REVEAL: Real-Time Volume Estimates from Probe Traffic Data

State of the Industry and Recommendations for the Eastern Transportation Coalition Transportation Data Marketplace

Final Report

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This report characterizes the state of the industry to achieve real-time volume estimates from probe-based data sources in order to support various operations applications. The report makes recommendations for incorporating and encouraging continued development and refinement of real-time traffic volume and supporting applications within The Eastern Transportation Coalition Transportation Data Marketplace.

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Executive Summary

This report characterizes the state of the industry to achieve real-time volume estimates from probe-based data sources in order to support various operations applications. Volume estimation from non-sensor-based methods offers the opportunity to scale geographically much in the same way that travel time and speed measures have been revolutionized by probe data beginning in the mid 2000's. Travel time estimates on signs, performance metrics, and situational awareness at traffic management centers were once lacking in data that comprehensively characterized congestion across the entire network. Such applications had to rely on a network of video cameras (pre-artificial intelligence), sensors, direct feedback from the public in terms of hotlines or 911, and even 'eyes in the sky' from local traffic reporting. In the mid-2000s, that began to change when the proliferation of telematics with GPS technology-enabled vehicle probe data began to scale first to freeways, then to major arterials, and now nearly saturates the entirety of the public roadway network. While travel time and speeds provide information on the speed of the traffic flow, volume information at scale and in real-time remains lacking.

The Eastern Transportation Coalition (TETC) has been highly active in the development of technology and uses cases for probe-based volume information. In approximately 2010, as travel times and speeds from probe-data were beginning to scale across multiple states, several transportation systems management and operations (TSMO) professionals observed that large scale shifts in travel behavior were being revealed through speeds and travel feeds during major weather events such as blizzards and hurricanes. The speed and travel time data along with the confidence score allowed traffic professionals to infer traffic flow on the roadway to a crude level of accuracy. This spawned the idea that volume measures may be possible through probe vehicle data. At that time probe source data was growing at a steady pace, doubling approximately every 18 months.

In 2013, TETC proposed a research project through the Multistate Corridor Operations and Management Program (MCOMP) to determine if volume could be estimated through probe data, and if so, to what level of accuracy. The research grant that was awarded was used to develop the foundational statistical science (based on emerging artificial intelligence and machine learning technology) that much of the current-day volume estimation techniques utilize. Further, in 2020, TETC funded a project to demonstrate these methods at scale across five southeastern states using the then-emerging connected vehicle data from OEMs marketed by Wejo. This demo provided proof positive of the capability to monitor volumes in real time using probe data, while also exposing the significant big data management challenges that remained.

More recently, the Model Inventory of Roadway Elements (MIRE) reporting requirement for DOTs stirred discussions of alternative ways to estimate Annual Average Daily Traffic (AADT) for federal reporting. This resulted in a USDOT pooled fund initiative to investigate 'non-traditional methods for assessing AADT for MIRE reporting requirements, which spurred the development of various industry products to provide planning level volume measures. In 2022 the Coalition incorporated volume measures in its Transportation Data Marketplace (TDM), resulting in over five firms providing planning level volume measures informed by vehicle probe data. Even though the TDM invited proposals for real-time volume data and associated applications as part of the 2022 TDM, no vendor responded with products at that time. Now in 2025, three years into the third phase of the TETC TDM, this REVEAL project examines the status of industry to begin to provide real-time volume data, the need for such data for TSMO applications, and the pathway toward achieving this capability.

This report begins by tracing the key and pivotal initiatives (briefly outlined above) contributing to the development of probe-based volumed estimates both for non-real time (referred to as planning level volume estimates) and real-time TSMO applications. It then provides evidence from validation activities by the Coalition of current industry capacity to report day and time-specific volume reflecting atypical volume measures caused by incidents, events or severe weather. The validation results showed that industry is on the cusp of being able to provide broad-based, geographically scalable volume monitoring with sufficient accuracy to support TSMO applications – though not yet in real-time. The report also provides a synopsis of an assessment conducted by the Florida Department of Transportation (FDOT), a Coalition member agency, in late 2024, which focused on emerging intersection real-time volume tools (a tool currently available through the TDM as an ancillary product). The FDOT assessment, similar to the validation, indicates industry is nearing the capability to deliver volume data from probe sources for real-time intersection and corridor management applications.

