Volume & Turning Movements Project

Steering Committee Meeting #7

February 13, 2018
Housekeeping Items

• Please call xxx-xxx-xxxx 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
## Attendees

<table>
<thead>
<tr>
<th>Agencies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado DOT</td>
<td>NREL</td>
</tr>
<tr>
<td>Durham MPO (NC)</td>
<td>Pennsylvania DOT</td>
</tr>
<tr>
<td>FHWA</td>
<td>Port Authority NY &amp; NJ</td>
</tr>
<tr>
<td>Georgia DOT</td>
<td>South Carolina DOT</td>
</tr>
<tr>
<td>HERE</td>
<td>StreetLight Data</td>
</tr>
<tr>
<td>I-95 Corridor Coalition</td>
<td>Texas DOT</td>
</tr>
<tr>
<td>Kentucky Transportation Center</td>
<td>Texas A&amp;M Transportation Institute</td>
</tr>
<tr>
<td>Maryland DOT/MdSHA</td>
<td>TomTom</td>
</tr>
<tr>
<td>MWCOG</td>
<td>UMD CATT</td>
</tr>
<tr>
<td>New Hampshire DOT</td>
<td>Virginia DOT</td>
</tr>
<tr>
<td>North Carolina DOT</td>
<td></td>
</tr>
</tbody>
</table>
Speakers

Denise Markow, PE  
TSMO Director  
I-95 Corridor Coalition  
dmarkow@i95coalition.org

Kaveh Sadabadi, PhD  
Center for Advanced Transportation Technology - University of Md.  
(UMD CATT)  
kfarokhi@umd.edu

Stanley Young, PhD, PE  
National Renewable Energy Laboratory (NREL)  
Stanley.young@nrel.gov

Yi Hou, PhD  
National Renewable Energy Laboratory (NREL)  
yi.hou@nrel.gov
Please confirm that your line is **muted**

*6

Thank you!
## Agenda

<table>
<thead>
<tr>
<th>Topic</th>
<th>Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong> Welcome &amp; Project Status Update</td>
<td>Stan Young, NREL</td>
</tr>
<tr>
<td><strong>2</strong> Ubiquitous Volume Estimation on Lower Functional Class Roads</td>
<td>Yi Hou, NREL</td>
</tr>
<tr>
<td><strong>3</strong> Traffic Volume Estimation using GPS Traces: Florida and New Hampshire Update</td>
<td>Kaveh Sadabadi, UMD CATT</td>
</tr>
<tr>
<td><strong>4</strong> First Look on AADT Estimation</td>
<td>Yi Hou, NREL</td>
</tr>
<tr>
<td><strong>5</strong> Next Steps &amp; Wrap Up</td>
<td>Stan Young, NREL; Denise Markow, I-95 Corridor Coalition</td>
</tr>
</tbody>
</table>
Project Status Update
Project Goal

Accelerate the timeframe to a viable volume and turning movement data feed ---

• Anywhere/anytime on the network
• Archive and real-time
• Freeway and Non-Freeway

Ensure that initial data products meet members’ information needs for operations, performance measurement, and planning.
Status of Project – Feb 2018

Calibration / Validation Testbed

UMD/NREL

Calibration Data (TMAS / States)

Validation Methods [Led by TTI]

Collaborators

INRIX / UMD

TomTom / NREL

HERE

Streetlight Data

Data Experimentation

• VTM products
• Validated
• Consistent formats
• Meets Coalition needs
Visualizing the Solution

• A volume estimator
• ATRs & 48 hour counts uses as ‘base stations’
  • Calibrate estimate
  • Assess accuracy
• Uses a variety of data
  • Probe data is key
• Complements existing sensors
How Good is Good Enough?

