

# Volume & Turning Movements Project

## Steering Committee Meeting #4

APRIL 13, 2017

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



## 2 | 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



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# WELCOME!

Denise Markow, I-95 Corridor Coalition



**Welcome to  
Volume & Turning  
Movements Project**



# Introductions

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**Denise Markow, PE**  
TSMO Coordinator  
I-95 Corridor Coalition  
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**Stanley Young, PhD, PE**  
National Renewable Energy Laboratory  
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**Steven Jessberger**  
Office of Highway Policy Information  
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## Attendees

Agencies	
Colorado DOT	South Carolina DOT
DVRPC	Virginia DOT
FHWA	USDOT - BTS
Georgia DOT	INRIX
Maryland DOT/MdSHA	Texas A&M Transportation Institute
MWCOG	NREL
New Hampshire DOT	I-95 Corridor Coalition
NJTPA	UMD CATT
Pennsylvania DOT	UMD CATT Lab
Port Authority NY & NY	



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Please confirm that  
your line is **muted**  
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**Thank you!**



# 7 | Agenda

	Topic	Speaker
1	Project Tasks Status Update	Stan Young, NREL
2	Technical Updates <ul style="list-style-type: none"><li>• UMD Analysis of INRIX data</li><li>• NREL Analysis of TomTom data</li></ul>	Kaveh Sadabadi, UMD CATT Yi Hou, NREL
3	Travel Monitoring Analysis System (TMAS)	Steven Jessberger, FHWA
4	Wrap Up	Stan Young, NREL & Denise Markow, I-95 Corridor Coalition