A survey of Coalition members revealed that the leading applications producing market demand for highly granular, real-time volume can be organized into three broad categories. These include: (1) operations performance measures, (2) turning movement counts at signalized intersections, (3) atypical volume flows resulting from major incidents, events, severe weather, and construction zones. Interviews conducted with vendors providing volume products to the transportation industry re-affirmed the feedback from members with respect to leading applications, and these interviews also provided additional insight on industry capacity and constraints. Several vendors are positioned to begin providing probed-based volume estimates in either real-time (such as 5-minute, 15-minute or 60-minute latency) or near-real-time (24-hour to 48-hour latency). However, the ability to provide real-time volume estimates at a state-wide or national level remains technically challenging due to varying probe penetration rates across geographies combined with uncertainty of market demand. Current industry capacity for real-time volumes exists for specific corridors, intersections or regions, on roadways with significant vehicle flows. In these situations, relative volume measures (the percentage of observed probe vehicle observations relative to nominal conditions) can be provided in the near term, while absolute volume estimates remain challenging, but technically achievable at limited scale. Initial products are emerging and can be tested, although the market demand for real-time volume data remains uncertain. An evolutionary path to such products, customized to high priority TSMO applications, that allows DOT's to 'try before they buy' is recommended.

As a result of the findings in this report, the Coalition makes the following general observations.

- Volume estimations for planning measures such as AADT, ADT, and AHDT are available from multiple vendors, and the quality appears to be maturing quickly based on TETC validation results. These products are finding a market, primarily for planning functions, which continue to drive investment by the industry.
- High granularity volume data is emerging and is currently tested as part of the TETC validation (though not delivered in real-time), but the maturity of these products and ability to be refined to productive applications is still in development.
- Application specific real-time volume estimation for signalized intersections and integrated corridor management are beginning to emerge as witnessed by the Florida assessment. This capability is consistent with the vendor feedback that real-time volume at limited geographic scope for specific corridors and applications can now be considered.
- Broad based volume monitoring for all state highways (similar to how state DOTs are accustomed to ingesting travel time and speed data) is not available on the market at this time, though evidence points toward technical feasibility in the near future as data

supply chains mature. The current variability in probe penetration rates presents significant technical challenges for broad-based scaling AND uncertainties in demand for such a data product on a large geographic scale also limits development initiatives at this time.

This report makes the following recommendations for incorporating and encouraging continued development and refinement of real-time traffic volume and supporting applications within in the Eastern Transportation Coalition Transportation Data Marketplace.

- The Coalition should continue volume validation activities (currently once yearly), rooted in planning level measures, but ever evolving to more granular and time dynamic measures as evidence in the market reveals capability.
- The Coalition should provide opportunities for new products/vendors to participate in the validation activities with respect to real-time volume products and applications and subsequently outline the method for inclusion in the marketplace if technical capacity is demonstrated.
- The Coalition is well positioned to provide market education in an unbiased, neutral manner such as webinars and symposiums. Such events would not only provide opportunities for vendors to characterize current capability but also help to normalize/standardize the vocabulary with respect to volume estimation. The latter helps to avoid market confusion, allow DOTs to 'sort out the market', and come up the learning curve quickly and efficiently.
- The Coalition should use validation activities to help determine reasonable guidelines for the technical parameters for the delivery of real-time volume such as aggregation times and latencies needed to support various TSMO applications.
- The Coalition should encourage DOTs to 'dip their toe in the water' with respect to these emerging capabilities through technical support by the Coalition staff as well as appropriate pricing mechanisms in the TDM that allow for 'try before you buy' approaches.