• Error to Capacity (ETCR) or Max Flow (EMFR)
  \(< 10\% \text{ becomes useful} \quad < 5\% \text{ is target}\)

• Mean Absolute Percentage Error (MAPE)
  
  **Volume dependent - estimate**
  
  • 10-15\% High Volume
  • 20-25\% Mid Volume
  • 30-50\% Low Volume
  
  (Mean Absolute Error may be appropriate)

<table>
<thead>
<tr>
<th>AADT Range</th>
<th>Decreasing (-)</th>
<th>Increasing (+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 19</td>
<td>-100%</td>
<td>400%</td>
</tr>
<tr>
<td>20 - 49</td>
<td>-40%</td>
<td>50%</td>
</tr>
<tr>
<td>50 - 99</td>
<td>-30%</td>
<td>40%</td>
</tr>
<tr>
<td>100 - 299</td>
<td>-25%</td>
<td>30%</td>
</tr>
<tr>
<td>300 - 999</td>
<td>-20%</td>
<td>25%</td>
</tr>
<tr>
<td>1,000 - 4,999</td>
<td>-15%</td>
<td>20%</td>
</tr>
<tr>
<td>5,000 - 49,999</td>
<td>-10%</td>
<td>15%</td>
</tr>
<tr>
<td>50,000-</td>
<td>-10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

MNDOT Example
Today’s Agenda

• Colorado Off Freeway Results
  • Yi Hou and Venu Garikapti, NREL

• Florida, Full Network
  • Kaveh Sadabadi, UMD

• AADT Estimates
  A First Approximation
  • Yi Hou, NREL

• Summary & Next Steps
  • Stan Young, NREL
Ubiquitous Volume Estimation on Lower Functional Class Roads

Yi Hou, Venu Garikapati, Stan Young

February 13, 2018
Outline

• Motivations & previous study
• Hourly volume estimation on lower functional class roads
• Summary
Motivation & Previous Study
Ubiquitous Traffic Volumes

- Traffic sensors for any given city cover only a small amount of the road network (5-10%), leaving the remaining (90-95%) network with no volume information.

- Increasing availability of probe vehicle data provides a more practical and affordable pathway to obtain network wide traffic volumes.

- **Solution**: Use information from existing traffic sensors and combining it with probe vehicle data as well as other relevant information to estimate network wide traffic volumes.
Volume Estimation Work at NREL

Freeway Volume Estimation
- Previous analysis

Lower Functional Class Roads
- Focus of today’s presentation

AADT Estimation
- Sneak peek of preliminary results
Previous Study – Freeway Volume Estimation

Calibration Network

Input
- Probe Data
- Road Characteristics
- Daily Weather Info
- Temporal Info

Estimator

Output – Hourly

Total 14 Automatic Traffic Recorder stations
Results of Freeway Volume Estimation

- Results exceed the survey expectation: ETCR < 10%
- All have very similar accuracy
- XGBoost is the most computational efficient

<table>
<thead>
<tr>
<th>Model</th>
<th>Overall MAPE</th>
<th>Overall ETCR</th>
<th>Median R²</th>
<th>Training Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF</td>
<td>17.8%</td>
<td>5.2%</td>
<td>0.92</td>
<td>73s</td>
</tr>
<tr>
<td>GBM</td>
<td>18.3%</td>
<td>4.8%</td>
<td>0.93</td>
<td>124s</td>
</tr>
<tr>
<td>XGBoost</td>
<td>17.7%</td>
<td>5.3%</td>
<td>0.91</td>
<td>13s</td>
</tr>
</tbody>
</table>

MAPE – Mean Absolute Percentage Error  
ETCR – Error to Theoretic Capacity Ratio  
RF – Random Forest  
GBM – Gradient Boost Machine  
XGBoost – Extreme Gradient Boost
Hourly Volume Estimation on Lower Functional Class Roads
Lower Functional Class Roads

- FHWA functional classification

  **Freeways**
  - Interstates
  - Other Freeways

  **Lower Class Roads**
  - Principal Arterials
  - Minor Arterials
  - Major Collectors
  - Minor Collectors
  - Local Streets

<table>
<thead>
<tr>
<th></th>
<th>Lower Class Roads</th>
<th>Freeways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of Miles</td>
<td>98.5%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Percentage of Lane Miles</td>
<td>96.7%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Percentage of VMT</td>
<td>68.5%</td>
<td>31.5%</td>
</tr>
<tr>
<td>HPMS Monitoring Cycle</td>
<td>6-year</td>
<td>3-year</td>
</tr>
<tr>
<td>Monitoring Method</td>
<td>Short-term counts</td>
<td>ATRs &amp; Short-term counts</td>
</tr>
</tbody>
</table>