# Status Update on Volume & Turning Movements from Probe Data Project

Stan Young, NREL

*April 13, 2017*



## 9 | 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.

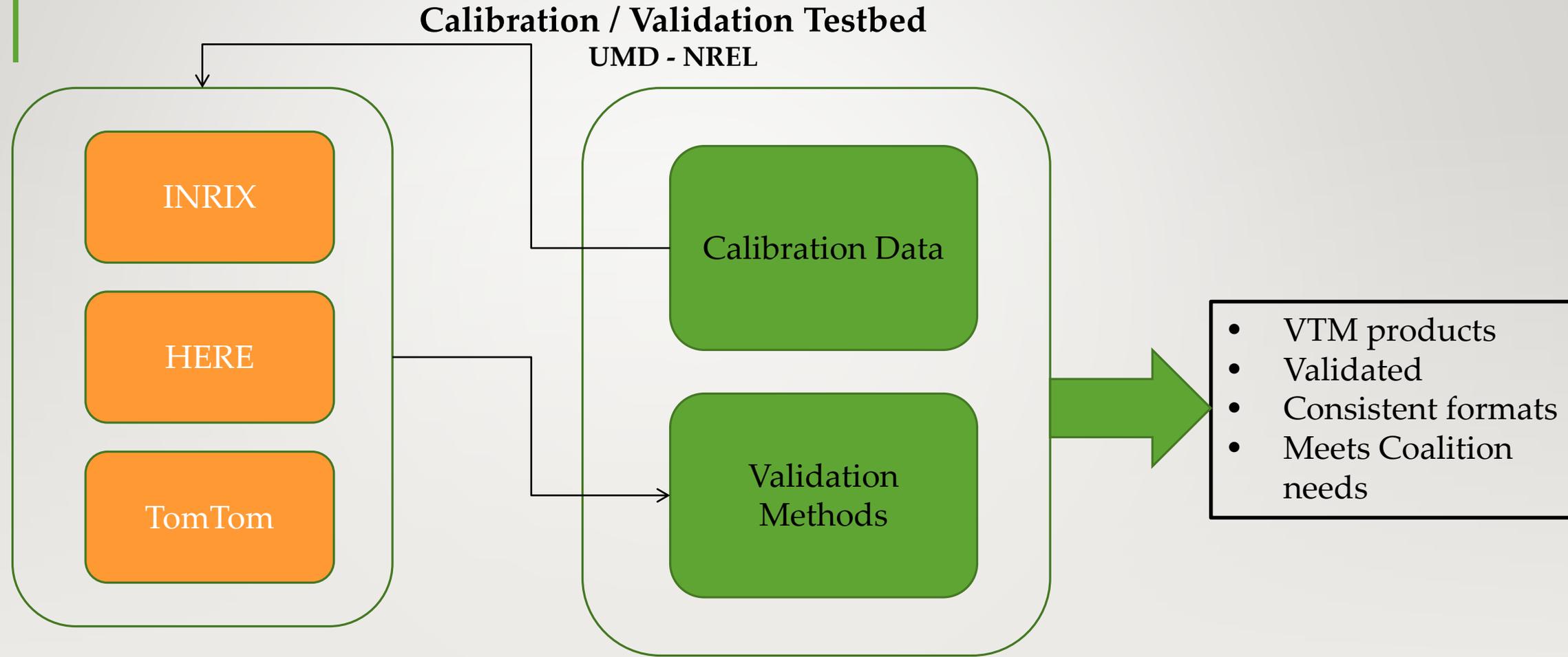


## Objectives - Original

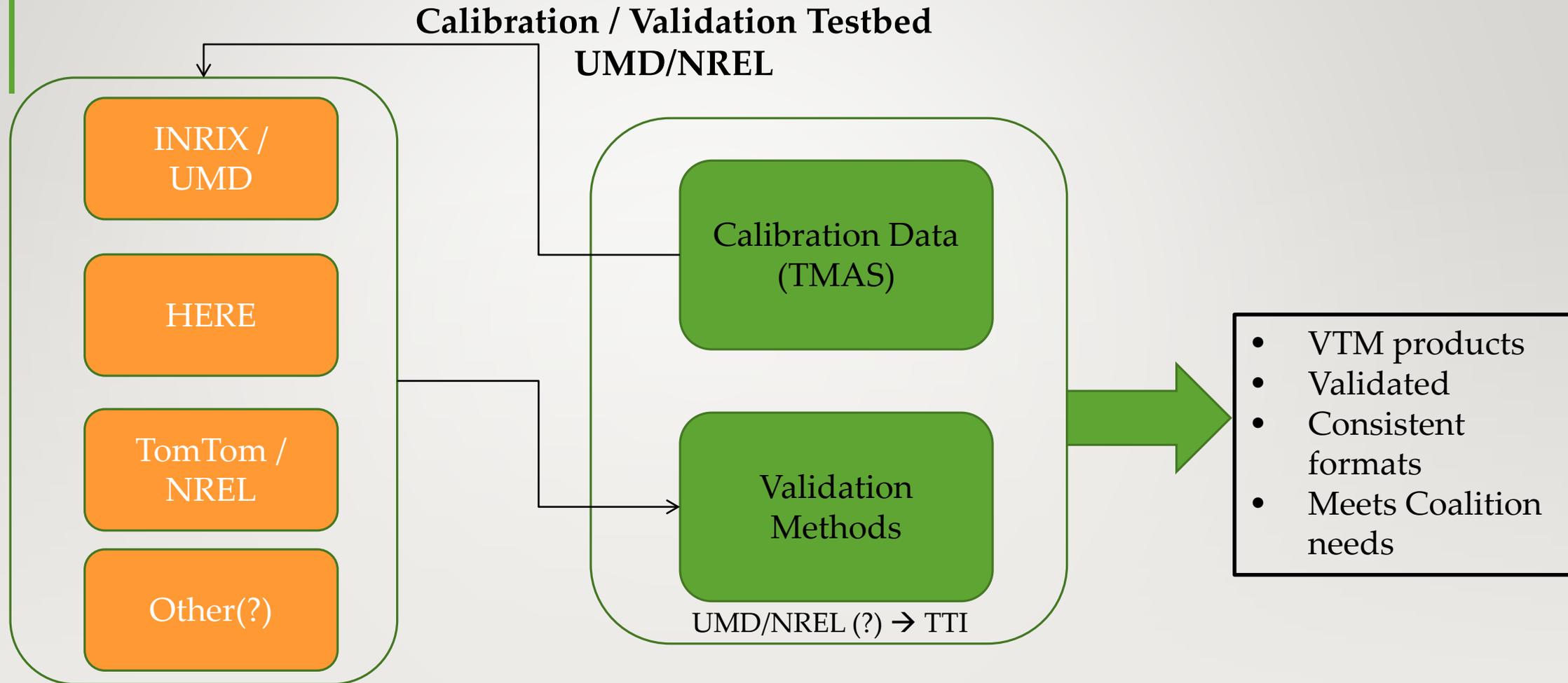
- Define a *practical and logistical framework* for the delivery of probe-based volume and turning movement data
- Understand, document, and share *data requirement needs for a variety of DOT applications* requiring such data
- Create a *calibration and validation testbed* to assist vendors' initial 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



