Volume & Turning Movements Project

Steering Committee Meeting #3

JANUARY 26, 2017

Conference call number:

2 Introductions

Kaveh Sadabadi, PhD
Research Faculty
Center for Advanced Transportation Technology
University of Maryland
kfarokhi@umd.edu
(301) 405-1352

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

(603) 321-0990

Dr. Stanley Young, PhD, PE
National Renewable Energy Laboratory (NREL)
U.S. Department of Energy
Stanley.young@nrel.gov
(301) 792-8180

Other Project Contacts

UMD Project Manager/Contracts: Kathy Frankle (UMD-CATT), 301-405-8271 or kfrankle@umd.edu

Steering Committee Coordinator: Joanna Reagle (KMJ Consulting, Inc.), 610-228-0760 or jreagle@kmjinc.com

3 Attendees

Agencies
FHWA
Maryland DOT/SHA
MWCOG
NHDOT
PennDOT
Port Authority of NY & NJ
South Carolina DOT
Virginia DOT
USDOT
HERE
INRIX
TTI
NREL
I-95 Corridor Coalition
UMD CATT
UMD CATT Lab
I-95 Corridor Coalition (support)

4

Please confirm that your line is muted *6

Thank you!

5

Agenda

- Very brief project overview
- Survey results
- Analysis of Maryland data
- New project one-pager
- Steering committee input
- Next steering committee meeting/webinar

Project Overview

- Initiated in 2013 as part of the **I-95 Corridor Coalition MCOMP** proposal
- Goal of project is to **accelerate the timeframe** to achieve viable **volume and turning movement data** through **probe data**
- Hypothesis: Information in existing probe data can be used to infer volume levels both for real-time operations and for historical planning applications

7

Project Background

- Network wide **volume and turning movement data** remain key **missing dimensions** for operational awareness and assessing system performance
- Turning movement data is only available in special studies
- There is a need for 24x7x365 volume (or density) estimates across the network

8 Projected Benefits / Uses

OPERATIONS

- Improved incident management monitoring and action
- Enhanced work zone monitoring, impact analysis, and safety
- More accurate user delay cost reporting
- Special event management
- Improved traffic signal system timing management

PLANNING

- Additional insight to anticipate and verify "jam" conditions
- Detailed after-action reviews
- Improved system performance evaluation
- Expanded project / program assessment
- Advance travel demand modeling accuracy
- Better address air quality, emissions requirements and energy analysis inquiries

9 Approach / Tasks / Objectives

- Define a framework for delivery of probe-based volume & turning movement data.
- Understand, document, & share data needs for various DOT applications requiring such data.
- Create a calibration and validation testbed to assist vendors' initial development efforts.
- Provide representative data products
- Set appropriate expectation for data fidelity, form, granularity, and usability.
- Anticipate the need for an ongoing calibration network
- Estimate resources needed to maintain/operate a national calibration/validation testbed.

10 Survey Structure / Stats

- 14 completed surveys
  - 11 member agencies
  - 3 outside of coalition
- 10 additional partial surveys
- 18 survey questions that queried
  - Need for data
  - Accuracy
  - Format
- Prompted for comments
- A full report available

Metropolitan Washington Council of Governments
Federal Highway Administration
Maryland State Highway Administration / Department of Transportation
South Carolina Department of Transportation
North Jersey Transportation Planning Authority
Delaware Valley Regional Planning Commission
Colorado Department of Transportation
National Renewable Energy Laboratory
Pennsylvania Department of Transportation
New Hampshire Department of Transportation
Virginia Department of Transportation

11 Overview of Survey Results

VOLUME DATA

- **Great interest from a planning perspective** for all aspects of this type of data.
- **Real time volume data has a higher perceived value for incident management monitoring than for traveler information**.
- The **preferred volume metric was vehicle flow** (vph) as opposed to percent capacity or vehicle density.
- The **needed level of accuracy for flow data** to support application -within **10% of roadway capacity.**
- The minimum time interval/aggregation - **15 minute intervals for real time**, however **archived flow data could be longer intervals of 30 minutes to 1 hour**.
- **An overwhelming additional desirable attribute was the percentage (or volume) of heavy duty trucks.**

TURNING MOVEMENT DATA

- **The need for archived turning movement data is more defined** for planning and performance measures.
- **There is a perceived need for real time turning movement data, particularly for detours and evacuation**.
- The need for and use of the data for day to day operations application is less defined than for archived turning movement data.
- With respect to turning movements, there was **no clear preference for a defined metric.**
- Either estimates of volume in each direction or percent of turning movements in each direction were acceptable.
- If **percentage of turning vehicles was reported**, accuracy (and precision) to within **10% is preferred**.
- Similar to volume, turning movements should be reported at **15 minute time aggregations.**

Statewide Traffic Volume Estimation using GPS Traces: Machine Learning Approach

Przemysław Sekuła, Nikola Marković

Center for Advanced Transportation Technology (CATT)
Department of Civil & Environmental Engineering
University of Maryland

psekula@umd.edu, nikola@umd.edu

Presented by Stanley Young

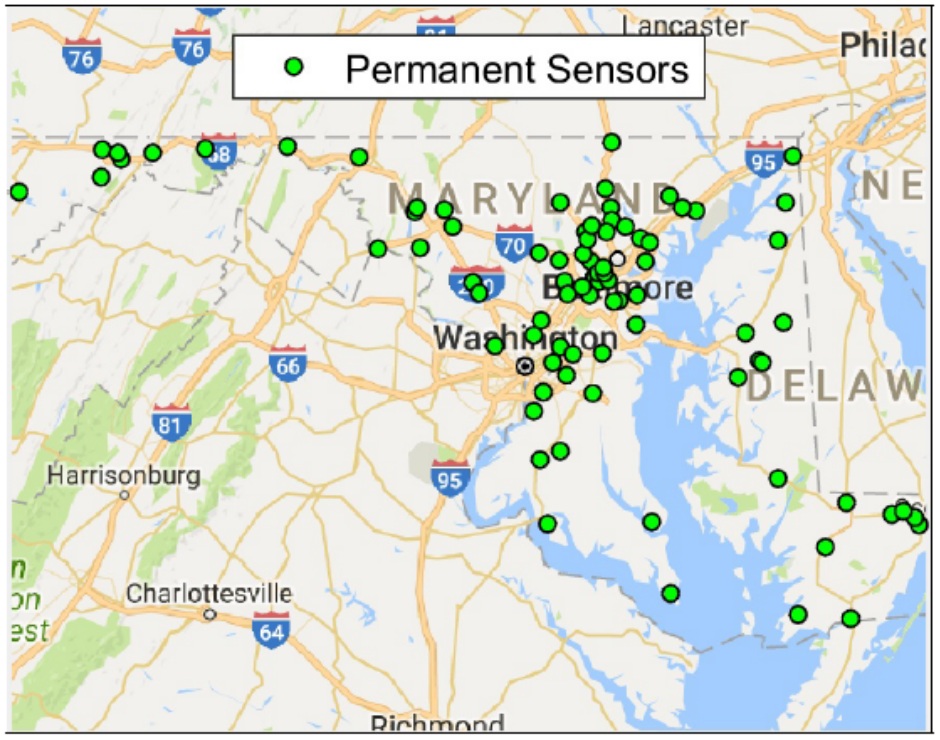
January 17, 2016

Outline

1. Introduction
2. Data
3. Regression
4. Conclusions

Traffic Volumes

- Detailed information about traffic volumes is of utmost importance both for transportation planning and traffic engineering



Maryland

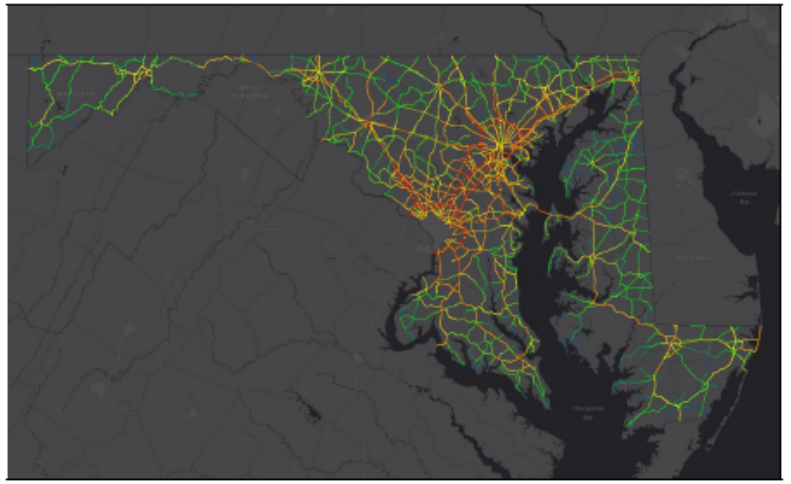
- 84 permanent automatic traffic recorder (ATR) stations
- Provide hourly counts broken down to vehicle classes
- However, we need to know volumes throughout the state

- How do we estimate volumes at road links without ATR stations?

Research Questions

- Can we use GPS traces to estimate hourly volumes throughout the state of Maryland?