HPMS – Highway Performance Monitoring System
Locations of 48-hour Volume Count Collection

<table>
<thead>
<tr>
<th>Lower Class Roads</th>
<th>Freeways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume data source</td>
<td>48-hour short-term count</td>
</tr>
<tr>
<td>Number of locations / Data points</td>
<td>359 / ~35,000</td>
</tr>
<tr>
<td>Data collection period</td>
<td>Jan. – Sep., 2017 (9 months)</td>
</tr>
</tbody>
</table>

- 300 for training/calibrating
  - Total of 30,096 data points
- 59 locations for testing
  - Total of 5,118 data points
- Fully randomized
Model Validation and Test Method

- Training locations were randomly and evenly divided into 10 groups
- Repeat this for 10 times
  - 9 groups are used for model training
  - 1 group is used for model validation
- Find model hyperparameters that yield the best estimation results
- Train a model using all training data and test model on test data

1st iteration  2nd iteration  3rd iteration  10th iteration
Hourly Volume Distribution

- Volume data is directional – both for volume and probe counts
- Lower functional class
  - More than 25% of hourly volumes are between 0 to 50 vehs/hr
- Freeway
  - ~1% of hourly volumes are between 0 to 100 vehs/hr
## Data Characteristics by Functional Class

- ~80% of observations on principal and minor Arterials
- Volume on local streets are extremely low
- Few probe counts and low penetration rate on local streets

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Arterial</td>
<td>52%</td>
<td>619</td>
<td>47.1</td>
<td>7.7%</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>27%</td>
<td>257</td>
<td>16.9</td>
<td>7.7%</td>
</tr>
<tr>
<td>Major Collector</td>
<td>13%</td>
<td>129</td>
<td>5.9</td>
<td>4.1%</td>
</tr>
<tr>
<td>Local Street</td>
<td>8%</td>
<td>19</td>
<td>0.6</td>
<td>3.1%</td>
</tr>
<tr>
<td>Overall</td>
<td>100%</td>
<td>414</td>
<td>29.8</td>
<td>6.4%</td>
</tr>
</tbody>
</table>
Input Variables for Hourly Volume Estimation

- **TomTom Traffic data from probes**
  - Hourly average speed and probe count
  - *Only included present hour, not previous hours*

- **Hourly weather information (previously daily)**
  - Temperature, precipitation, visibility, fog, rain, snow

- **Road characteristics**
  - Road class, urban or not, speed limit
  - **2015 AADT**
  - **Longitude, latitude**

- **Temporal information**
  - Month, day of week, hour of day
• Machine Learning
  o A subfield of computer science that gives computers the ability to learn from data without being explicitly programmed

• Extreme Gradient Boost (XGBoost)
  o One of the most recent developed tree-based machine learning models
  o Used successfully in classification and regression predictive modeling problems
Model Evaluation Criteria

• Mean Absolute Percentage Error: MAPE = \( \frac{1}{N} \sum_{i=1}^{N} \frac{|V_i - \hat{V}_i|}{V_i} \)
  - Reflect the absolute volume accuracy

• Coefficient of Determination: \( R^2 = 1 - \frac{(\hat{V}_i - V_i)^2}{(V_i - \bar{V})^2} \)
  - Explanatory power of model

• Error to Maximum Flow Ratio: EMFR = \( \frac{1}{N} \sum_{i=1}^{N} \frac{|V_i - \hat{V}_i|}{V_{\text{max}}} \)
  - Reflect volume to capacity fidelity

• Mean Absolute Error: MAE = \( \frac{1}{N} \sum_{i=1}^{N} |V_i - \hat{V}_i| \)
  - Reflect the absolute error
  - Effective for low volume roads

\( V_i \) – Observed volume \( \hat{V}_i \)– Estimated volume \( V_{\text{max}} \) – Max volume at the location
Model Results Comparison