# 13 | Flow Chart - Initial



# As it Evolved / is Evolving Flow Chart



## 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 cordoning available data by time



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# Questions





# Statewide Traffic Volume Estimation Using GPS Traces: INRIX Dataset - Maryland

Analysis Performed by:  
**Przemyslaw Sekula & Nikola Markovic**

Presented by:  
**Kaveh Sadabadi**

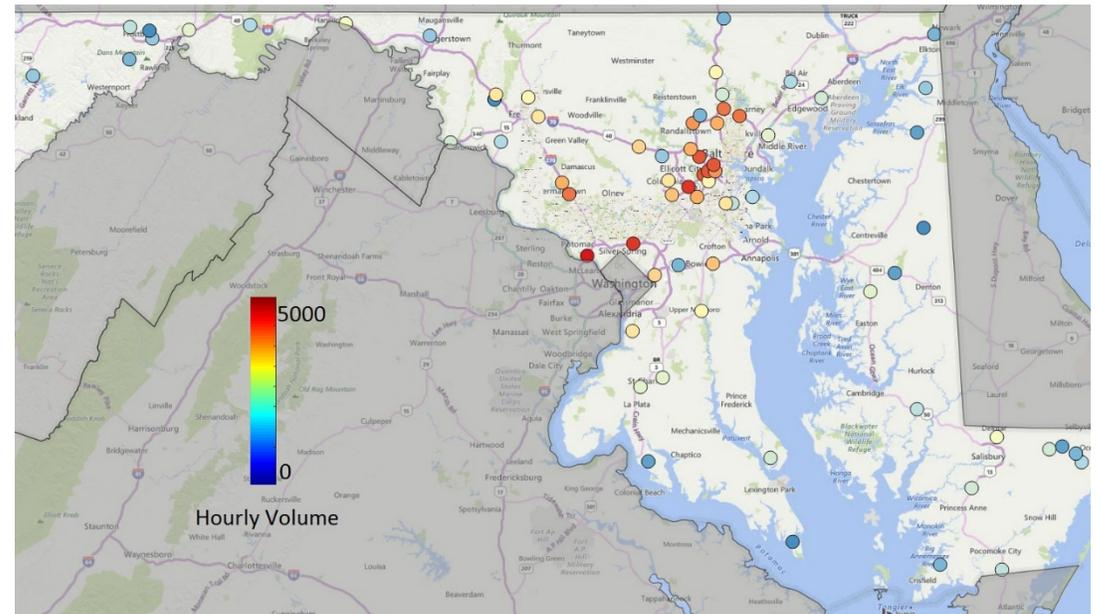
**VTM Steering Committee Meeting**  
April 13, 2017

# Today's Presentation

- Background & State of the practice
- Objectives
- INRIX dataset
- Regression analysis
- Results
- Next steps
- Q & A

# Background

- 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

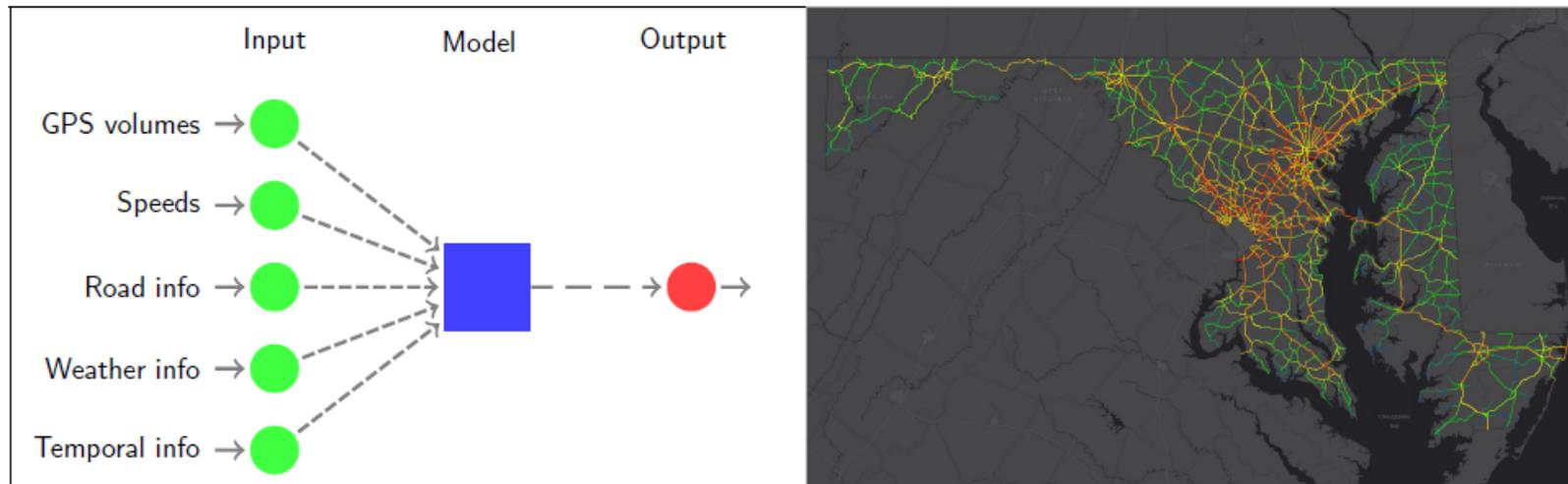
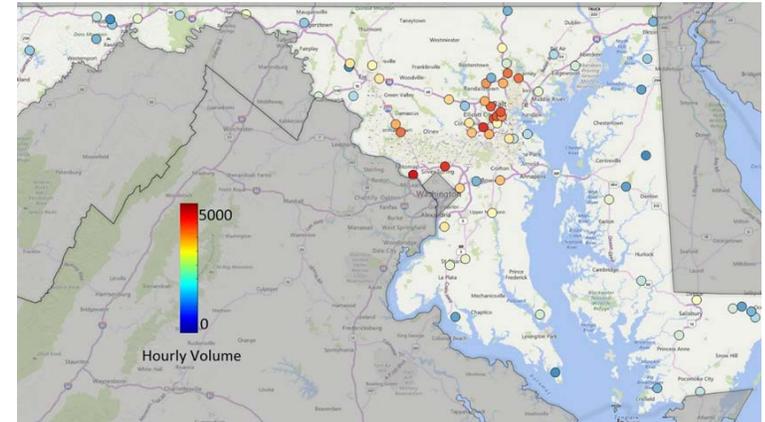