Table of Contents

List of Acronyms

AADT – Annual Average Daily Traffic
ADT – Average Daily Traffic
AHDT – Average Hourly Daily Traffic
CCS – Continuous Count Station
CVD – Connected Vehicle Data
DOT – Department of Transportation
FDE – Fundamental Data Elements
FDOT – Florida Department of Transportation
FHWA – Federal Highway Administration
HEIDI - High-definition Engineering Intersection Data via Integrative modeling
HPMS – Highway Performance Monitoring System
HSIP – Highway Safety Improvement Program
MAP-21 – Moving Ahead for Progress in the 21st Century Act
MCOMP - Multistate Corridor Operations and Management Program
MIRE – Model Inventory of Roadway Elements
NFAS – Non-Federal Aid System
REVEAL - Real-Time Volume Estimates from Probe Traffic Data
STC – Short Term Counter
TDM – Transportation Data Marketplace
TETC – The Eastern Transportation Coalition
TSMO - Transportation Systems Management and Operations

Introduction

"Real-time volume data at scale remains the key missing dimension in operations data with the potential to greatly improve the accuracy of assessing transportation system performance and improving management. Although agencies have invested in fixed sensors, volume data remains relatively sparse and of varying quality on the majority of the freeway and major arterial networks. Anticipated volume, a by-product from factoring of Highway Performance Monitoring System (HPMS) data, remains the state-of-the-practice in assessing performance measures involving user cost, emissions, and energy efficiency network wide. However, factored volumes do not reflect atypical traffic conditions induced by major weather episodes, major incidents, special events, or major road construction. Quality volume data is required to effectively assess user costs, assess extent of delay and congestion, detect real-time perturbations to the network, understand traffic density during major weather events such as blizzards and hurricanes, dynamically adjust traffic signals, and to estimate congestion impact in terms of travel time and delay and their corresponding economic, environmental, and energy impacts. The cost of collecting accurate high-quality volume data with traditional infrastructure sensors remains prohibitively expensive despite advances in sensor technology. A sensor approach would require sensors to be installed approximately every 1 to 5 miles on the transportation network. Deriving real-time volume data from probe-based sources provides a cost-effective means to leverage existing continuous count stations to scale vehicle observations from commercial probe data for network-wide, 24x7x365 accurate volume estimates."

The above description was paraphrased from material prepared in the 2014-15 timeframe for an MCOMP grant application and was altered minimally to reflect where industry stands today. This effort in the REVEAL project marks the next step in the Coalition's leadership to make highly granular, real-time volume estimates from probe data a reality.

The Eastern Transportation Coalition (TETC) has been a national leader in research and demonstrating the feasibility of volume estimates from outsourced probe data. As a result of such initiatives, historical volume estimates are now available through the TETC Transportation Data Marketplace (TDM) as of 2022 when the 3rd phase of the TDM was instituted. The current TDM now contains various planning level volume estimates such as Annual Average Daily Traffic (AADT), Average Daily Traffic (ADT), and Average Hourly Daily Traffic (AHDT). The TDM also contains estimates of daily and hourly volumes for a specific roadway at a specific time – though not in real-time. Evidence from research conducted by TETC and others, as well as the TETC's Southeast States Hurricane Evacuation Monitoring pilot point toward the viability of acquiring real-time volumes from probe data to support a variety of TSMO applications.

The objective of this REVEAL project is to move this concept to the next level by assessing the state of industry -- both the technical capacity to produce such volume information to an acceptable level of quality, as well as the demand for such data from practicing traffic operations and traffic signal engineers within departments of transportation. The technical capacity is accomplished by testing existing data as part of the TDM validation program, focusing on the ability to support highly granular volume estimates (hourly) to measurable levels of accuracy during atypical traffic situations. Though current data is not delivered in real-time, this activity tests if the current probe data supply chains are sufficient to detect perturbance in volume. Additionally, and fortuitously, an assessment of real-time turning movement counts performed in late 2024 by the Florida DOT provides evidence of the ability to deliver such data in real-time. The market demand for volume estimation is assessed through stakeholder interaction. A survey was conducted with Coalition members to discern TSMO applications' needs. Interviews with vendors supplying first generation volume estimation products were also conducted.

The information from these tasks informed recommendations to the Coalition for fostering continued maturation of this technology leading toward integration of real-time volume estimates and associated products into the TDM. The first generation of travel time and speed data product from probe-based sources was met with latent demand to accelerate adoption. The market path to real-time volumes differs in nature and must be rooted in the applications it enables. Availability of real-time traffic volumes can support a variety TSMO applications such as traffic signal management and timing, integrated corridor management, ramp metering operations, special event management, work zone management, major event (such as hurricane) management, operations performance metrics, and incident response just to name a few. Survey of Coalition members helped to prioritize and rank the applications with the greatest potential for improvement.