• Much more accurate than linear regression and AADT based methods

<table>
<thead>
<tr>
<th>Model</th>
<th>MAPE*</th>
<th>MAE</th>
<th>EMFR</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>XGBoost</td>
<td>50.6%</td>
<td>89.2</td>
<td>13.2%</td>
<td>0.88</td>
</tr>
<tr>
<td>Linear</td>
<td>314.7%</td>
<td>153.1</td>
<td>29.5%</td>
<td>0.80</td>
</tr>
<tr>
<td>AADT Based Method</td>
<td>161.7%</td>
<td>304.4</td>
<td>26.5%</td>
<td>0.16</td>
</tr>
</tbody>
</table>

*The results include extreme low volume

• Further examine MAPE and EMFR for volume > 20 vehs/hr

<table>
<thead>
<tr>
<th>Model</th>
<th>MAPE (Vol&gt;20)</th>
<th>EMFR (Vol&gt;20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XGBoost</td>
<td>29.7%</td>
<td>10.8%</td>
</tr>
<tr>
<td>Linear Regression</td>
<td>90.4%</td>
<td>20.5%</td>
</tr>
<tr>
<td>AADT Based Method</td>
<td>124.9%</td>
<td>28.1%</td>
</tr>
</tbody>
</table>

• Need to look at accuracy in volume ranges
MAPE of Different Volume Range – PAY ATTENTION

- Volume > 300 vehs/hr: MAPE is low and stable
- Volume < 300 vehs/hr: MAPE is high, but model is still good
MAPE of Different Volume Range – PAY ATTENTION
48-Hour Prediction on Test Locations

**Principal Arterial**

Station ID: 106501, MAPE=35.8%, MAE=68.2

**Minor Arterial**

Station ID: 900152, MAPE=24.8%, MAE=30.6

**Major Collector**

Station ID: 106992, MAPE=29.4%, MAE=29.6

**Local Street**

Station ID: 901909, MAPE=38.6%, MAE=3.1
Residual Analysis

- Model is well fitted!
- Model is not biased!
- Underestimate for extreme high volumes (likely training set issue)

Machine learning methods not great at extrapolating beyond bounds of training set
Variable Importance

- Most relevant factors for volume estimation: Hour, temperature, speed, probe count, GPS location, and AADT
• Machine learning rocks! XGBoost, are promising tools for hourly volume estimation on lower functional class roads
• Model performs well for all ranges of volume
  Extremely low volume – use MAE, not MAPE
• Underestimation at higher volumes: likely due to lack of sufficient observations to appropriate train
• Temp, hour of day, GPS, & probe count significant; Probe count less significant for off-freeway
Thank You!

Discussion
Traffic Volume Estimation using GPS Traces: Florida and New Hampshire Update

Analysis Performed by: Przemyslaw Sekula and Zachary Vander Laan

Presented by: Kaveh Farokhi Sadabadi

VTM Steering Committee Meeting
February 13, 2018
Presentation Overview

• Status update
• Florida analysis
  • Dataset
  • Results
  • Statewide Estimation
• New Hampshire analysis
  • Dataset
• Next Steps
• Q & A
Status Update

Previously:
• Maryland INRIX dataset (2015)
• Develop / evaluate MD model: 45 ATR locations
  – 23% MAPE, 4-7% Error-to-capacity ratio
  – Estimation accuracy depends on probe penetration rate

Currently:
• Florida (2016 Q4) & New Hampshire (2017 Q3) INRIX datasets
• Develop / evaluate FL model: 173 ATR locations
• Apply FL model statewide!
  – INRIX data snapped to XD
  – Requires input data collection at ~20k TMCs
• Will repeat with NH

Primary focus: model development / feature selection at ATR locations
Primary focus: statewide application of model
Florida Dataset (Q4 2016)

Data needed at all TMCs

- **GPS probe data** (INRIX)
  - 75M trips, 3.4B pts (20M trips, 1.4B pts in MD)
  - Penetration rate: 2.1% median (1.9% in MD)
  - Snapped to XD segments

- **Probe Speed data** (HERE)

- **Road characteristics**
  - NPMRDS TMC shape file features
  - Open Street Map (OSM) conflation

- **Weather data** (permanent stations)

