



I-95 CC – Volume & Turning Movement Project

Steering Committee Meeting #6

November 9, 2017

Agenda:

	Topic	Speaker
1	Welcome & Project Status Update	Denise Markow, I-95 Corridor Coalition Stan Young, NREL
2	Spotlight Presentation: Traffic Volume Estimation using INRIX GPS traces: Updated Maryland Results and New Datasets	Zach Vander Laan, UMD CATT
3	TTI MnDOT Study Review	Shawn Turner, TTI
4	State DOT Feedback - shaping future direction	Steering Committee members
5	Next Steps & Wrap Up	Stan Young, NREL Denise Markow, I-95 Corridor Coalition

Next Steering Committee Meeting: Thursday, March 8, 2017 (10:30 am – 12:00 pm EST)

Meeting Notes:

- **Welcome – Denise Markow, I-95 CC**
 - Opening remarks and highlighted the year in review
 - User Survey – Complete
 - Preliminary Data Analyses
 - Maryland - Complete
 - Rhode Island – target for next analysis**
 - Florida – target for next analysis
 - Colorado (Denver Area) – complete
 - Calibration (FHWA TMAS)
 - Validation (TTI)
 - Noted that a Lexicon of terms related to the VTM project was distributed to members. It is intended to complement other project deliverables by providing additional detail and background.
- (**Subsequent to the Meeting: Another Coalition member state will replace Rhode Island in the upcoming analysis.)
- **Project Tasks Status Update – Stan Young, NREL**
 - Reviewed the project goals, objectives, and status
 - Stan briefly explained the status of currently available volume data and its limitations. The goal and objectives were reviewed as well as where the effort currently stands related to these objectives.
- **Traffic Volume Estimation using INRIX GPS Traces: Updated Maryland Results and New Datasets- Zach Vander Laan, UMD CATT Lab**
 - Goal: to develop an estimator/model which takes in various sources of data and produces volume estimates
 - The estimator trains on locations with ATRs and aims to be able to predict volumes in locations without ATRs
 - There have been some updates to the estimator since the previous steering committee meeting:



- The estimator now incorporates TTI volume estimates as model inputs
- Included some features from OpenStreetMap
- There have been some updates to the model architecture, but it is still machine learning/artificial neural network (recurrent neural network)
- Added 10 low-volume ATR locations for training
- Data Sources:
 - Same data sources utilized as previous iteration, but model inputs are now different
 - Incorporates four months of INRIX data from 2015 (February, June, July, October) which contains 20 million trips, 1.4 billion waypoints (spaces one second apart)
 - This data is a set of GPS latitude and longitudes and work was required to associate them with the road network (snapping and map-matching)
 - Penetration in this data set is variable
 - TTI volume estimates are highly correlated with ATR counts, GPS volumes, and number of lanes
- Model Structure
 - Previous structure was a fully connected artificial neural network (ANN) and did not use TTI volume estimates as input
 - Now using long short-term memory network (LSTM)
 - The model uses recurrent neural networking but leverages temporal patterns and also incorporates TTI volume estimates (this model can 'remember' certain things like the weather the hour before the data requested)
- Model Evaluation
 - Utilized 44 ATRs for training and one for testing
 - Repeated 45 times for report test
 - Model performance varies by location
 - Error to capacity ratio (ETCR) and error to max flow (ETMF) are better performance measures than R-squared or mean average percent error (MAPE)
- Model Performance Changes with Number of GPS Probes
 - For testing, divided locations into three bins (high, medium, and low probe counts) and calculated error based on each group
 - Higher GPS probe counts give greater model accuracy
 - The newer model is estimated better than the old model and TTI volume estimates (much fewer outliers in low-volume groups)
 - The new model has a 27% average improvement relative to TTI volume estimates and a 17% average improvement relative to the previous artificial neural network model
 - In MD data, GPS probe penetration is 2% but the model performs in the 4-6% ETCR range (where 3% is very good, 5% is acceptable/useful, and <10% is 'beginning to provide value')
- New Datasets
 - Obtained INRIX GPS data from FL
 - Data is already snapped to XD segments which eliminates a lot of effort from the MD set