The scope of this project includes (1) documenting current industry capacity as well as previous research and development work toward real-time volumes, (2) testing current data feeds for technical ability to reflect volume fluctuations on specific roadways and report in real-time, (3) identifying key issues (both technical and non-technical) that need to be addressed in order to provide real-time volume estimation products in the TDM, and (4) making recommendations to the Coalition to address these issues. The output of this work will inform development of extensions/additions to the current TDM to encourage development and maturation of real-time volume data and applications.

Background and Relevant Literature

The pursuit of real-time volume estimation from probe-based data sources can be traced to significant initiatives and milestones dating from the early 2010s. At that time, probe-based travel-time and speed data was maturing quickly and the quantity of probe data observations in the supply chain were doubling approximately every 18 months. TSMO practitioners were gaining confidence in the data and using it for a number of real-time applications such as travel time on changeable message signs, situational awareness of network congestion within Traffic Management Centers, and incident detection to name a few. The ability of probe data to observe major weather-related regional traffic phenomena such as major winter storms and hurricanes provided initial evidence of the potential of probe data to not only report travel time and speed related information, but also to detect when travel volumes plummeted and thus infer a crude estimate of volume.

Inferences of Traffic Volume from the TDM Travel Time and Speed Data ~2012

TDM requires reporting to be not only speed and travel time, but also a confidence indicator. The confidence indicator reflects if sufficient real-time data is available to produce a statistically significant and accurate estimate of roadway speed and travel time, or whether base probe data is lacking (in quantity). In the event of insufficient data, travel time and speed are typically inferred from free-flow travel speed, or the prevailing speed limit on the roadway. Confidence in travel time and speed data was coded as a 10, 20 or 30. A 30 indicated that there was sufficient real-time probe data to accurately infer travel time and speed from probe data. A 10 indicated that such data was lacking and the system was reporting a speed and travel time based on free-flow assumptions (or the posted speed limit). A 20 indicated that some data existed but was augmented with free-flow inferences. Under normal roadway operations (when no weather or major incidents or events impacted traffic) the confidence indicator correlated with the time of day. During normal daylight hours (for example 7 AM to 10 PM), the confidence was typically very high, with mostly 30s as a confidence score. After 10 PM, the confidence score would begin to revert to primarily 20s and then 10s by midnight. From midnight to 4 or 5 AM, the confidence score would remain at a 10, and the corresponding reported speed and travel-time was based on assumptions of free-flow traffic conditions rather than on observed data. In the early morning, the process would reverse and by 7 AM, a confidence score of primarily 30 would be achieved and sustained in the traffic data feed. An example of this is shown in the Figure that follows. The confidence score was a pseudo-measure of low traffic conditions. [Note, the exact definition of confidence score or confidence indicator varies by vendor and has evolved over time. The reader is referred to vendor specific literature for current definitions. The description above is consistent with the use of the confidence indicator during the first phase of the TDM, circa 2012.]

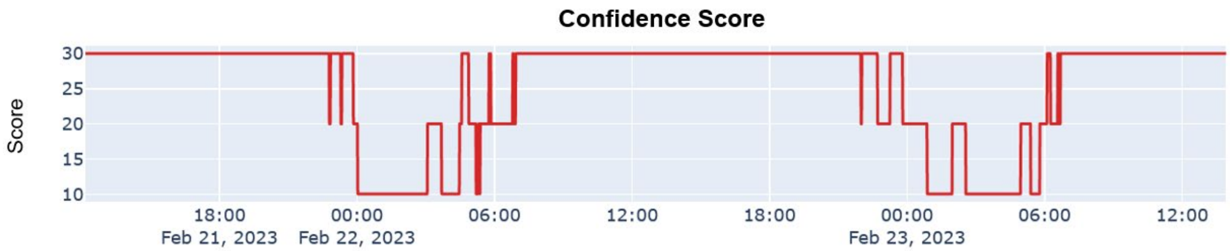

Figure 1: A 24-hour plot of confidence scores that accompanies travel time and speed data within the TDM