INRIX probes generate GPS traces

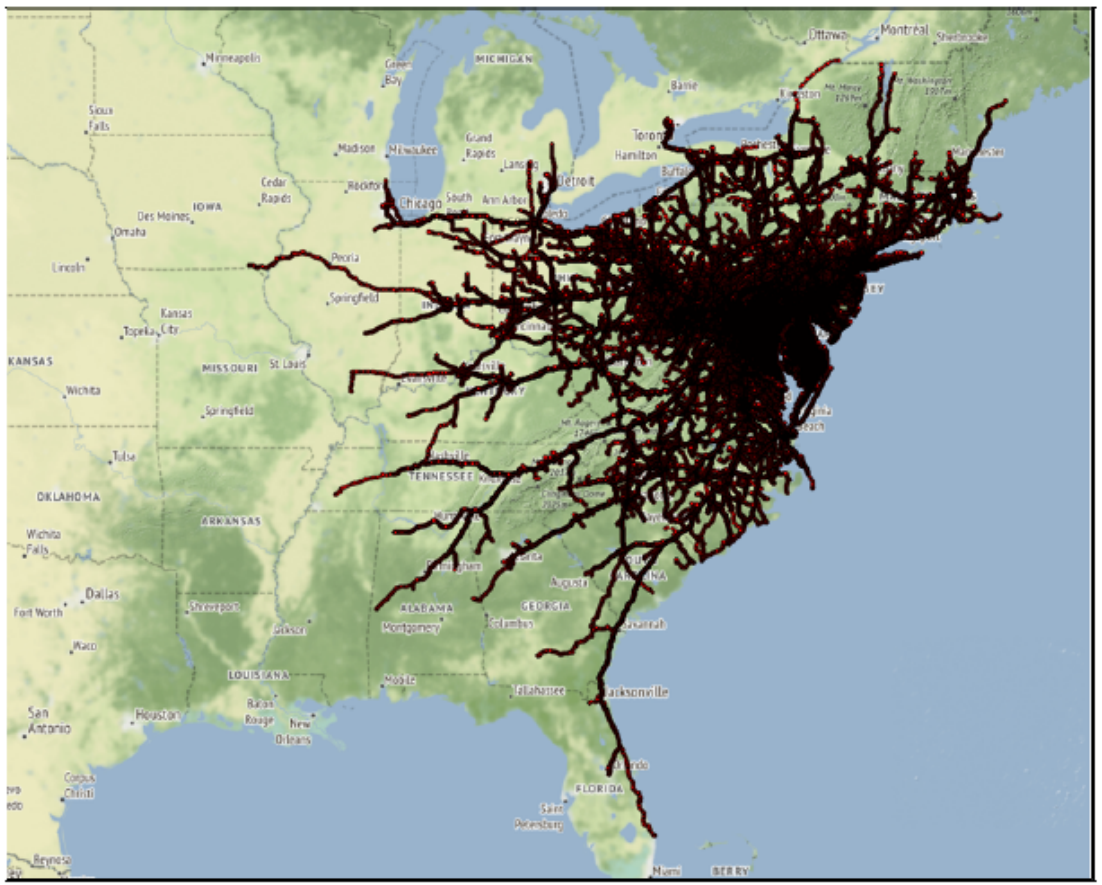


Volumes in MD

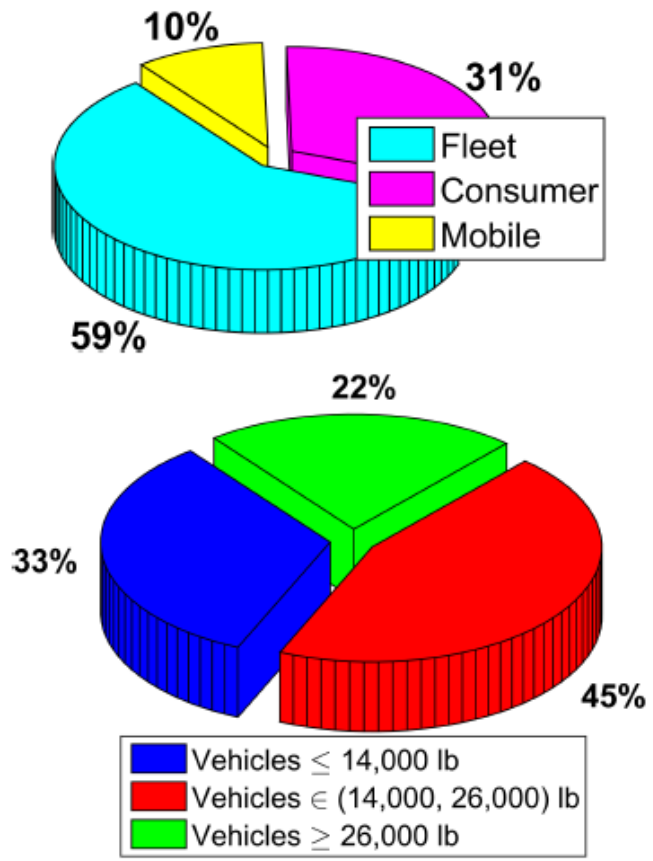
- Can we compare GPS traces and ATR data, learn the underlying relations, and then estimate volumes throughout the network?
- How accurate would those estimates be?

GPS Traces

- 4 months of INRIX data during 2015 (February, June, July, October)
  - 20 million trips, which include 1.4 billion way points
  - 112 GB of data



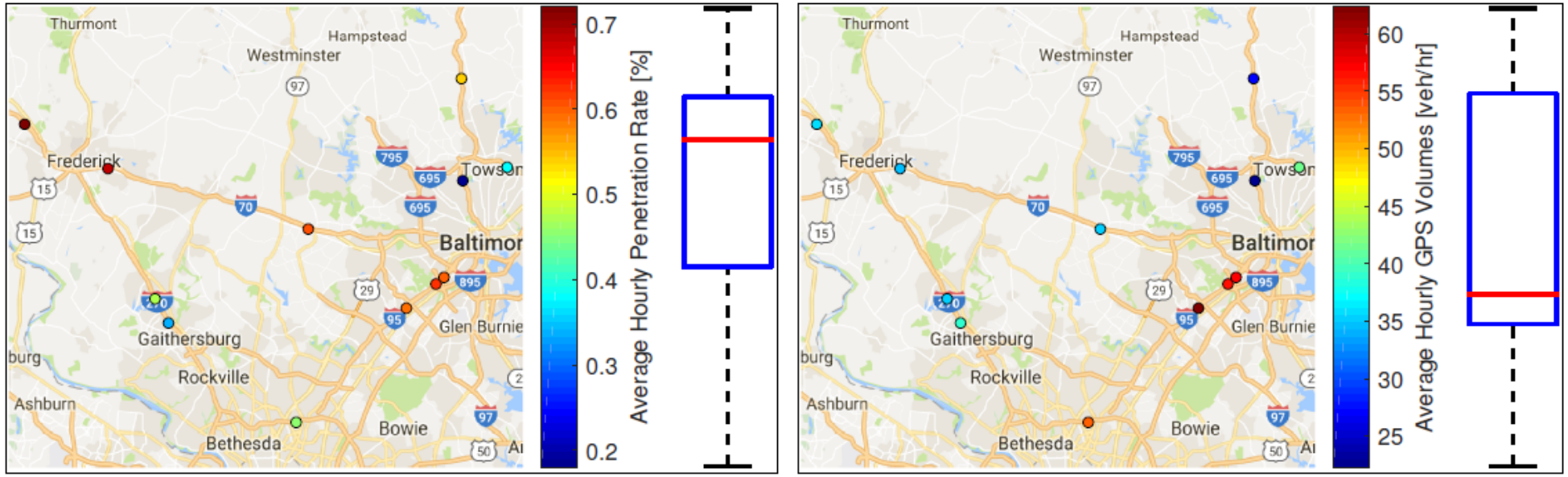
Way points are typically 1 sec apart



Providers and vehicle classes

GPS Traces

- Average hourly penetration rates of GPS traces are computed at 12 ATR locations based on all 4 months of data



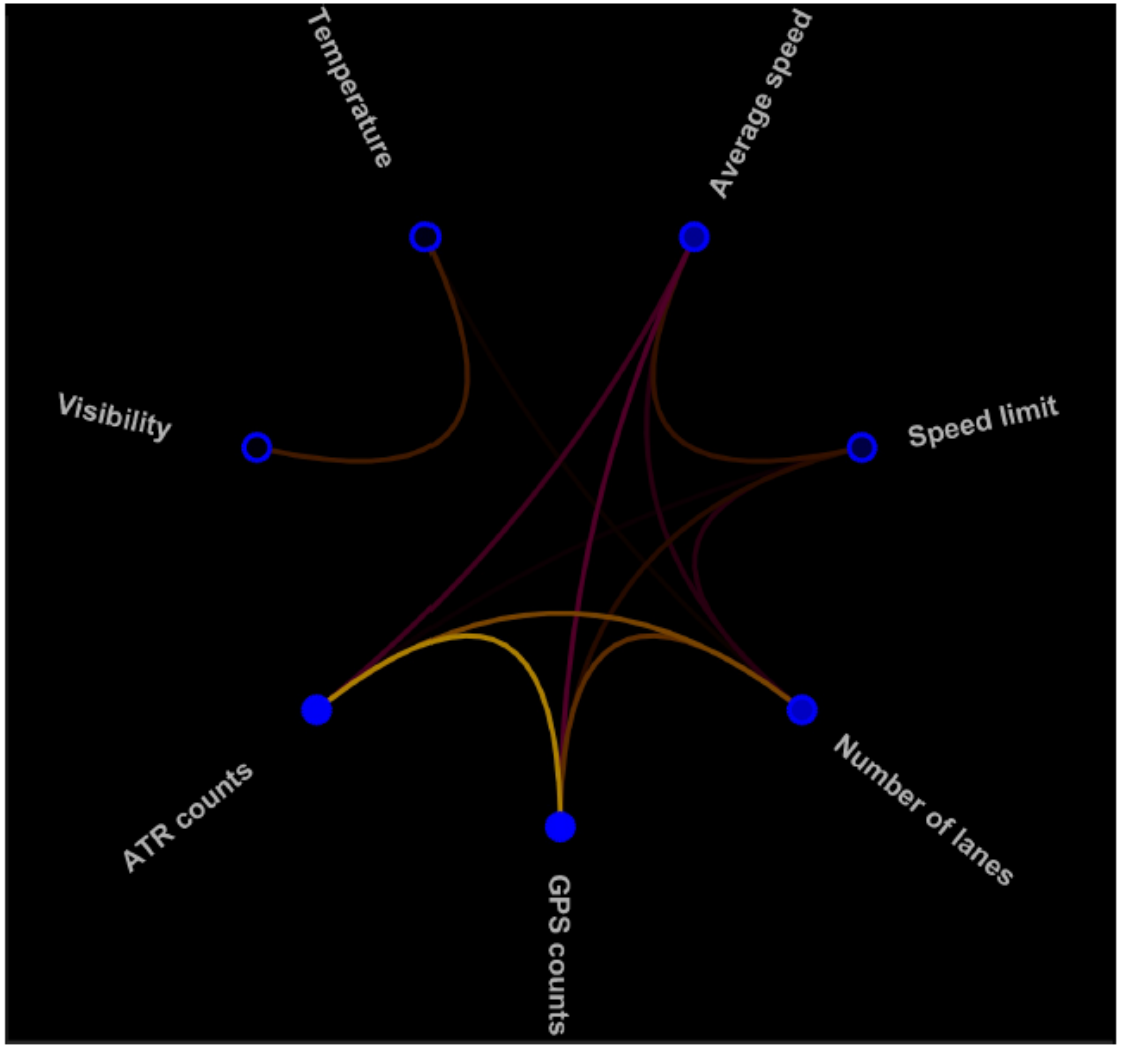
- Average hourly penetration rates vary from 0.18% to 0.72%, with the median of 0.57%
- Average hourly GPS volumes vary from 22.3 to 62.3 vehicles, with the median of 37.3 vehicles