# State of Practice

- 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 ( $R^2 = 0.5$ )

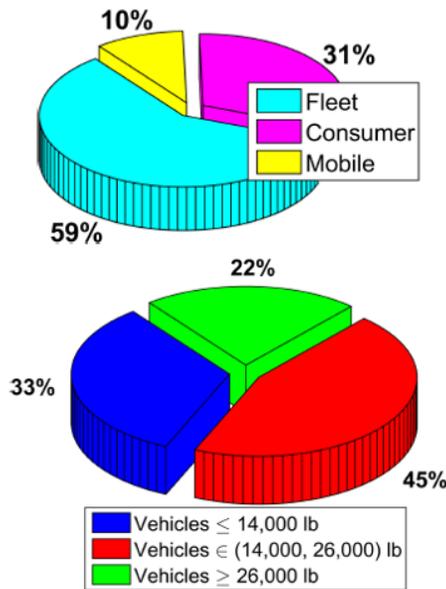
# Objectives

- 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

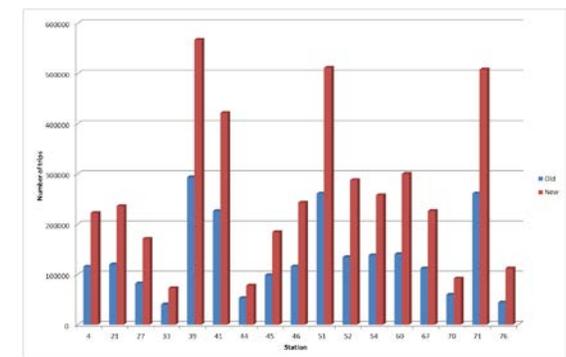
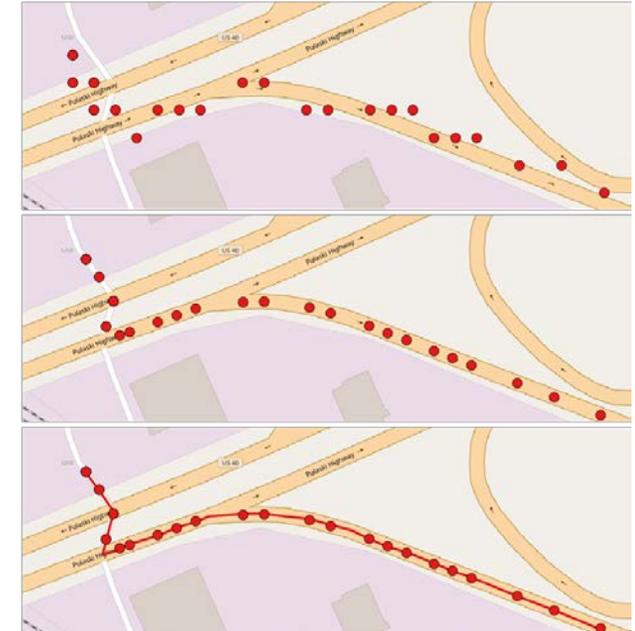
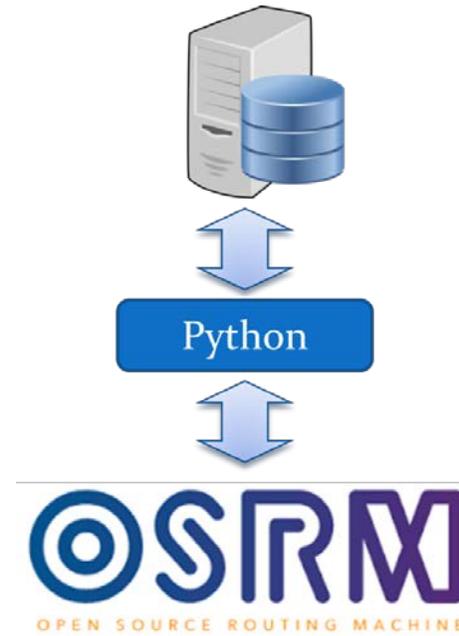