At that time, it was observed that during major winter storm events, the confidence score served to provide an indicator of traffic density. A major winter storm producing significant quantities of snow such that authorities either closed roadways (officially) or that conditions dictated that drivers stay home from work, school or other activities were reflected in the confidence score. If traffic became so sparse or low due to winter travel conditions, the confidence score behaved similarly as an overnight period. At the onset of a major winter storm, the subsequent deterioration of roadway conditions was reflected first in a decrease in speed of the facility, and then the confidence score would begin to reduce from 30s to 20s to 10s, reflecting a significant decrease in traffic volume. During the peak of the storm and while road crews were busy recovering, the confidence score remained at 10 due to lack of vehicles on the roadway. As the roads were cleared and travel recovered, the confidence score would eventually return to 30s, indicating a return to normal roadway operations. The use of the confidence score, originally developed to flag time periods during which not enough base probe-data was available to confidently report the speed of the traffic stream, was being used as a pseudo volume indicator reflecting when roadway conditions were so extreme that it prevented normal travel. The phenomenon was researched as a means to monitor the impacts of extreme weather events across an entire network and the time it took to return to normal roadway operations.[1] An example of this is shown in Figure 2 below.

[1] "Estimating Winter Weather Road Restoration Time Using Outsourced Traffic Data: Three Case Studies in Maryland" [Conference Paper], E Sharifi, S Young, T Jacobs, S Rochon, Transportation Research Board Annual Meeting, January 2014 [Paper# 14-2996]

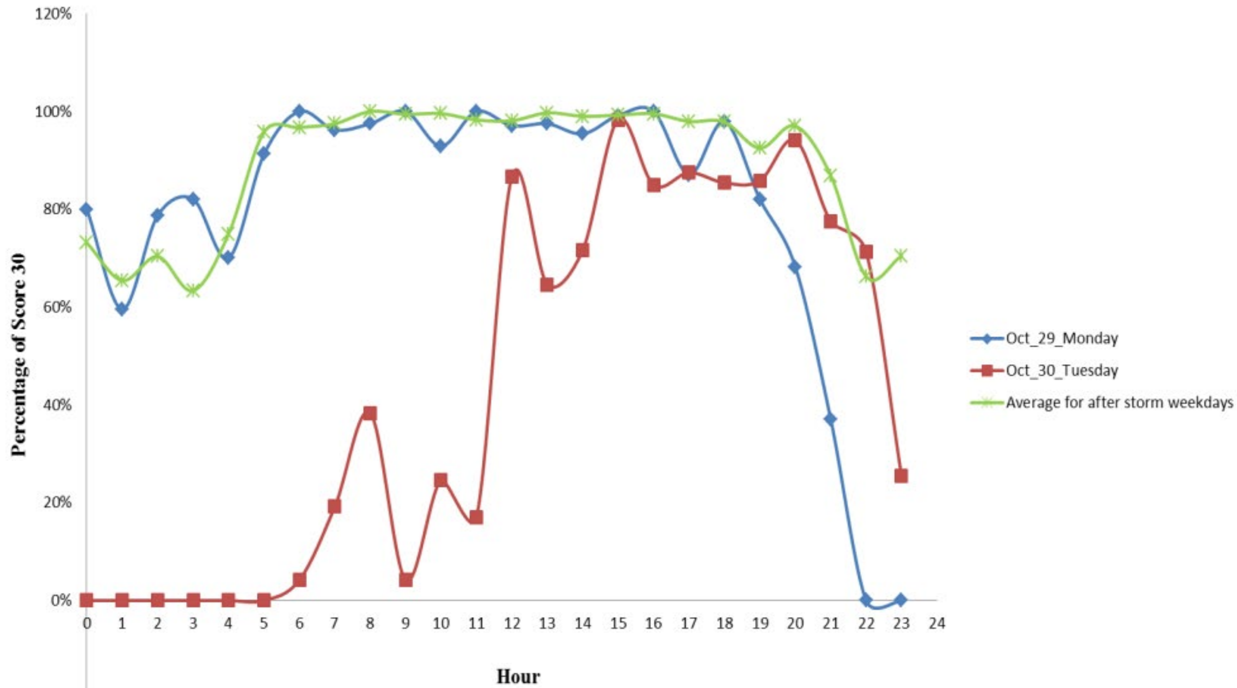

Figure 2: Example of the behavior of the confidence score during a major winter event on I-68 in Maryland[2]

At a multi-state scale, the same phenomenon, that of decreased speeds and changing confidence scores, provided a method to monitor the impacts of hurricanes and blizzards on the eastern seaboard as the wind, rain and snow significantly impacted the number of travelers that were on the roadway.