Additional Data

- Speed info
  - Speeds estimated directly from GPS traces
  - Speeds from RITIS
- Road characteristics
  - Type of the road (IS, US, MD), number of lanes, speed limit, directions separated (yes/no)

- Weather info
  - Temperature, humidity, pressure, visibility, wind speed, precipitation, conditions (e.g., clear, cloudy, fog)
- Incident reports (work in progress)
  - All the information available on RITIS (e.g., work zones, collisions, disabled vehicle, obstructions)

Correlation



Yellow/magenta: positive/negative correlation

Positive correlation between

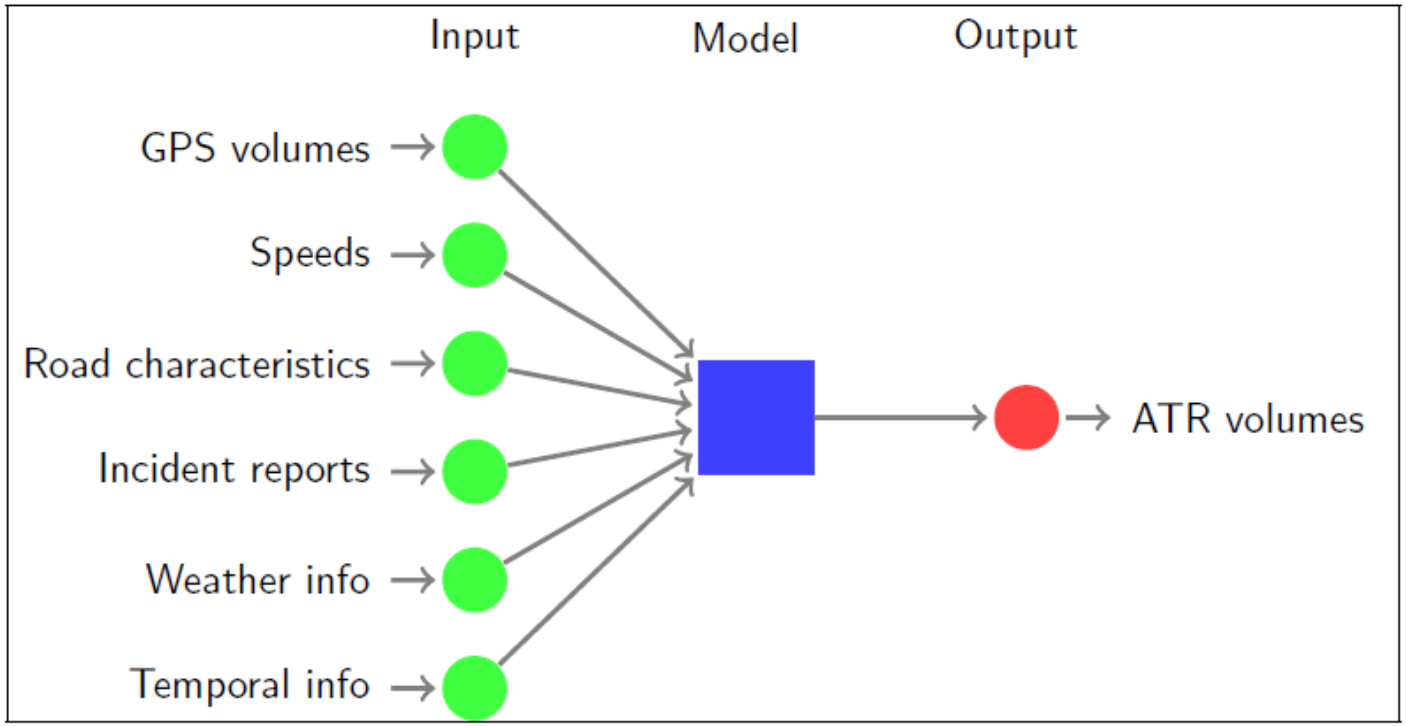
- ATR and GPS counts
- ATR/GPS counts and number of lanes
- Speed and speed limit

Negative correlation between

- ATR/GPS counts and speed

Regression

- Infer relation between GPS and ATR volumes at the hourly level
- Use this relation to estimate volumes at roads without ATR stations