Providers and vehicle classes



# 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

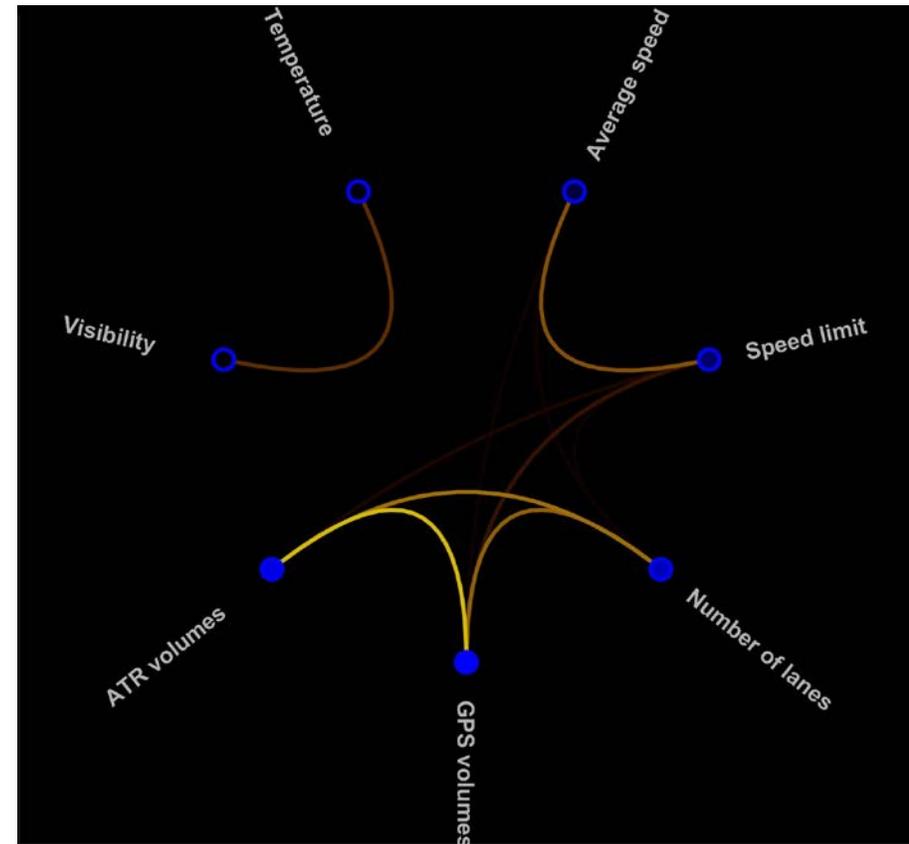


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# Other Data & Correlations

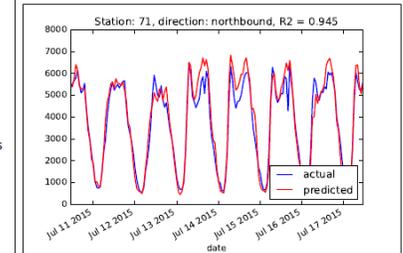
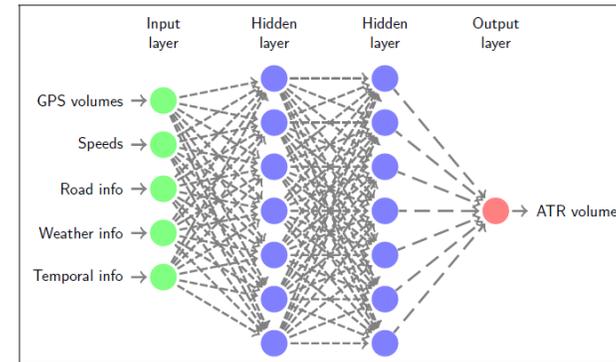
- Speed data from RITIS
- Road characteristics
  - Type of the road (IS,US,MD),
  - Number of lanes,
  - Speed limit,
  - Directions separated
- Weather data
  - Temperature, humidity, pressure, visibility, wind speed, precipitation
- Temporal characteristics
  - Hour of day, day of week, federal holiday