- FL dataset is much larger than MD dataset, with higher penetration rates (and also have associated ATR data)
- Questions:
 - Daivamani Sivasailam (MWCOG) noted that the current model seems to work better for low volume estimates. Zach Vander Laan concurred.
- **Using Mobile Device Samples to Estimate Annual Average Traffic Volumes in Minnesota (MnDOT Study Review) – Shawn Turner, TTI**
 - Project Synopsis
 - Began 18 months ago
 - Multiple companies were interested but only StreetLight Data provided volume estimates for the study
 - TTI used MnDOT counts as a benchmark for testing – MnDOT planning maintain permanent ATRs and put out temporary ATRs in some locations
 - StreetLight Data used MnDOT ATR data to calibrate their own model
 - Temporary ATR Locations
 - 7,837 locations with 48-hour counts utilized (there is some uncertainty about the accuracy of these short-term counts)
 - The study showed the importance of volume levels on accuracy – the more probes, the more accurate the data (similar to Zach’s findings)
 - Permanent ATR Locations
 - 69 locations with permanent counters utilized
 - Better study results here, though StreetLight Data largely knew the general AADT at these locations
 - This was more of a test of how accurately they could stratify the traffic volumes among the hours in the day
 - The study still showed the importance of volume levels on accuracy even at the permanent locations
 - Non-Public Permanent ATR Locations
 - These locations had count data that was non-public information (StreetLight Data did not know AADT here)
 - Study showed less accuracy than the other 69 permanent locations.
 - StreetLight had to rely on their calibration from other locations which introduced more error
 - Conclusions
 - There is potential here but it’s not quite ready yet
 - StreetLight Data has plans for more granular estimates and refinements to their analytics
 - Some locations were in the 10-20% MAPE range while others were much higher
 - Did not use ETCR (better measure because it incorporates capacity – more probes, better data)
 - MnDOT has generally a planning focus (instead of operations) – they want accurate volumes even at low capacities, which is not ready yet
 - Questions:
 - Stan Young (NREL) asked about a qualitative interpretation of MAPE values. Shawn Turner (TTI) provided a quick breakdown. At lower volumes, 20-30% MAPE is good, 30-40% MAPE is floating outside acceptability, and



40% MAPE is unacceptable. You can scale those errors as you move toward higher volumes (50,000-100,000 AADT) where 5-10% MAPE is great, 10-20% MAPE is in the periphery, and greater than 20% MAPE is unacceptable. When more companies enter the playing field, we'll need something similar to how the Coalition worked with travel time data (provide consensus for contract requirements in validation, testing, or range of quality for full payment)

- **State DOT Feedback – Shaping Future Direction – Stan Young, NREL**
 - Stan noted that the team's goal is to see what they can get out of the data with remaining funding
 - He thanked Colorado DOT, Kansas DOT Planning, Virginia DOT Planning, Operations, and Traffic (Thanks Mena and Mike!) for their input.
 - Top Issues noted among agencies
 1. Off-Freeway Performance (Arterials, Rural Highways)
 2. Performance Characterization (volume, time-of-day, roadway class, congestion level, better statistical measures, confidence measures)
 3. Operationalizing — Looking to identify project-level opportunities going forward
 4. Other:
 - Major Event Impact (e.g. the Eclipse of 2017)
 - Spatial and Time Transferability (how do these models perform in Kansas if they've been calibrated in Colorado?)
 - Min-Maxing Number of Calibration Locations (is there a point of diminishing returns where more calibration doesn't improve model performance?)
 - Heavy Truck Volumes
 - More specific AADT for the planning community (being able to predict average for a Friday afternoon in the spring)
 - Future Work
 - FL dataset – we have the data already
 - NREL is working for CO for non-freeway error characterization, confidence measures, AADT and other aggregate measures (special thanks to CO for sending data less than four hours after requesting it)
 - Establishing future validation framework with TTI and testing it – we need to make it fair for both agencies and the companies providing the data



- **Wrap up – Stan Young, NREL**

- We can only develop spatially ubiquitous, omni-present volume data for both real-time and historic applications in conjunction with traditional continuous counters for calibration and validation. This project is not intended to replace the existing network of high quality count stations, only augment in space and time.
- The evidence from the R&D suggests that probe data is approaching a point to support volume estimation everywhere and at all times.
- Challenges for the future:
 - Variation in penetration rates (8-12%) presents issues
 - The Colorado results indicate that the calibration data set must span the full range of volumes expected to be experienced on the network. Or in other words, calibration data sets have to have a large breadth of conditions.
 - Large fluctuations in estimated volume along a roadway are a concern, and are being investigated
 - Making a constrained model will require more research/considerations

- **Closing Remarks & Discussion – Denise Markow (I-95 Corridor Coalition)**

- Denise thanked all members for their participation and reminded them about the **next steering committee meeting - Thursday, March 8, 2017 (10:30 am – 12:00 pm EST)**
- Final Questions/Discussion
 - Shawn Turner (TTI) and Mena Lockwood (VDOT) had a lengthy discussion about the future of the project and ubiquitous volume data. Some highlights:
 - StreetLight Data maintains an online beta analytics tool – they are the only provider that has publicly offered for their data to be tested. Other companies put out estimates but the accuracy was questionable and they revoked that data. This project is trying to bridge DOT expectations with commercial availability. DOTs may be looking for 10% error even at low-volumes before they start accepting 3rd party data.
 - Shawn noted that there is a lot of similarity between volume estimates now and travel time estimates 10 years ago so we should apply the same process. We should start with freeways and then follow a similar implementation pathway.
 - We have some low confidence in temporary data collection sites the same way we do with floating-car travel time runs to validate 3rd party travel time data
 - Wenjing Pu (FHWA) noted that requiring both high-resolution temporal and spatial data may actually be hindering in some senses as having high-resolution of one limits the resolution of the other at this point. Shawn Turner (TTI) agreed and added that right now there's decent results on day-by-day estimates rather than hour-by-hour estimates. He noted that this may be the path of least resistance for implementation – this may appease planning department expectations.
 - Tianjia Tang (FHWA) asked about how changing penetration rates for GPS probes gets incorporated into the volume estimator. Shawn