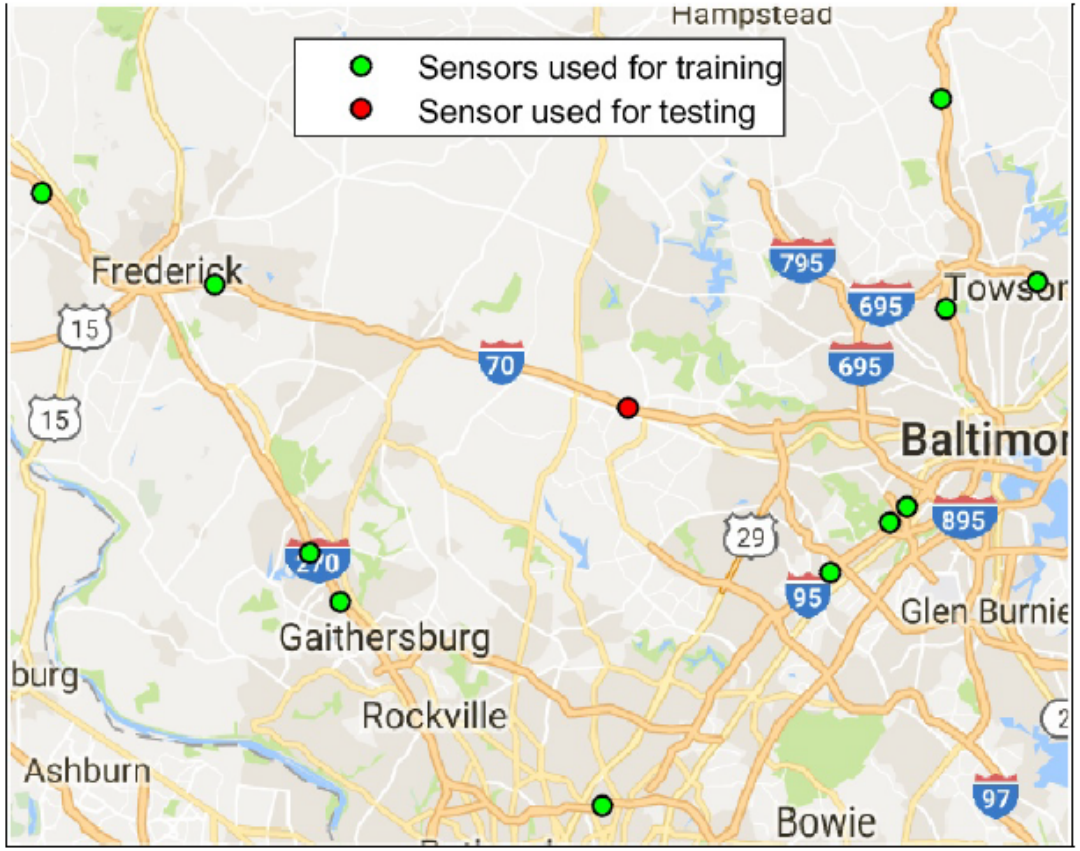
Models applied

- ANN *
- Random forest
- SVM

* Results shown based on ANN

Calibration and Evaluation

- Use 11 ATR stations for training and the remaining ATR for testing

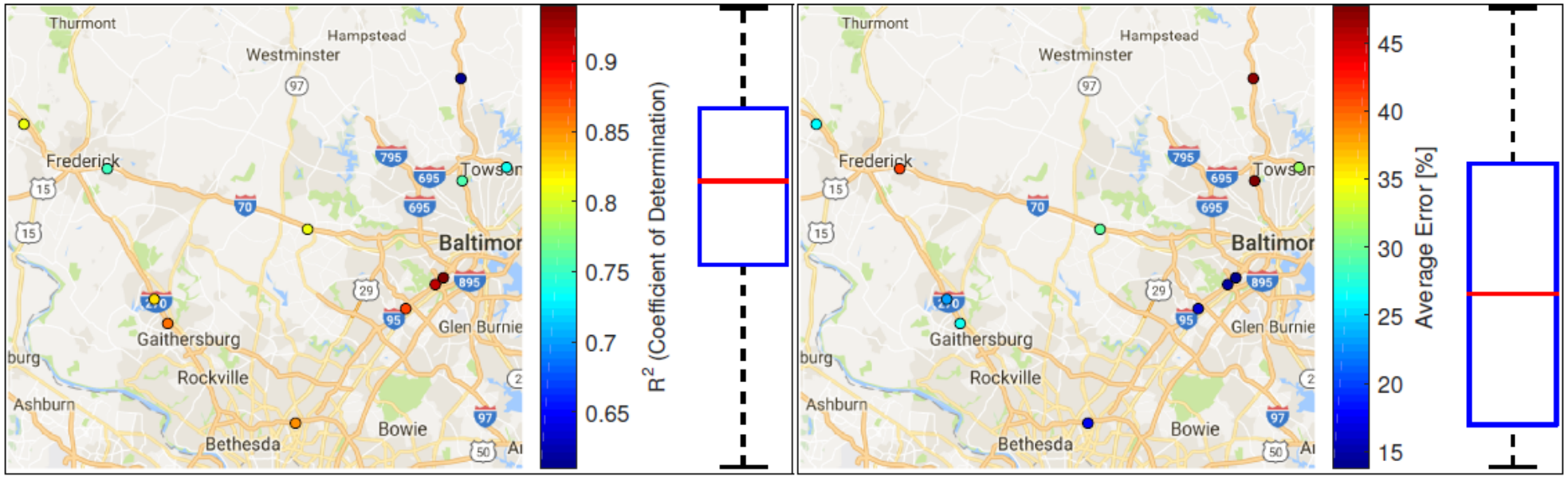


- Data from 11 ATR stations are used for regression
  - 66,000 data points for training
- Data from the remaining ATR are used for evaluation
  - 6,000 data points for testing

- Repeat this 12 times and report test results for all 12 locations

Result Summary

- Test results for all 12 sensors are reported in terms of R^2 and error



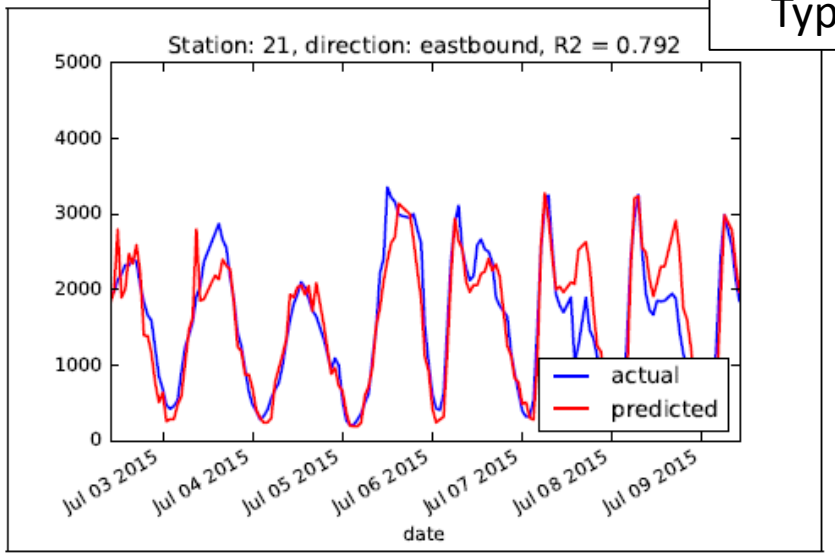
R^2 for test data

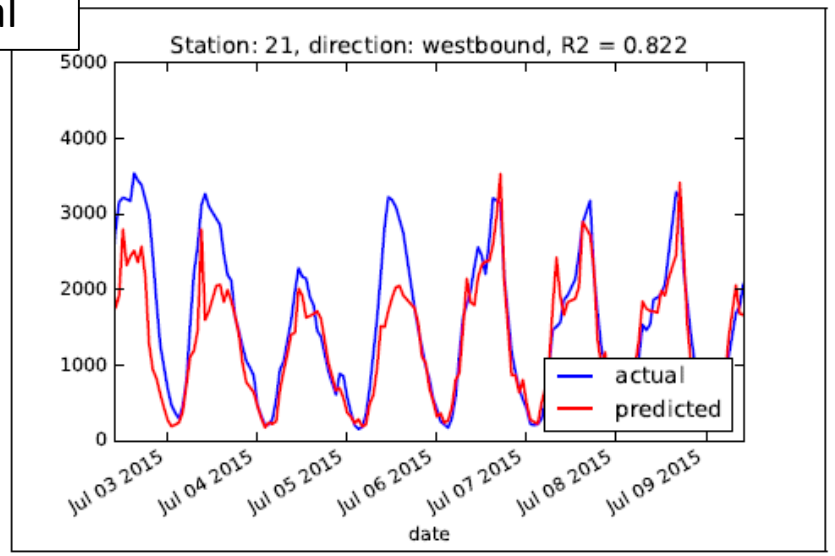
Error for test data

- The R^2 varies from 0.61 to 0.94, with the median of 0.82
- The error varies from 14% to 48%, with the median of 27%