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



# Results

- Error measures

- $R^2$

- Range: 0.61-0.94

- Median: 0.82

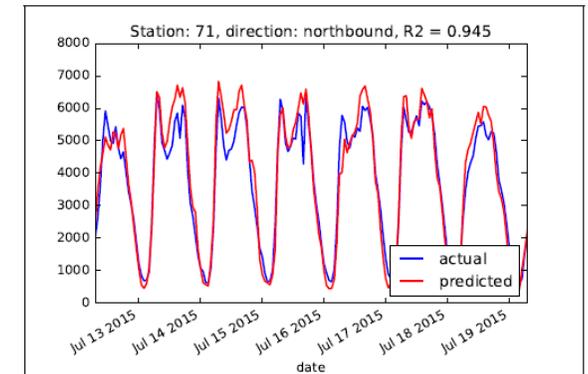
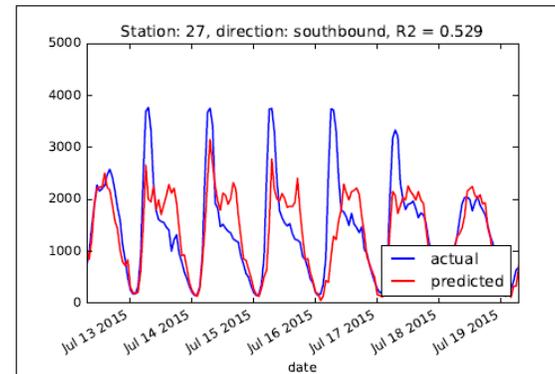
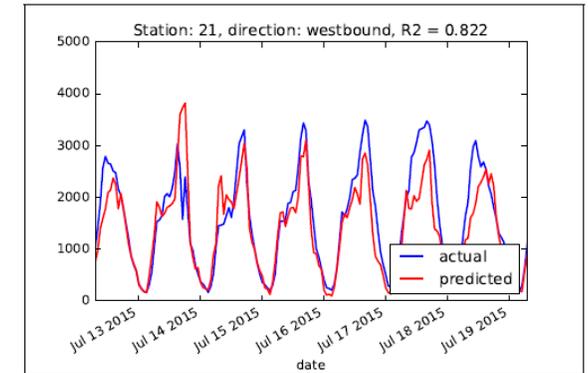
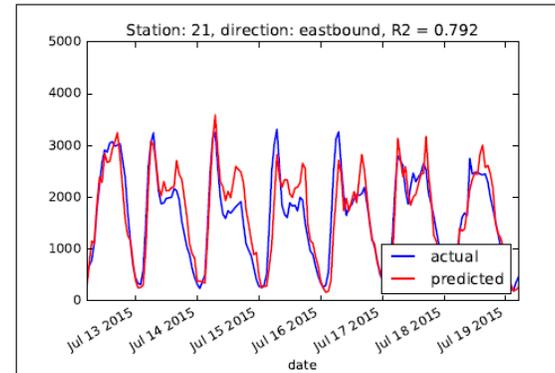
- Mean Absolute Percent Error (MAPE)

- 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

	R <sup>2</sup>	MAPE (%)	ECR (%)
Day (6am-8pm)	0.82	28	9
Night (8pm-6am)	0.86	25	11
Peak (7am-9am & 4pm-6pm)	0.85	29	10
Off-Peak	0.91	22	9
Hourly Volume (1000-2000)	0.73	29	10
Hourly Volume (2000-3000)	0.84	22	8
Hourly Volume (3000+)	0.88	17	7
Hwy Type - IS	0.83	22	8
Hwy Type - US	0.77	28	10
Hwy Type - MD	0.82	19	7
<b>Overall</b>	<b>0.82</b>	<b>22</b>	<b>8</b>

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

# 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

## Contact Information

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Center for Advanced Transportation Technology  
University of Maryland

April 13, 2017





## Real-time Volume Estimation – Denver Area

Yi Hou

April 13, 2017

- 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
- Total hourly volume
- Motorcycle volume
- Passenger car volume
- Bus volume
- Truck volume