Turner (TTI) noted that the permanent ATR count locations form the basis on which other scaling factors (including GPS probe penetration) are scaled. Stan Young (NREL) noted that each company has different penetration rates (and they increase in large chunks with major upgrades like a recent TomTom deployment). The key is to create a calibration/validation framework so that large jumps in penetration rate can be tested more quickly and efficiently.

- Wenjing Pu (FHWA) asked if there were plans to test the model on data outside the 45 permanent ATR locations. Zach Vander Laan (UMD CATT) noted the future testing in the FL data. Stan Young (NREL) noted that the original plan possibly included some tube counts but that was out of scope – but may appear in the next phase as a consideration so that all 3rd party providers play by the same rules (ground truth estimates would be independent of vendor estimates, etc.)
 - Tianjia Tang (FHWA) noted that FHWA is very interested on this effort as they don't have interest in putting ground sensors for a variety of reasons.
 - James Li (MWCOCG) asked about the reliability/accuracy of the 45 permanent ATR locations. Zach Vander Laan (UMD CATT) noted that these are considered ground truth but there is consensus that if an ATR is providing bad data it does affect the model negatively. Currently they prune data that is the result of an obvious malfunction. Stan Young (NREL) noted that in discussions with Colorado DOT Planning, they've noted some anomalies with their permanent ATRs, especially as speeds decrease due to weather or congestion. Right now, there's no formal approach to validating the permanent ATRs. Steven Jessberger (FHWA) noted that there are various issues with volumes and classification at low volumes and low speeds and that video counts are crucial to help verify ATR counts.
 - Denise thanked the group
- **POLL Results**
 - #1 - What is the most important priority for remaining research?
 - Results for non-freeway, low-volume roads – 5/13 (39%)
 - Better characterization of when/where the process works well and where it does not – 4/13 (31%)
 - Development of a confidence metric – 2/13 (15%)
 - Estimate AADT, and other tradition aggregate measures – 2/13 (15%)
 - # 2 - What is the next step to operationalize the results?
 - A collective effort at the Coalition level – 6/13 (46%)
 - Direct state effort (early adopter) – 2/13 (15%)
 - Project level initiative – 5/13 (39%)



Presenter Contact Info:

Real-time Volume Estimation - Denver Area:
Zachary Vander Laan, UMD CATT Lab zvanderl@umd.edu
Validation Framework:
Shawn Turner – Texas A&M Transportation Institute (TTI) s-turner@tti.tamu.edu
Project Contact Info:
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 Logistics – Justin Ferri (KMJ Consulting, Inc.) 610.228.0759 or jferri@kmjinc.com

Action Items:

#	Action Item	Whom	Status
VTM Steering Committee Meeting – July 27, 2017			
1	I-95 Corridor Coalition and Stan Young (NREL) to follow up with FHWA about FHWA’s interest in the VTM project as it moves to Phase 2.	Trish Hendren	FHWA meeting is being scheduled for mid-December
Previous VTM Steering Committee Meetings			
2	DOTs willing to submit traffic count data for validation (specifically continuous traffic counter data shortly after it is collected and prior to publishing to public) should contact Shawn Turner, TTI	Member agencies	



Participants:

Project Team:
Denise Markow, Patricia Hendren, I-95 Corridor Coalition Stan Young, NREL Kaveh Sadabadi, UMD CATT

Steering Committee:	
Erik Sabina	Colorado DOT
Steven Jessberger, Wenjing Pu, Tianjia Tang	FHWA
Paul Tanner	Georgia DOT
Amy Lopez	INRIX
Abhay Nigam	MDOT SHA
Daivamani Sivasailam, James Li	MWCOG
Sutapa Bandyopadhyay	NJTPA
Yi Hou	NREL
Scott Benedict	Pennsylvania DOT
Stephanie Molden	Port Authority New York & New Jersey
Michael Dennis	South Carolina DOT
Nick Cohn	TomTom
Shawn Turner	TTI
Mena Lockwood, Michael Fontaine	VDOT
Zach Vander Laan	UMD CATT
Ed Strocko	USDOT - BTS
Consultant Support Staff:	
Joanna Reagle, Justin Ferri, KMJ Consulting, Inc.	