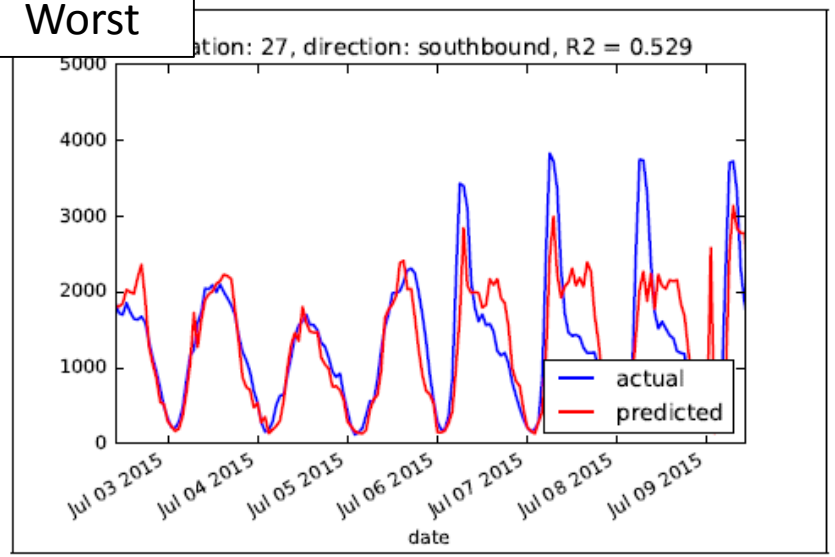
Example Results

Typical

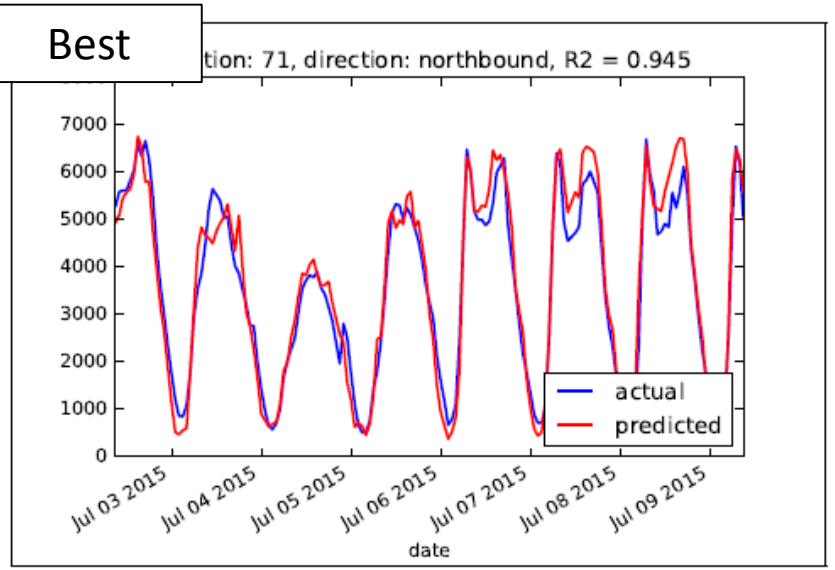




Worst

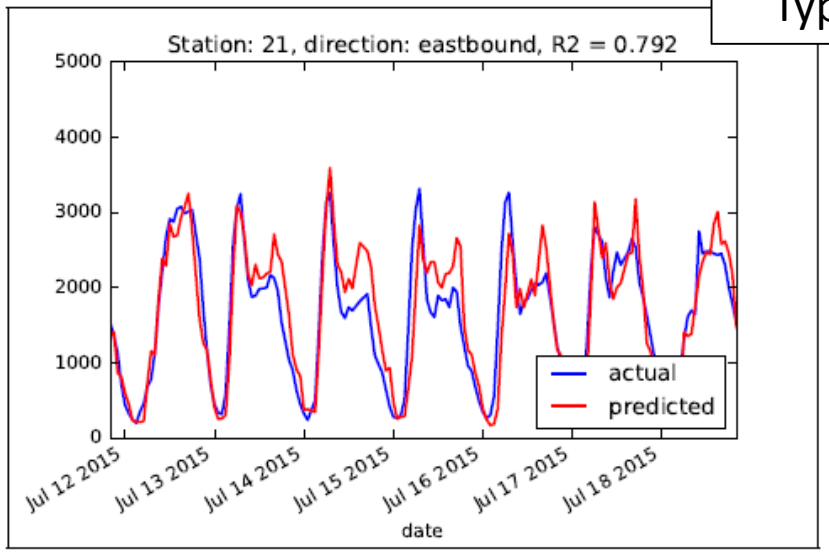


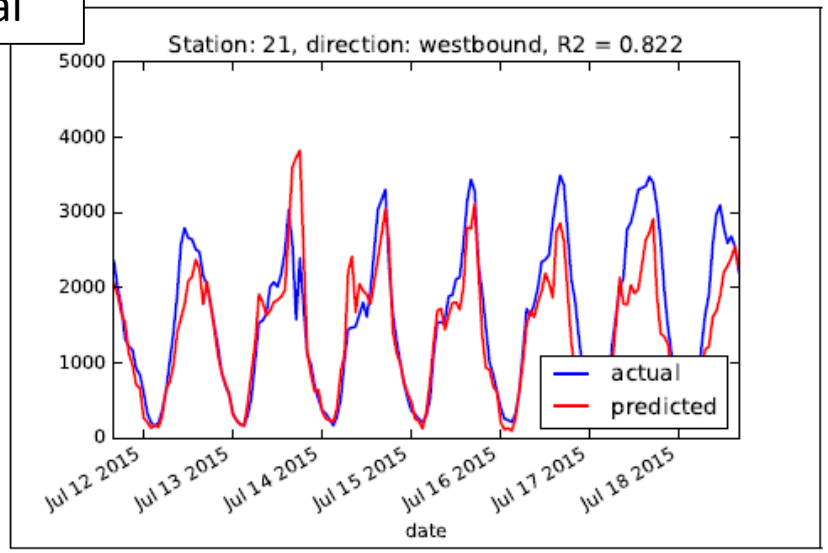
Best



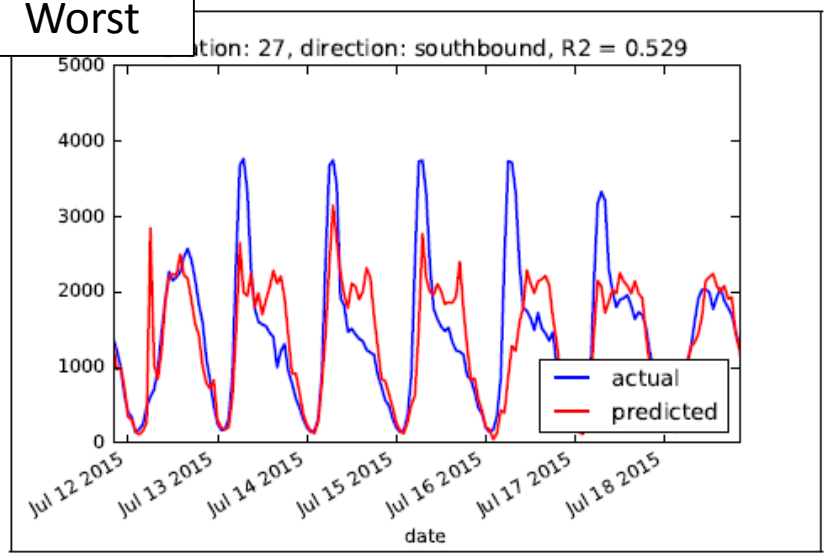
Example Results

Typical

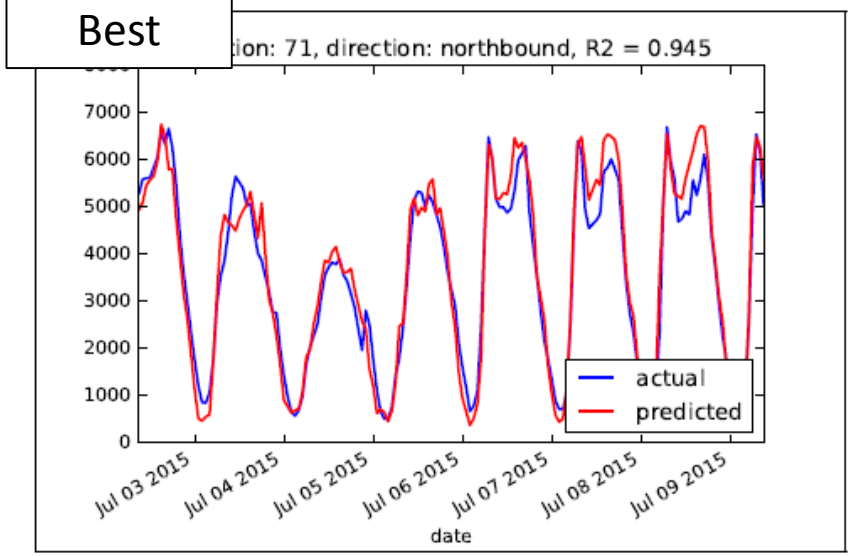




Worst

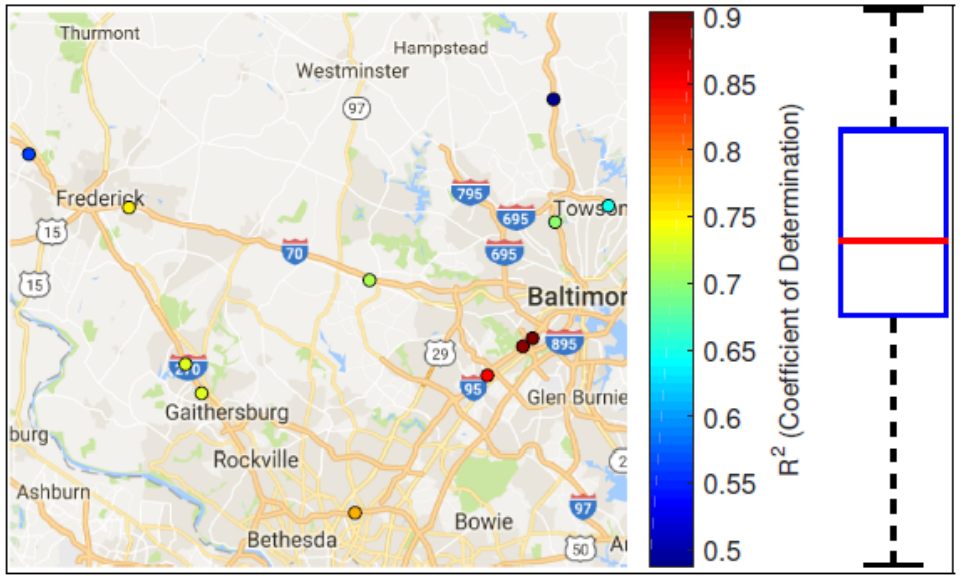


Best

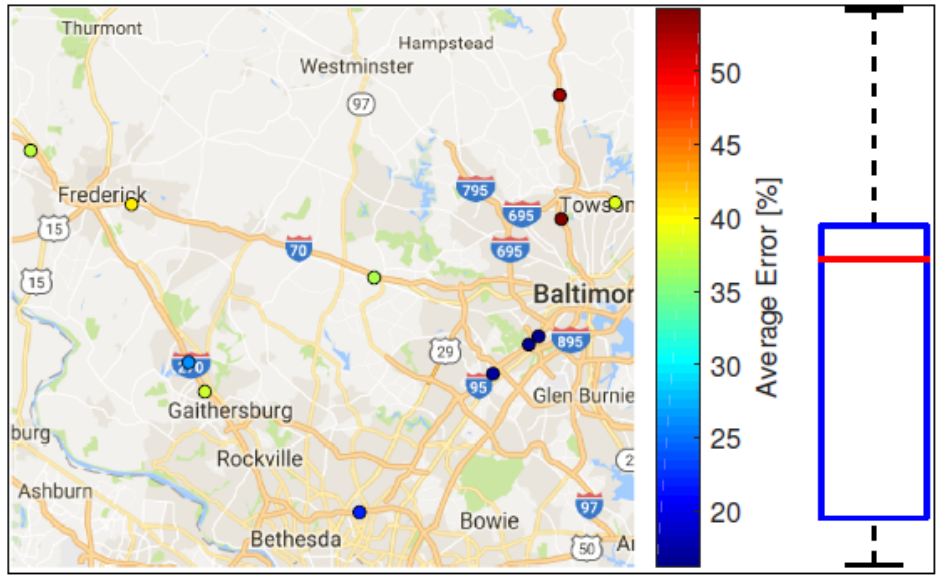


Contribution of GPS Traces

- Re-train and re-test the model without GPS traces



R^2 for test data

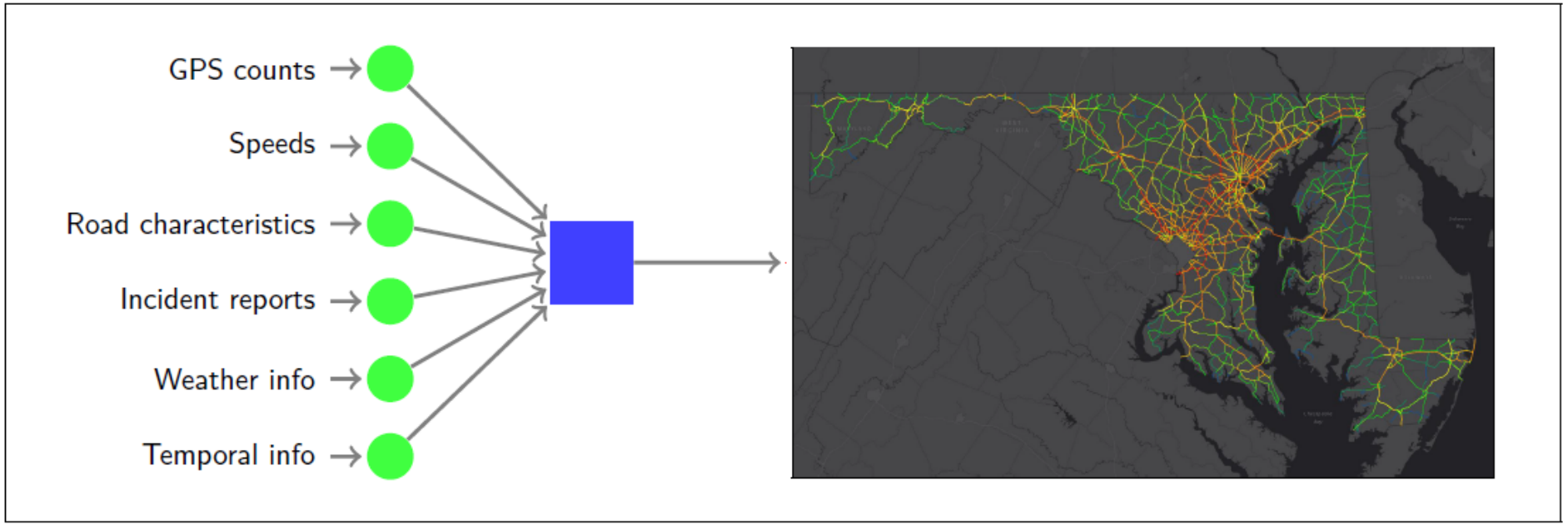


Error for test data

- The R^2 varies from 0.49 to 0.90, with the median of 0.73 (0.82)
- The error varies from 16% to 54%, with the median of 37% (27%)