- **TTI hourly volume estimates**

Data needed only at ATR stations

- **ATR counts** (FDOT)
  - Used for model training / evaluation
  - Used to estimate probe penetration rate

1: cars / light-duty trucks
2: medium-duty trucks
3: heavy-duty trucks

February 13, 2018
Florida Model Evaluation

- **Model**: “Dense” Artificial Neural Network (ANN)
- **Cross validation** (repeat 173 times)
  - Train model using data from 172 of 173 ATR stations
  - Generate model predictions using data from remaining station

- **Evaluation**: Compare predictions / ATR volumes & generate metrics
Florida Results: Summary

- FL error metrics comparable to MD
  - FL analysis includes lower class roads which weren’t in MD dataset
  - XD-snapped data not as high-res
  - Simpler model architecture

- EMFR around 7%
  - ETCR likely lower
  - “Beginning to become useful”

- Challenges with low-volume roads
  - 7 locations have 0 observed GPS counts for entire dataset

### Median Error Metrics

<table>
<thead>
<tr>
<th></th>
<th>R2</th>
<th>MAPE (%)</th>
<th>EMFR (%)</th>
<th>Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.83</td>
<td>25</td>
<td>7</td>
<td>694690</td>
</tr>
</tbody>
</table>

### Road Classification

<table>
<thead>
<tr>
<th></th>
<th>R2</th>
<th>MAPE (%)</th>
<th>EMFR (%)</th>
<th>Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeways (FRC 1)</td>
<td>0.86</td>
<td>21</td>
<td>6</td>
<td>195704</td>
</tr>
<tr>
<td>Maryland (mostly FRC 1)</td>
<td>0.86</td>
<td>23</td>
<td>7</td>
<td>158040</td>
</tr>
<tr>
<td>Principal Arterials (FRC 2)</td>
<td>0.82</td>
<td>26</td>
<td>7</td>
<td>370567</td>
</tr>
<tr>
<td>Major/Minor Arterials (FRC 3 &amp; 4)</td>
<td>0.83</td>
<td>33</td>
<td>7</td>
<td>128419</td>
</tr>
</tbody>
</table>

### Hourly Volume (vph)

<table>
<thead>
<tr>
<th>Hourly Volume (vph)</th>
<th>R2</th>
<th>MAPE (%)</th>
<th>EMFR (%)</th>
<th>Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1k</td>
<td>0.81</td>
<td>29</td>
<td>7</td>
<td>465591</td>
</tr>
<tr>
<td>1k-2k</td>
<td>0.86</td>
<td>22</td>
<td>6</td>
<td>164465</td>
</tr>
<tr>
<td>2k-3k</td>
<td>0.88</td>
<td>18</td>
<td>6</td>
<td>49221</td>
</tr>
<tr>
<td>3k+</td>
<td>0.87</td>
<td>19</td>
<td>6</td>
<td>15413</td>
</tr>
</tbody>
</table>
Florida Statewide Model

- Apply trained model to entire road network
  - Requires 3 months of hourly input data at ~20k TMCs
  - Generate hourly volume estimates at each input time/location
Florida Statewide Model: Tampa Bay Area

ATR station selected that exhibits typical (median) model performance
Data preparation currently in progress

- **GPS probe data** (INRIX)
  - 7M trips, 595M pts (20M trips, 1.4B pts in MD)
  - Snapped to XD segments
  - **Problem:** ~70% of snapped waypoints in NH dataset are located outside of NH

Snapping problem: Majority of waypoints are outside NH (along I-95 or in Boston metro)

1: cars / light-duty trucks
2: medium-duty trucks
3: heavy-duty trucks
Questions

Contact Information

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Przemyslaw Sekula
psekula@umd.edu

Zachary Vander Laan
zvanderl@umd.edu
First Look on AADT Estimation

Yi Hou, Venu Garikapati, Stan Young

February 13, 2018
• Now take a look at Estimating AADT
• Same modeling method
• Built a whole new model (rather than aggregate current)
• Used daily average volume of 48-hour count to approximate ground truth AADT
• First attempt ----- need feedback