As a result of these observations, a few researchers and practitioners began to investigate if accurate volume estimates could be produced from probe-based data at all times, going beyond the pseudo volume estimates derived from confidence measures indicating extremely low traffic volumes. This began a series of inquiries, research and demonstrations that informed the requirements and capacity of vehicle probe data to deliver a real-time traffic data product.

2015 -2018 Initial Research in Viability and Requirements of Probe-Data to Estimate Volumes

The first major research initiative was funded as part of a 2013 MCOMP grant awarded in 2015. The research resulted in a 2018 publication[3] for ITS World Congress that characterized the feasibility of the process. The objective of the research is best summarized by the abstract …

> *This [2018] paper examines the feasibility of using sampled commercial probe data in combination with validated continuous counter data to accurately estimate vehicle volume across the entire roadway network, for any hour during the year.*

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[2] https://cattworks.org/wp-content/uploads/2015/08/winter-weather-analysis-elham-edit.pdf

[3] Young, Stanley E., Kaveh Sadabadi, Przemysław Sekuła, Yi Hou, and Denise Markow. 2018. "Estimating Highway Volumes Using Vehicle Probe Data – Proof of Concept: Preprint." Golden, CO: National Renewable Energy Laboratory https://www.nrel.gov/docs/fy18osti/70938.pdf

> *Currently both real time and archive volume data for roadways at specific times are extremely sparse. Most volume data are annual average daily traffic (AADT) measures derived from the Highway Performance Monitoring System (HPMS). Although methods to factor the AADT to hourly averages for typical day of week exist, actual volume data is limited to a sparse collection of locations in which volumes are continuously recorded. This paper explores the use of commercial probe data to generate accurate volume measures that span the highway network providing ubiquitous coverage in space, and specific point-in-time measures for a specific date and time. The paper examines the need for the data, fundamental accuracy limitations based on a basic statistical model that takes into account the sampling nature of probe data, and early results from a proof-of-concept exercise revealing the potential of probe type data calibrated with public continuous count data to meet end user expectations in terms of accuracy of volume estimates.*

This research initiative concluded with the following findings summarized below:

- Initial applications, referred to as use cases, were identified that would benefit from real-time volume data. These included:
    - *Management of major events and traffic incidents*: Real-time volume flows would greatly benefit situational awareness. Broad-based volume flow data on various facilities would provide objective understanding of the impact during such events.
    - *Monitoring road closure and clearance of major events*: During events or weather that diminish roadway volume, it remains problematic to determine from probe-based data if the roadway is closed, extremely slow, or simply absent of demand (volume of vehicles). Augmenting real-time speed and travel time with flow (volume or demand) estimates would provide the additional dimension to better resolve such situations.
    - *Accurate Operations Performance Measures*: Real-time volumes, together with speeds, can be used to calculate real-time user delay costs which can be important to convey performance to management and elected officials.
    - *Diversion Routes during Incidents*: Volume flows and turning movements in the form of diversion paths from nominal would aid in understanding traffic diversion during incidents, predicting flows on adjoining roads, and possibly providing better traveler information on which alternate routes to use.
    - *Impact of Traveler Information on Diversion Routes*: Volume data provides a means to assess the effectiveness of traveler information such as changeable message signs (CMS), improving understanding of the relationship between message content and diversions.
    - *Volume Heat Maps*: Understanding Utilization of Existing Capacity: Monitoring diversion of traffic from one facility that is experiencing an incident to another facility can overwhelm capacity on the diversion route.

Understanding volume flows relative to capacity, and locating under-utilized capacity is essential to further operations effectiveness.

  - *Signal Timing Applications*: The availability of reliable volume data during non-recurring conditions would be a valuable resource for determination of effective signal timing to be used to address the non-recurrent congestion.