Conclusions

- We can use ML to estimate hourly volumes with average accuracy of:
  - 27% if GPS traces are available ($R^2 = 0.82$)
  - 37% otherwise ($R^2 = 0.73$)



- Estimated volumes can be used for computation of performance measures in RITIS

Acknowledgments

Contact Information

Przemysław Sekuła, Nikola Marković

Center for Advanced Transportation Technology

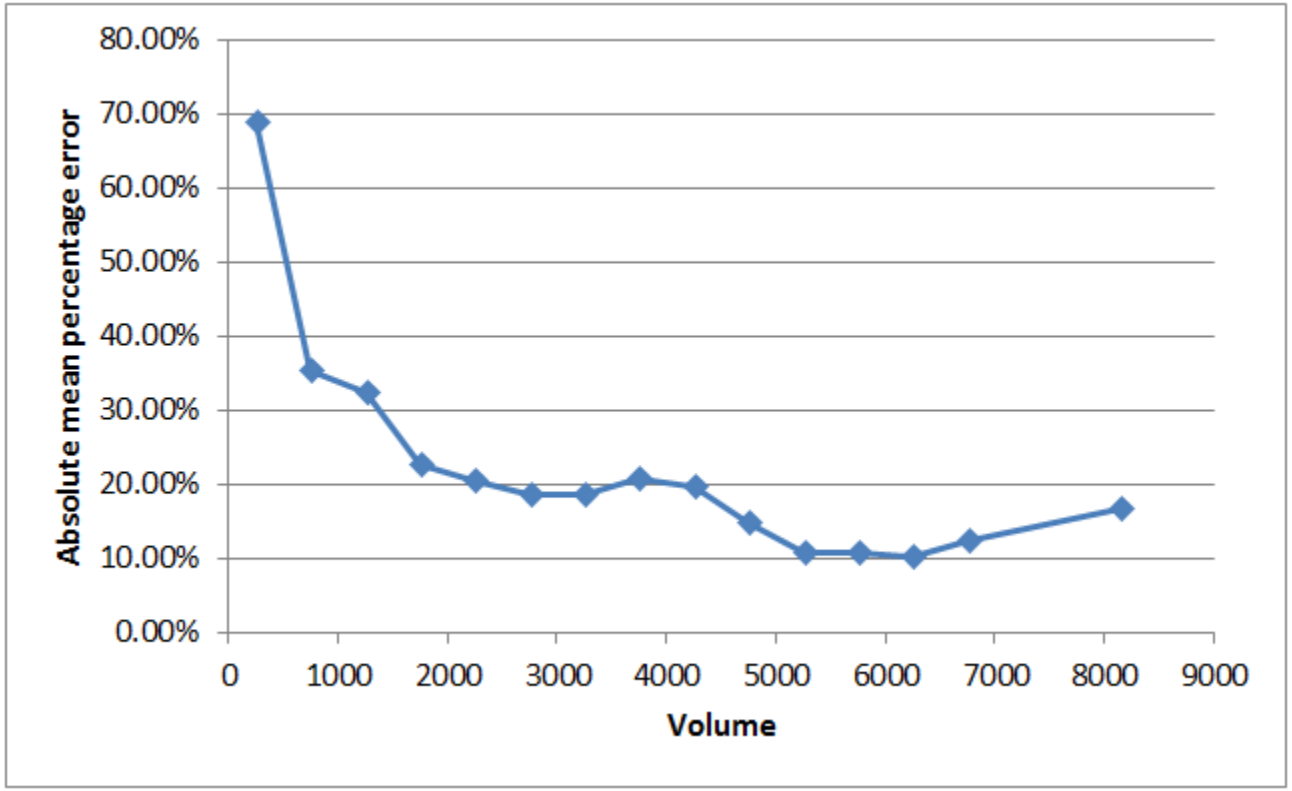
University of Maryland

psekula@umd.edu, nikola@umd.edu

From statistics to meaning….

- Results of initial MD analysis – from a roadway **VOLUME** perspective

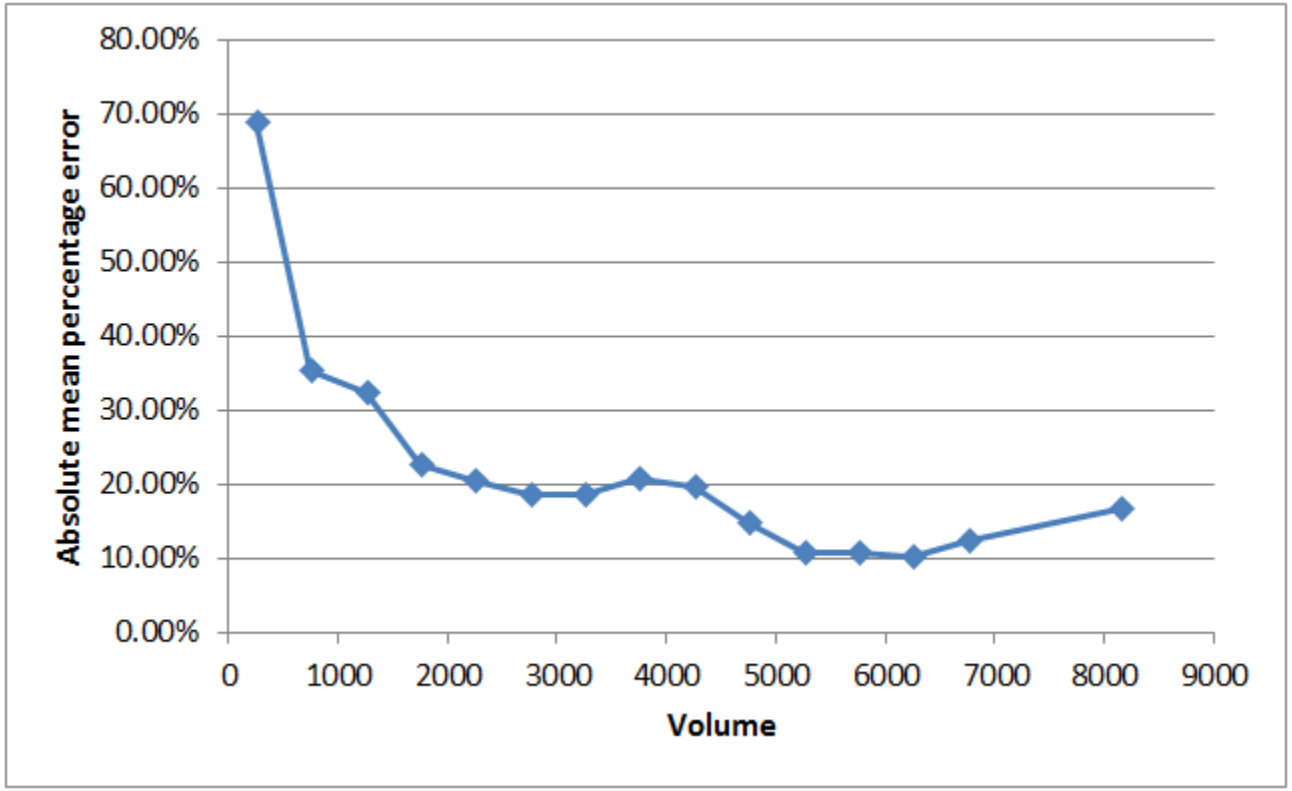
Volume (from)	Volume (to)	Number of samples	Error
0	500	8479	68.89%
500	1000	7701	35.34%
1000	1500	5946	32.26%
1500	2000	6352	22.64%
2000	2500	5879	20.42%
2500	3000	4711	18.62%
3000	3500	3221	18.59%
3500	4000	2650	20.63%
4000	4500	3235	19.56%
4500	5000	3621	14.89%
5000	5500	3313	10.80%
5500	6000	2554	10.61%
6000	6500	2304	10.16%
6500	7000	1876	12.29%
7000	9266	1592	16.81%



From statistics to meaning….