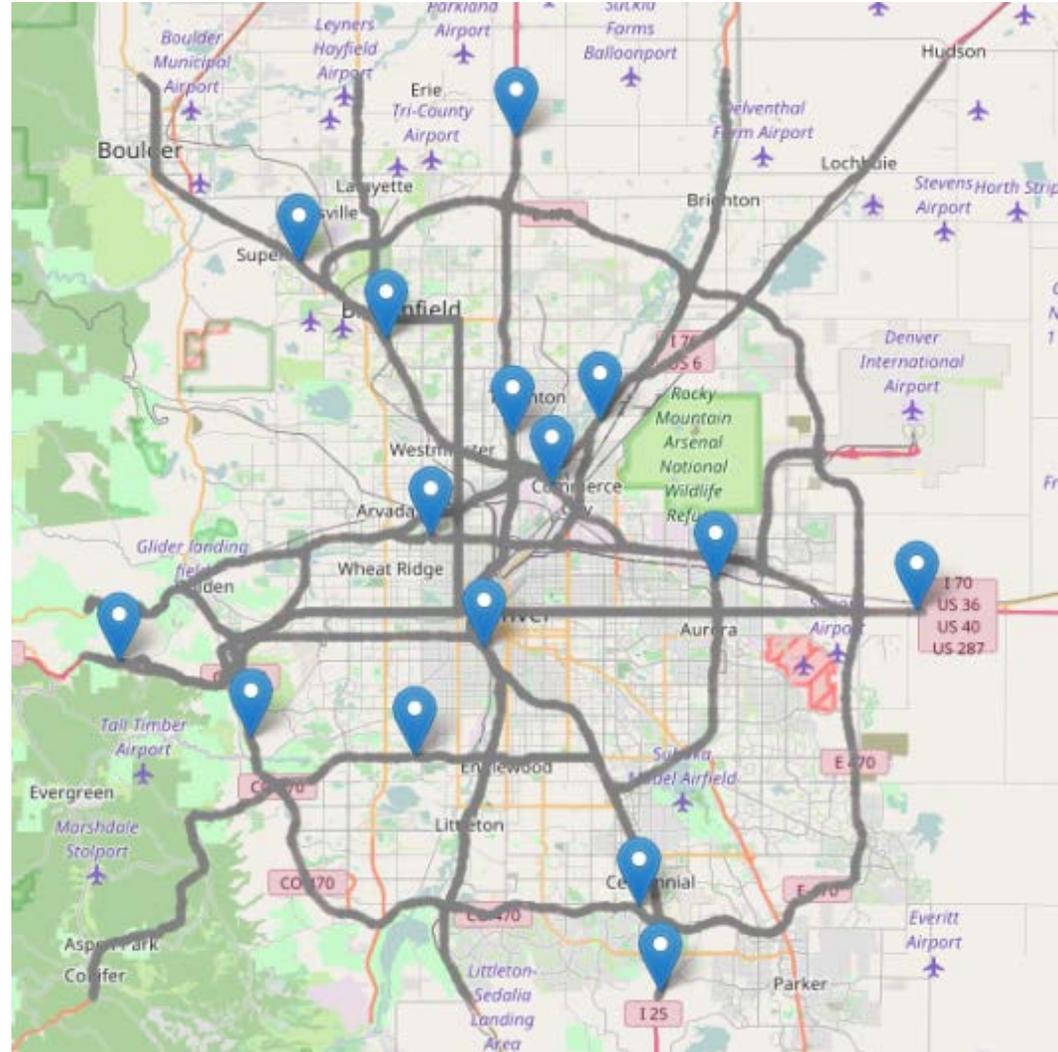
- Average temperature
- Visibility
- Wind
- Precipitation
- Snow
- Fog
- Rain
- Thunderstorm



- Travel time
- Speed
- Probe vehicle count
- Speed limit
- Street name
- Segment ID