- A survey of agencies, the majority of which were Coalition members, resulted in the following insights. Some selected highlights of the survey response from 2017 include:
  - There is great interest from a planning community with respect to volume data from probe resources – though this data is not needed in real-time.
  - Real-time volume data has higher value for incident management 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 begin to support anticipated applications was to within 10% of roadway capacity.
  - The minimum time interval/aggregation for real-time was from 15-minute intervals, though 30 minutes to 1-hour intervals could support some applications.
  - An additional desirable volume attribute was the percentage (or volume) of heavy truck traffic.
  - With respect to turning movements, accuracy to within 10% is needed to begin to support traffic signal applications, reported at 15-minute time aggregations.
- The estimated accuracy of probe-based volume data was assessed as a function of the probe penetration rate (also referred to as sampling percentage), time aggregation, and base traffic volume. The chart below reflects percentage error defined as the ratio of the binomial standard deviation (based on flow rate, reporting interval and sampling percentage) to the volume flow. This analysis was based only on observed probe volumes and using a simple factoring method to estimate volume. It did not include any supplemental data such as time of day, day of week, weather conditions, number of lanes, etc. -- attributes that would be useful for typical volume patterns, but less so for characterizing atypical volumes.

Table 1 : Estimated Accuracy of Real-Time Volume

	Time Aggregation (minutes)	Volume (vehicles/hour)						
		100	500	1000	1500	2000	3000	5000
5% Sampling	15	87%	39%	28%	23%	19%	16%	12%
	30	62%	28%	19%	16%	14%	11%	9%
	60	44%	19%	14%	11%	10%	8%	6%
10% Sampling	15	60%	27%	19%	15%	13%	11%	8%
	30	42%	19%	13%	11%	9%	8%	6%
	60	30%	13%	9%	8%	7%	5%	4%
25% Sampling	15	35%	15%	11%	9%	8%	6%	5%
	30	24%	11%	8%	6%	5%	4%	3%
	60	17%	8%	5%	4%	4%	3%	2%
50% Sampling	15	20%	9%	6%	5%	4%	4%	3%
	30	14%	6%	4%	4%	3%	3%	2%
	60	10%	4%	3%	3%	2%	2%	1%

- An initial technical proof of concept was conducted with available data probe data. This earliest known technical proof of concept resulted in the following:
  - GPS trace data from 12 locations coinciding with continuous count data on freeways within the Baltimore-Washington region were used with penetration rates (sampling) ranging from 0.18% to 0.72% with median of 0.57%.
  - The average hourly observed samples (vehicle traces that passed the 12 reference stations every hour) varied from 22.3 to 62.3 vehicles with median of 37.3 vehicles. [Note, the approximate daily traffic on these freeways varied roughly from 40,000 vehicles per day up to 110,000 vehicles per day.]
  - Additional data such as speed, road characteristics (i.e., type of the road, number of lanes, speed limit), incident reports (i.e., work zones, collisions) and weather info (i.e., temperature, humidity, visibility, precipitation) were also included in the machine learning model for volume estimation.
  - The model performance resulted in R^2 values from 0.61 to 0.94, with median of 0.82. Mean Absolute Percentage Error (MAPE) varied from 14% to 48% with median of 27%. Note this study encompassed periods that contained both typical and a-typical volume patterns, with typical volume patterns dominating. The model included many additional attributes than just probe observation counts and was able to obtain accuracies in the 14% to 48% range with just 0.57% penetration rate. In

comparison to Table 1, which takes into account only volume flows and penetration rates for estimating volume for a-typical conditions, the results were impressive. These early results pointed toward viable initial use of probe data for developing estimated volumes for planning level applications in which typical volume patterns were the objective.

- In order to demonstrate the contribution of probe data samples to the accuracy of volume, a model was constructed without utilizing the probe samples. The results showed that R^2 varies from 0.49 to 0.90, with the median of 0.73. Similarly the error MAPE varies from 16% to 54%, with the median of 37%. The reduction in goodness of fit parameters and increased in error metrics without probe data samples reinforced the hypothesis that probe data counts were a critical source for predicting volumes. However, even without probe data counts, the model was able to predict volumes effectively. This was due to the highly predictable nature of traffic volume by time of day and day of week on such facilities. This early study did not attempt to separate typical volume demand from a-typical volumes that may be experienced during inclement weather or special events.
- Model performance with respect to roadway capacity (rather than absolute volume) was assessed with respect to deciles of roadway capacity. The results showed a range of error between 3.5% to 13.7(%, with an average of 9.5%. The accuracy of volume estimation even in this early proof of concept was able to meet the stated preferred level of accuracy by respondents in the survey, which is within 10% of roadway capacity.