- Results of initial MD analysis – from a roadway **VOLUME** perspective

Volume (from)	Volume (to)	Number of samples	Error
0	500	8479	68.89%
500	1000	7701	35.34%
1000	1500	5946	32.26%
1500	2000	6352	22.64%
2000	2500	5879	20.42%
2500	3000	4711	18.62%
3000	3500	3221	18.59%
3500	4000	2650	20.63%
4000	4500	3235	19.56%
4500	5000	3621	14.89%
5000	5500	3313	10.80%
5500	6000	2554	10.61%
6000	6500	2304	10.16%
6500	7000	1876	12.29%
7000	9266	1592	16.81%

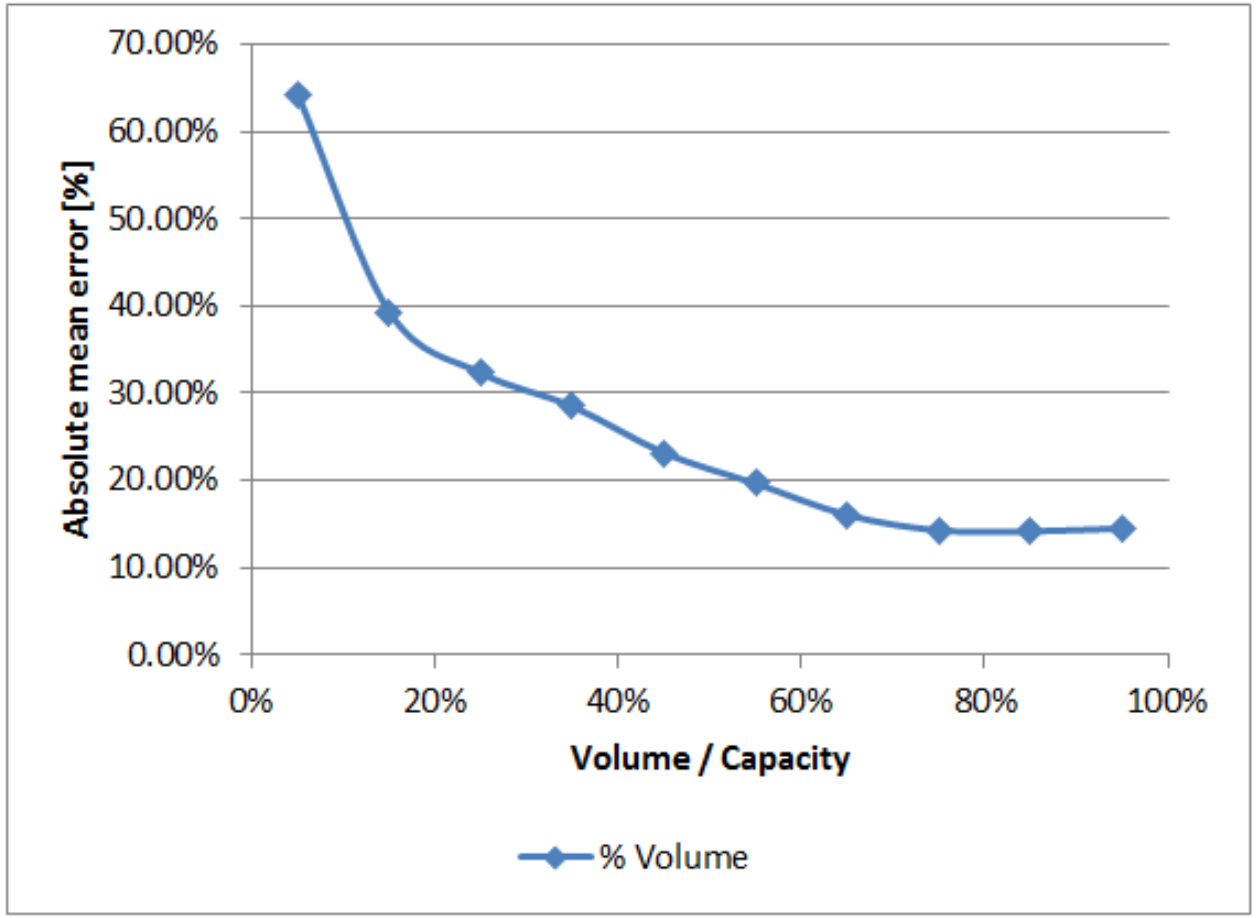


- The greater the volume the less the percent error

From statistics to meaning….

- Results of initial MD analysis – from a roadway **CAPACITY** perspective

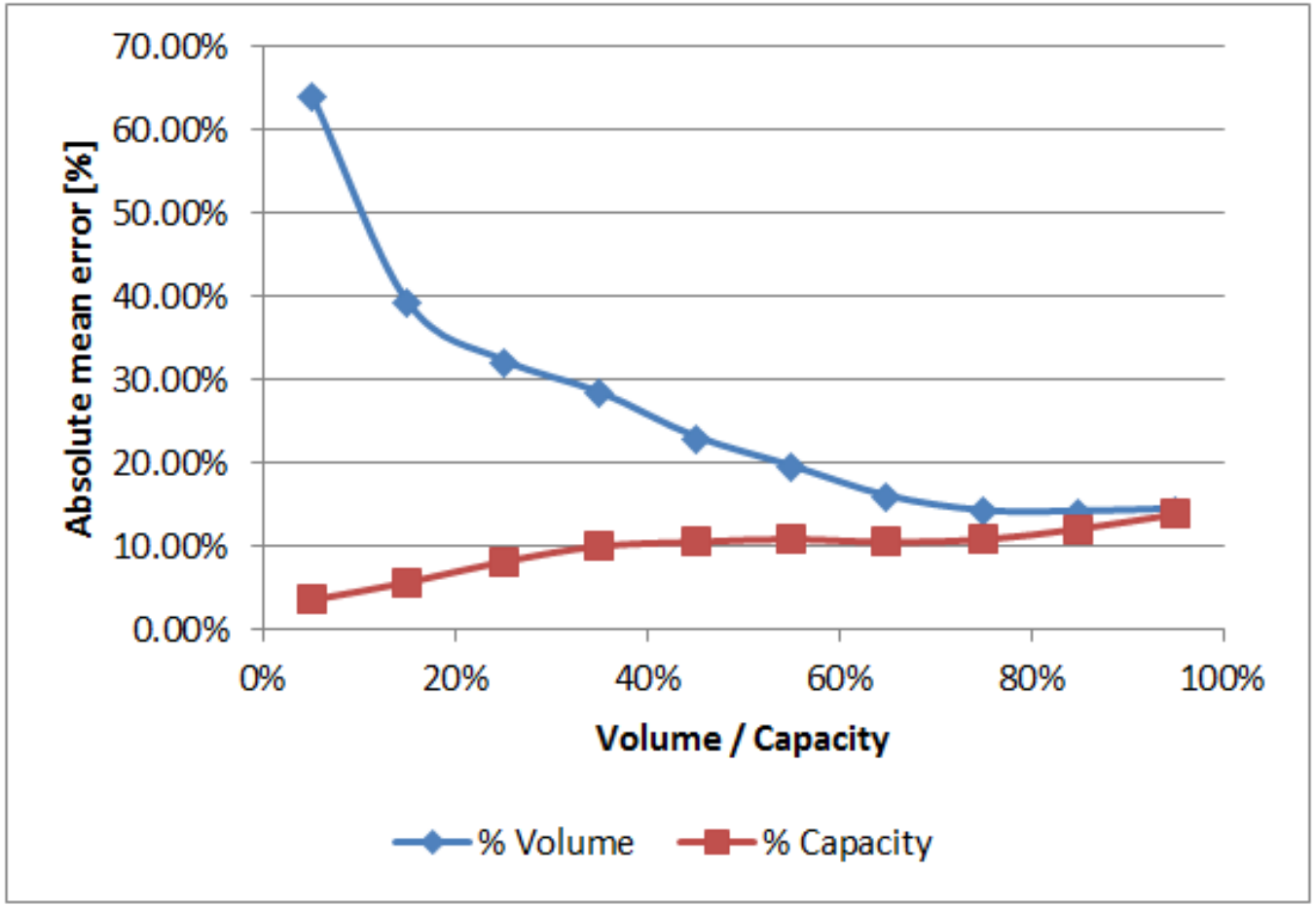
% Capacity (from)	% Capacity (to)	Number of samples	Error	
			% Volume	% Capacity
0%	10%	8348	64.23%	3.46%
10%	20%	7430	39.31%	5.57%
20%	30%	4985	32.31%	8.08%
30%	40%	4899	28.47%	9.92%
40%	50%	5497	23.15%	10.43%
50%	60%	6125	19.64%	10.76%
60%	70%	5818	16.04%	10.41%
70%	80%	6372	14.28%	10.71%
80%	90%	5912	14.17%	12.01%
90%	100%	5394	14.49%	13.74%



From statistics to meaning….