• Inputs – Daily (not hourly)
• Compare estimated daily volume to 48 hour average
• ~20% of locations has AADT less than 5000
# AADT Estimation Input Variables

<table>
<thead>
<tr>
<th>Variables included</th>
<th>Variables not included</th>
</tr>
</thead>
<tbody>
<tr>
<td>• TomTom GPS data</td>
<td>• Hourly weather information</td>
</tr>
<tr>
<td>• Daily average speed</td>
<td>• Temperature, precipitation, visibility, fog, rain, snow</td>
</tr>
<tr>
<td>• Total daily probe count</td>
<td>• 2015 AADT</td>
</tr>
<tr>
<td>• Road characteristics</td>
<td>• Temporal information</td>
</tr>
<tr>
<td>• Road class</td>
<td>• Month, day of week, hour of day</td>
</tr>
<tr>
<td>• Urban or not</td>
<td></td>
</tr>
<tr>
<td>• Speed limit</td>
<td></td>
</tr>
<tr>
<td>• Longitude</td>
<td></td>
</tr>
<tr>
<td>• Latitude</td>
<td></td>
</tr>
</tbody>
</table>
Model Comparison

- **MAPE: 33.7%**
- Significant progress with machine learning
- “Average error rates can rise quickly to 100% or above” (Gadda et al. 2007)
- Significant improvement compared with linear regression

<table>
<thead>
<tr>
<th>Model</th>
<th>MAPE</th>
<th>MAE</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>XGBoost</td>
<td>33.7%</td>
<td>3140</td>
<td>0.90</td>
</tr>
<tr>
<td>Linear Regression</td>
<td>165.0%</td>
<td>5427</td>
<td>0.81</td>
</tr>
</tbody>
</table>
Residual Analysis

- Model is well fitted
- Model is not biased

\[ y = x + 808 \]
### Contribution of Probe Vehicle Data

- Probe vehicle data has significant impact on AADT estimation accuracy

<table>
<thead>
<tr>
<th>Model</th>
<th>MAPE</th>
<th>MAE</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Probe Data</td>
<td>74.9%</td>
<td>5116</td>
<td>0.80</td>
</tr>
<tr>
<td>With Probe Data</td>
<td>33.7%</td>
<td>3140</td>
<td>0.90</td>
</tr>
<tr>
<td>Difference</td>
<td>-41.2%</td>
<td>-1976</td>
<td>+0.1</td>
</tr>
</tbody>
</table>

MAPE – Mean Absolute Percentage Error

MAE – Mean Absolute Error
• Basic modeling approach is effective
  o Machine learning Rocks!
  o Need to verify structure of model (are we estimating and comparing the right things)
• Probe data count very important to accuracy
• Need feedback ....
Thank You!

Discussion
Next Steps & Wrap Up
Summary

• Off-Freeway volumes significantly less
Colorado Off-Freeway Results

- Stable, unbiased estimates at low volume
- Performance is volume dependent
  - Principal & Minor Arterials – GOOD
  - Major Collector – Maybe
  - Local Street – Not likely
- Need Low-Volume Filter / Flag
Florida Results

- Trained network on Freeways through Minor Arterials
- EMFR < 7%
- Performance volume dependent

<table>
<thead>
<tr>
<th>Road Classification</th>
<th>R2</th>
<th>MAPE (%)</th>
<th>EMFR (%)</th>
<th>Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeways (FRC 1)</td>
<td>0.86</td>
<td>21</td>
<td>6</td>
<td>195704</td>
</tr>
<tr>
<td>Maryland (mostly FRC 1)</td>
<td>0.86</td>
<td>23</td>
<td>7</td>
<td>158040</td>
</tr>
<tr>
<td>Principal Arterials (FRC 2)</td>
<td>0.82</td>
<td>26</td>
<td>7</td>
<td>370567</td>
</tr>
<tr>
<td>Major/Minor Arterials (FRC 3 &amp; 4)</td>
<td>0.83</td>
<td>33</td>
<td>7</td>
<td>128419</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hourly Volume (vph)</th>
<th>R2</th>
<th>MAPE (%)</th>
<th>EMFR (%)</th>
<th>Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1k</td>
<td>0.81</td>
<td>29</td>
<td>7</td>
<td>465591</td>
</tr>
<tr>
<td>1k-2k</td>
<td>0.86</td>
<td>22</td>
<td>6</td>
<td>164465</td>
</tr>
<tr>
<td>2k-3k</td>
<td>0.88</td>
<td>18</td>
<td>6</td>
<td>49221</td>
</tr>
<tr>
<td>3k+</td>
<td>0.87</td>
<td>19</td>
<td>6</td>
<td>15413</td>
</tr>
</tbody>
</table>
How Good is Good Enough?