# ATR Locations and Denver Road Network

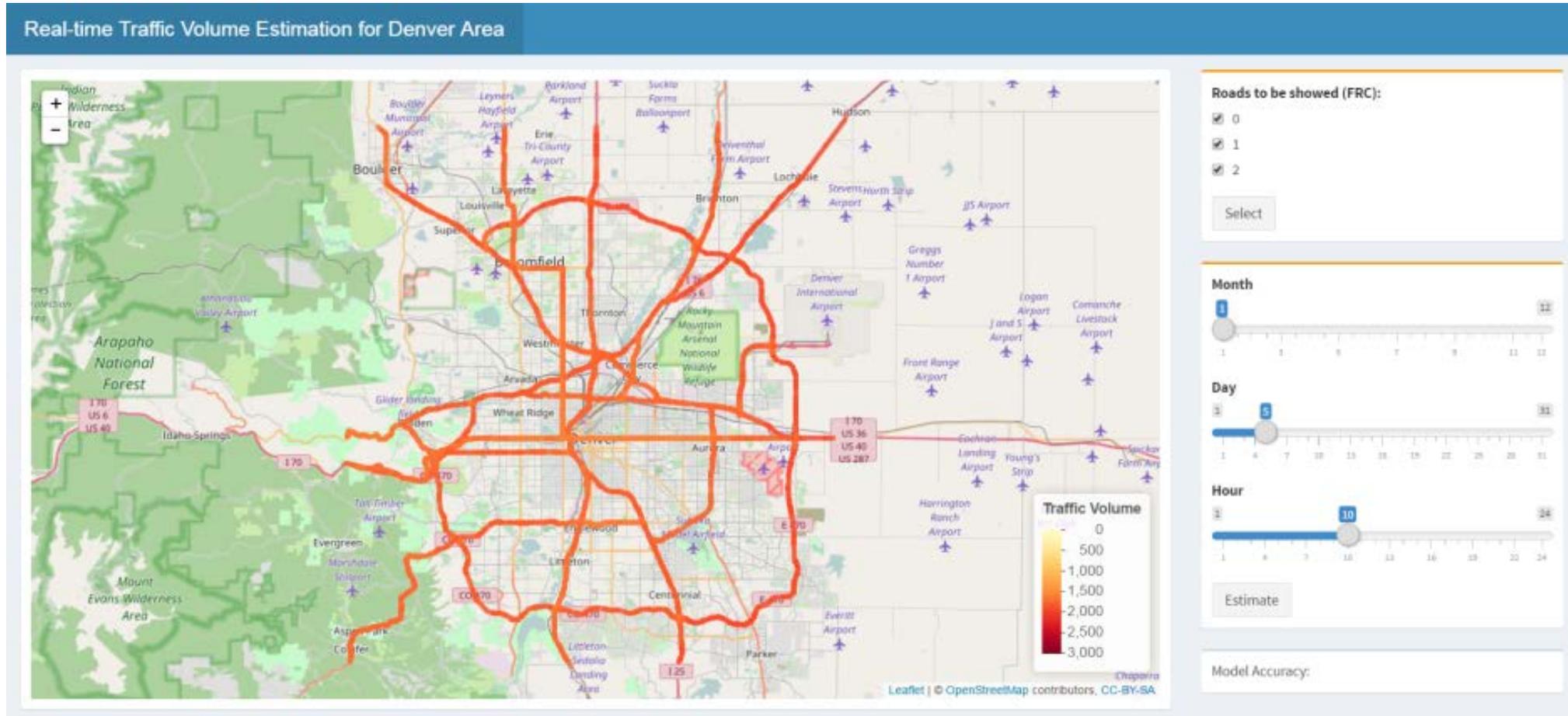


# Snapshot of Combined Data

	segment_id	speed_limit	Temp	Visibility	Wind	Precip	Snow	Fog	Rain	Thunderstorm	state	station_id	direction	FC	NE	lat	long	RS	RN	month	day	weekday	hour	volume
1	-8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	2	E	U	2	39.73987	-104.6718	I	70	1	1	5	1	164
2	-8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	2	W	U	2	39.73987	-104.6718	I	70	1	1	5	1	148
3	-8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	4	E	U	2	39.94692	-105.1490	US	36	1	1	5	1	422
4	-8.84e+13	55	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	4	W	U	2	39.94692	-105.1490	US	36	1	1	5	1	452
5	8.84e+13	55	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	12	N	U	4	39.51219	-104.8704	I	25	1	1	5	1	435
6	8.84e+13	55	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	12	S	U	4	39.51219	-104.8704	I	25	1	1	5	1	869
7	-8.84e+13	55	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	103	N	R	3	40.02159	-104.9809	I	25	1	1	5	1	30
8	8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	103	S	R	3	40.02159	-104.9809	I	25	1	1	5	1	53
9	-8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	107	E	U	3	39.70889	-105.2874	I	70	1	1	5	1	384
10	-8.84e+13	75	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	107	W	U	3	39.70889	-105.2874	I	70	1	1	5	1	208
11	8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	501	N	U	5	39.71819	-105.0053	I	25	1	1	5	1	1052
12	-8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	501	S	U	4	39.71819	-105.0053	I	25	1	1	5	1	2990
13	8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	504	E	U	2	39.90147	-105.0815	US	36	1	1	5	1	688
14	8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	504	W	U	2	39.90147	-105.0815	US	36	1	1	5	1	572
15	8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	506	N	R	2	39.65338	-105.0598	US	285	1	1	5	1	419
16	-8.84e+13	55	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	506	S	R	2	39.65338	-105.0598	US	285	1	1	5	1	529
17	-8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	507	E	U	2	39.81536	-104.9534	I	270	1	1	5	1	547
18	8.84e+13	55	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	507	W	U	2	39.81536	-104.9534	I	270	1	1	5	1	692
19	-8.84e+13	55	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	510	E	U	3	39.78478	-105.0469	I	70	1	1	5	1	754
20	8.84e+13	55	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	510	W	U	3	39.78478	-105.0469	I	70	1	1	5	1	992
21	-8.84e+13	65	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	512	E	U	3	39.66412	-105.1860	CO	470	1	1	5	1	567
22	8.84e+13	75	14	7	7	0.23	TRUE	FALSE	FALSE	FALSE	8	512	W	U	3	39.66412	-105.1860	CO	470	1	1	5	1	345

# Web App Framework Prototype

<https://yihou.shinyapps.io/volume/>



- 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](http://www.nrel.gov)



# FHWA

## Travel Monitoring Analysis System (TMAS – version 2.5)

Steven Jessberger – System Owner  
FHWA – Office of Highway Policy Information  
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202-366-5052

5/2/2017

# 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

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## 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

	R <sup>2</sup>	MAPE (%)	ECR (%)
Hourly Volume (1000-2000)	0.73	29	10
Hourly Volume (2000-3000)	0.84	22	8
Hourly Volume (3000+)	0.88	17	7
Hwy Type - IS	0.83	22	8
Hwy Type - US	0.77	28	10
Hwy Type - MD	0.82	19	7
<b>Overall</b>	<b>0.82</b>	<b>22</b>	<b>8</b>
Previous UMD Freeway Results	0.82	27	9.5
State of practice – Factored HMPS	-	50	-
Targets	-	-	10/5



## 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?



# 51 | Wrap Up

## Next meeting/webinar (DATE CHANGE)

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



50 | Questions



# 59 | Thank You!

- For Questions, please contact:
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