- Results of initial MD analysis – from a **CAPACITY** perspective

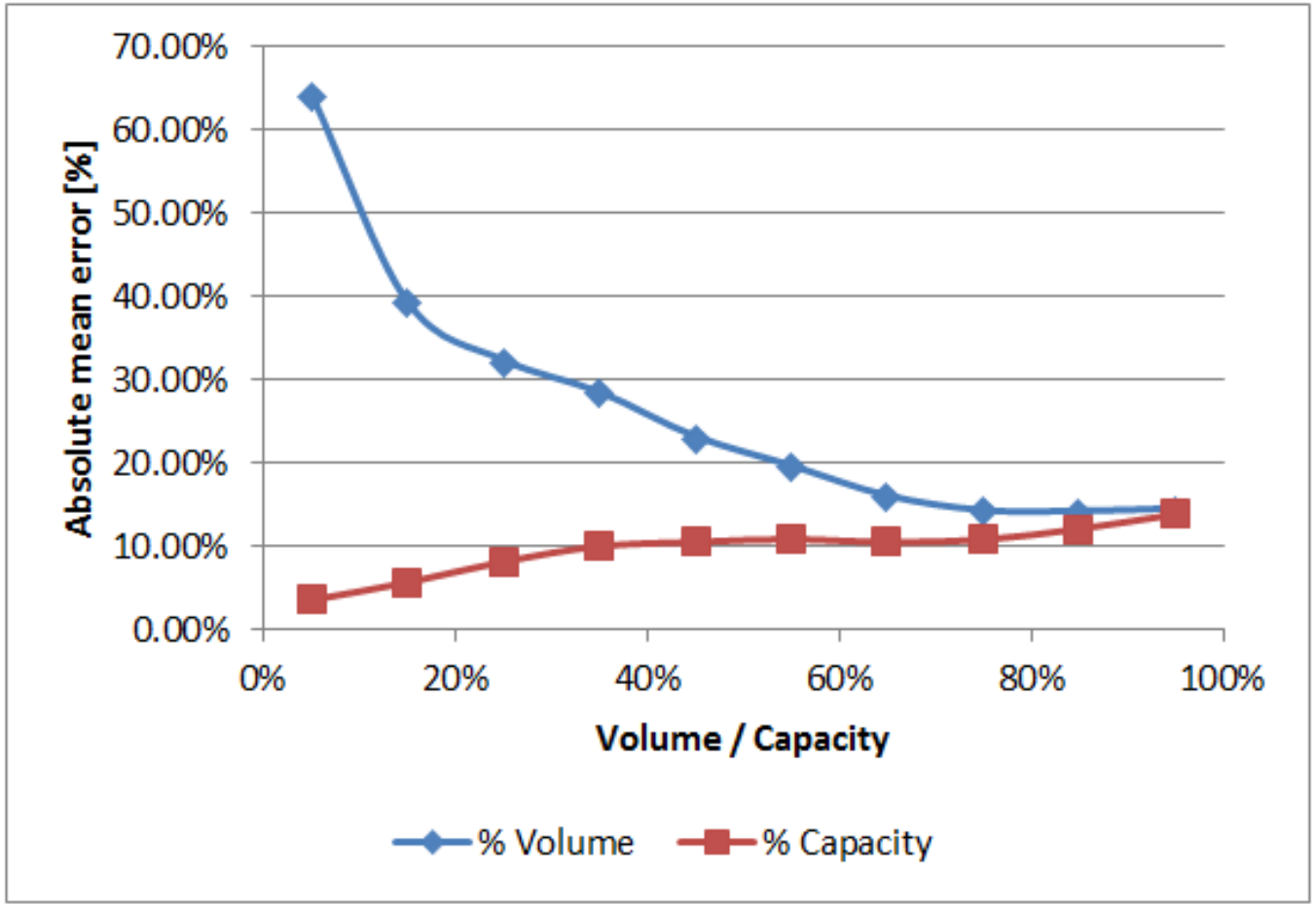
% Capacity (from)	% Capacity (to)	Number of samples	Error	
			% Volume	% Capacity
0%	10%	8348	64.23%	3.46%
10%	20%	7430	39.31%	5.57%
20%	30%	4985	32.31%	8.08%
30%	40%	4899	28.47%	9.92%
40%	50%	5497	23.15%	10.43%
50%	60%	6125	19.64%	10.76%
60%	70%	5818	16.04%	10.41%
70%	80%	6372	14.28%	10.71%
80%	90%	5912	14.17%	12.01%
90%	100%	5394	14.49%	13.74%



From statistics to meaning….

- Results of initial MD analysis – from a **CAPACITY** perspective

% Capacity (from)	% Capacity (to)	Number of samples	Error	
			% Volume	% Capacity
0%	10%	8348	64.23%	3.46%
10%	20%	7430	39.31%	5.57%
20%	30%	4985	32.31%	8.08%
30%	40%	4899	28.47%	9.92%
40%	50%	5497	23.15%	10.43%
50%	60%	6125	19.64%	10.76%
60%	70%	5818	16.04%	10.41%
70%	80%	6372	14.28%	10.71%
80%	90%	5912	14.17%	12.01%
90%	100%	5394	14.49%	13.74%



- The average error with respect to capacity is **9.5**% !!!

Overview of Survey Results

- There is great interest from a planning perspective and for planning applications for all aspects of this type of data.
- Real time volume data seems to have a higher perceived value for incident management monitoring than for traveler information.
- The preferred volume metric was vehicle flow (vehicles per hour) as opposed to percent capacity or vehicle density.
- **The needed level of accuracy for flow data to support anticipated application was to within 10% of roadway capacity.**
- The minimum time interval/aggregation that was recommended was 15 minute intervals for real time, however archived flow data could be longer intervals of 30 minutes to 1 hour.
- An overwhelming additional desirable attribute was the percentage (or volume) of heavy duty trucks.

Additional/Caveats on existing analysis …

- Current 9.5% error with respect to **capacity** ….
  - More data should decrease error
  - Current calculations are with respect to observed maximum capacity …
    Error with respect to theoretical capacity even lower.
- Caveats
  - Current error metric is Average Absolute Error
  - Survey accuracy response may be more aligned with 95% (2- sigma) limit
- Bottom line – we are in the Ball Park … Stay Tuned

New Project One-Pager

I-95 Corridor Coalition Project Profile

› Volume & Turning Movements from Probe Data

A new frontier in probe data and analytics

The I-95 Corridor Coalition is sponsoring research to achieve viable volume and turning movement data through outsourced probe data for both operations and planning purposes. Our primary goal of the project is to ensure that initial product offerings meet practitioner information needs for operations, performance measurement, and planning applications, and that Coalition members understand the fidelity, potential and limitations of such data.

A pioneering project

The I-95 Corridor Coalition was the first to put forth the proposition of providing traffic volumes through outsourced probe data as part of a 2013 **Multistate Corridor Operations and Management Program (MCOMP)** proposal, foreseeing that probe data will ultimately drive many of the operations and planning business processes.

UMD and NREL recognize that the success of this project is critical to broader national initiatives which require quality data to operate and model the transportation system with the goal to optimize for safety, mobility and energy efficiency.

The need for quality flow data

Network wide 24x7 volume data is required to effectively assess user costs, extent of delay, and congestion, and is critical to monitor real-time perturbations to the network resulting from major weather episodes, special events, or traffic incidents. Such data is needed to estimate congestion impact in terms of travel time and delay and their corresponding economic, environmental, and energy impacts.

Turning movement counts which reflect the patterns of vehicle distribution through interchanges and intersections, (the first step in basic origin-destination assessment) are also of key interest. With such information, Coalition members will be able to assess the effectiveness of traveler information in response to incidents or to recognize unusual demand patterns that may result from a special event. This project is being pursued in close coordination and partnership with the leading probe data providers: INRIX, HERE, and TomTom. The ultimate measure of this project's success will be near term availability of viable volume and turning movement products from the private sector.

Our project timeline

Phase 1: Proof-of-Concept (Q1 2017)
Users specifications, theoretical limits, validation methodology, testbed initialization

Phase 2: Product testbed and validation (Q4 2017)
Calibration / validation testbed development, testing historical archive products/concepts, assessment of volume and turning movement data products

Project Objectives

- ✓ 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 expectation 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.

Principal Investigator

Kaveh Sadabadi
Center for Advanced Transportation Technology
kfarokhi@umd.edu

Co-Principal Investigators

Stanley Young
National Renewable Energy Laboratory
stanley.young@nrel.gov

Denise Markow
I-95 Corridor Coalition
dmarkow@umd.edu

I-95 Corridor Coalition Project Profile

› Volume & Turning Movements from Probe Data

Project Value

For many agencies, network-wide volume and turning movement data remain key missing dimensions for complete and actionable situational awareness, accurately assessing transportation system performance and developing targeted, cost-effective mobility projects and programs. Having the ability to easily access and leverage these data (both in real-time and historic) along with probe speed and travel time data, offers these substantial benefits:

- ✓ Improved incident management monitoring and action
- ✓ Enhanced work zone monitoring, impact analysis, and safety
- ✓ Additional insight to anticipate and verify "jam" conditions
- ✓ More accurate user delay cost reporting for weather, sporting or other events
- ✓ Comprehensive special event management with the ability to monitor roadway utilization in event of an emergency evacuation
- ✓ Improved traffic signal system timing management, enabling more cost effective, timely, and accurate updates to signal timing plans
- ✓ More complete after-action reviews
- ✓ Faster problem identification / root cause analysis / project development
- ✓ More accurate system performance evaluation
- ✓ Expanded project / program assessment
- ✓ Advance travel demand modeling accuracy
- ✓ Better address air quality and emissions requirements and energy analysis inquiries

What our members are saying

"Real-time volume data would be of great value to NCDOT, especially for incident and work zone management - including timelier detouring or route diversions – better control of evacuations in the event of a hurricane, and improved special event traffic management."

Kelly Wells
Mobility Program Manager
North Carolina Department of Transportation

"Good quality traffic volume data derived from probes would significantly enhance performance measurement, work zone analysis, and incident management programs, especially for more rural facilities where traditional point detectors are widely spaced."

Michael Fontaine
Associate Principal Research Scientist
Virginia Transportation Research Council

"Having robust estimated volume and turning movement data derived from probe data would be a tremendous asset for DVRPC, complementing the speed and travel time data we're already using from the Probe Data Analytics (VPP Suite) to facilitate analysis of our entire road network, including problem identification, project development, and comprehensive, accurate system performance evaluation."

Jesse Buerk
Senior Capital Program Coordinator
Delaware Valley Regional Planning Commission

"Summer recreational travel is problematic on I-95 along the Maine & New Hampshire border - severe traffic delays regularly occur for motorists traveling northbound on Fridays and Saturdays.

Though NHDOT can calculate average travel times along the corridor to get an idea of minutes of delay, what's missing is the ability to define how many drivers are being impacted by this delay.

Being able to quickly and easily access volume data in real-time would allow for better traffic management planning and execution, the ability to promptly apprise our Executive Office of the highly congested area(s) and give the public timely, actionable information for better travel decision-making."

Susan M. Klasen, PE
TSMO Administrator
New Hampshire Department of Transportation

- On Coalition Website (VPP page)
- Reached out to steering committee for quotes – Thank You
- Need help enunciating anticipated benefits

36 Steering Committee Participation and Feedback

- Proactive in populating test bed data
  - Count data in 15 minute intervals (minimum) with vehicle class
- Comments on initial MD Analysis
  - Insights, suggested direction, balance of light-duty / heavy-duty
- Enunciating the benefits of this project

37

Questions

Wrap Up

Closing remarks

Next meeting/webinar

- Thursday, April 13, 2017
- 10:30a.m. - 12:00p.m. (EDT)
- Agenda
  - **Specifications & validation/calibration methodology**
  - **First look at other data sets**

39

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