• Error to Capacity (ETCR) or Max Flow (EMFR)
  
  \(< 10\% \text{ becomes useful} \quad < 5\% \text{ is target}\)

• Mean Absolute Percentage Error (MAPE)

  **Volume dependent - estimate**

  • 10-15\% High Volume
  • 20-25\% Mid Volume
  • 30-50\% Low Volume

  (Mean Absolute Error may be appropriate)

<table>
<thead>
<tr>
<th>AADT Range</th>
<th>Acceptable % Change</th>
<th>Increasing ((+))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 19</td>
<td>-100%</td>
<td>400%</td>
</tr>
<tr>
<td>20 - 49</td>
<td>-40%</td>
<td>50%</td>
</tr>
<tr>
<td>50 - 99</td>
<td>-30%</td>
<td>40%</td>
</tr>
<tr>
<td>100 - 299</td>
<td>-25%</td>
<td>30%</td>
</tr>
<tr>
<td>300 - 999</td>
<td>-20%</td>
<td>25%</td>
</tr>
<tr>
<td>1,000 - 4,999</td>
<td>-15%</td>
<td>20%</td>
</tr>
<tr>
<td>5,000 - 49,999</td>
<td>-10%</td>
<td>15%</td>
</tr>
<tr>
<td>50,000-</td>
<td>-10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

MNDOT Example
Off–Freeway Take-aways

• Stable, unbiased estimates at low volume
• Performance is volume dependent
  • High Volume – 10-20% MAPE (Freeways, Principal Arterials)
  • Mid Volume – 20-30% MAPE (Minor Arterials and Major Collectors)
  • Low Volume - 30-50% MAPE (Major Collectors and Local Streets)
• Accuracy targets by volume class are met
  • Need consistent accuracy metrics by volume class
• Need confidence or error estimate
Initial AADT Results

• Initial compared to average of 48 hour counts
• MAPE or MAE depending on volume
• Initial results positive, but requires iteration
• Compares favorably with MNDOT Results – however NOT Apples to Apples
• Need consistent evaluation framework

• Stay-Tuned

Provide Input

MNDOT Results

<table>
<thead>
<tr>
<th>Traffic Volume Level Category</th>
<th>Number of Hourly Values</th>
<th>Mean Absolute Percent Error</th>
<th>Mean Absolute Difference</th>
<th>Mean Signed Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1,000 vehicles per hour (vph)</td>
<td>1,247</td>
<td>53%</td>
<td>165</td>
<td>-63</td>
</tr>
<tr>
<td>1,000 to 5,000 vph</td>
<td>334</td>
<td>34%</td>
<td>535</td>
<td>-433</td>
</tr>
<tr>
<td>5,000 to 10,000 vph</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>&gt; 10,000 vph</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>All Traffic Levels Combined</td>
<td>1,581</td>
<td>45%</td>
<td>243</td>
<td>-141</td>
</tr>
</tbody>
</table>
Future Work – Next Steps

• NREL – Refine AADT initial efforts
• UMD to extend work to NH
• (Candidate) Next Steps
  • Technical work
    • Low-volume / Confidence flag or metric
    • Accuracy metric indexed to abnormal/special events
    • Relative importance of input (temp, time of day, location, probe data)
    • Issues when volumes exceed training data
    • Error with respect to probe counts
  • AADT work – framework, high and low volume, PFS
  • Truck Volumes / Turning movements
Wrap Up

• Next Meeting/Webinar
  • June 2018
  • Look for more information!
Final Questions
Thank You!

For Questions, please contact:

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