formats)
TMAS Quality Control

• All QC setting can be set by site

• Volume QC:
  • 24 hours of data
  • Consecutive zeros (7)
  • Adjacent zero (50 vehicles)
  • Directional split (+/-20% from 50%)
  • Maximum by lane throughput (3,000 vphpl)
  • Monthly Average Daily Traffic (MADT) (+/- 20%)

vphpl – vehicles per hour per lane
TMAS 3.0 Features

- For volume data – am/pm volume check
- For class data – class 8 vs. 9 check
- For class data – improved DOW historical done by class volumes if low and % if high
- For weight data – speed/ATS check from PVF (per vehicle format)
- For weight data – QC of all classes (even 1-3)
- For weight data – ACF (axle correction factor) from PVF or WIM data
- GIS (HPMS base layer),
- Pavement Design Guide (PDG) export and grouping,
- **Speed (5, 15 or 60 min),**
- **Per Vehicle Format (PVF),**  [FL, HI, ID, IN, NV, MD, MT, PA, RI, ...]
- Reclassification of either weight and PVF and
- Query for all users

**Collect data once correctly use it many times!!**
Volume Reports

- VOL 1: Monthly National TVT Report (only FHWA has access)
- VOL 2: State TVT Report (full access)
- VOL 3: Station by Hour Report (full access, searchable fields to aid when looking for data in other states)
- VOL 4: MADT by Month by Station/State Report (full access)
- VOL 5: Volume data upload by State and Month Report (full access)

TVT – Traffic Volume Trends, a national Vehicle Miles Traveled (VMT) report that FHWA produces within 60 days after the close of any given month.

MADT – monthly average daily traffic, indicator of travel changes over months and years and often used for QC of volume data.
Analytical Reports

• ANA1: Growth Factors Report (full access, used for HPMS review)
• ANA6: Data Submittal Timelines Report (full access)
• ANA7: Historical Vehicle Miles Traveled Report (full access, used for seasonal VMT analysis)
Classification Reports
(axle or length based)

- CLS 1: Class by Day by Hour by Site
  (full access)
- CLS 2: Class by Station with no Data in Weight Column
  (full access)
- CLS 3: Class by Station Month by Day (full access, searchable fields to aid when looking for data in other states (like VOL 3))
- CLS 5: Class by Station Multi-year by Month Report
  (full access)
- CLS 6: Class by HPMS6 Vehicle types by State
  (full access)
Questions and Comments

Steven Jessberger
202-366-5052
steven.jessberger@dot.gov
Summary of Technical Analysis to Date

- UMD results indicate an average absolute error of 8% with respect to capacity, and 27% with respect to volume
- Current state of practice – factored HPMS to hourly volume has error of 50% with respect to volume
- Target – with respect to capacity
  - 10% applications becomes viable
  - 5% ‘sweet-spot’ target

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Next Steps – anticipated material at next meeting

• Formulate validation methodology

• Data Analysis
  • UMD to select additional areas, acquire, and test methodology
  • NREL to complete initial volume estimates using TomTom data in select areas
  • HERE to initiate analysis

• Research confidence score, and initiate discussion on consistent format
Steering Committee Participation and Feedback

1. How do volume estimates need to be packaged/formatted for agency use?

2. Are the accuracy discussions using $R^2$, MAPE and ECR meaningful?

3. What are the concerns to get from research to product?
Wrap Up

Next meeting/webinar (DATE CHANGE)

- Thursday, July 20, 2017
- 10:30a.m. - 12:00p.m. (EDT)
Questions
Thank You!

• For Questions, please contact:
  • PI – Kaveh Sadabadi (UMD-CATT) 301-405-1352 or kfarokhi@umd.edu
  • Co-PI – Denise Markow (I-95 Corridor Coalition) 301-789-9088 or dmarkow@i95coalition.org
  • Co-PI – Stanley Young (NREL) 301-792-8180 or Stanley.Young@nrel.gov
  • UMD PM/Contracts – Kathy Frankle (UMD-CATT) 301-405-8271 or kfrankle@umd.edu
  • Logistics – Joanna Reagle (KMJ Consulting, Inc.) 610.228.0760 or jreagle@kmjinc.com