This initial proof of concept was followed by additional research on various other data sets using a variety of machine learning and AI modeling techniques and various industry available source data. The research resulted in multiple technical papers and presentations which formed the basis for future work. The efforts funded by the MCOMP grant marked the earliest and most significant academic research work into the technical feasibility and usefulness to transportation practice of probe-based volume estimates.

2020 TETC Hurricane Proof of Concept Demonstration

In 2020, TETC launched an ambitious project to provide proof-of-concept for using emerging connected vehicle data (CVD) as the primary source for monitoring traffic flows across a multi-state region. Note that CVD in this context is a form of probe vehicle data in which the position and speed of vehicles, along with other onboard data are relayed to the manufacturer (as opposed to a fleet telematics provider) via wireless communication in real-time. The primary purpose of this data is to provide value added services to the customer, but such data that is de-identified can support a myriad of transportation operations and planning applications. The final report[4] for the Hurricane Proof of Concept study provides an overview of the objectives and insights gained. These are paraphrased below.

[4] https://tetcoalition.org/wp-content/uploads/2021/03/MT2008_Wejo_HurricaneReport_2021.pdf

In 2019, CVD appeared on the market for the first time from automobile manufacturers. Since approximately 2014, manufacturers began to embed broadband communications directly into vehicle electronics, allowing vehicles to communicate with the manufacturer. The availability of GPS for location referencing, paired with the ability to communicate, resulted in sufficient data to test real-time CVD for volume estimation purposes. In 2020, the Coalition partnered with a data provider, Wejo, to run a hurricane pilot study. Many questions arose with the Proof of Concept:

- *Could CVD that comes directly from OEM manufacturers from all across the world be used as a real time data source? The intent was to evaluate this data source as a viable real time traffic feed in the context of the hurricane season in the Southeast US, a growing concern with global warming.*
- *Given that the data feed was viable, could the traffic data be processed and visualized in real time, and if so, what would the issues and challenges be working with this type of data source?*
- *Could the Coalition use CV data to generate traffic volume estimates in real time so that this data source could be used to monitor hurricane evacuations broadly across a multi-state region?*
- *Lastly, could the Coalition provide meaningful feedback to the operators on travel patterns related to hurricane preparedness and evacuation. This includes people traveling to get outside of the path of the storm or taking appropriate precautions (sheltering in place for example).*

The proof of concept was conducted during the 2020 hurricane season. The visualization of regional CVD as individual vehicles in a live data stream brought amazing intuitive value. CVD data at the time was setting new benchmarks with respect to traffic data size and velocity, and new methods to visualize real time volume and its patterns of origins and destinations (O&D) needed to be created. Five southeastern states participated in the pilot; hence the size of data was huge. There were over 75B data points per month across the multi-state region, which resulted in over 230B total data points in the 3-month pilot study period. The biggest lesson learned from this pilot study was that managing CVD at scale was challenging for the industry and that sheer size and velocity of the data required an efficient and fast processing architecture, as well as streamlined calibration, calculation and conflation techniques. The method used to estimate volumes from the CVD data in the study was a simple scaling factor based on roadway class, time-of-day, day-of-week, and state. This method was demonstrated to provide a workable and sufficiently accurate traffic volume estimate.

Select insights gained from the project included:

- CV data, with a penetration rate of ~2%, provided a viable base dataset from which to create value-added real-time traffic information (such as volume and O&D), and it would only grow in size and velocity as new vehicles replace older vehicles in the general public fleet.
- Processing and managing CV data at scale was challenging for the industry; sheer size and velocity of the data would require efficient processing

architecture, as well as streamlined calibration, calculation and conflation techniques.

- Visualization of CV data (individual vehicles moving on a map) brings incredible intuitive value to such transportation data
- Simple scaling factors based on roadway class, time-of-day, day-of-week, and state were demonstrated to provide a workable and sufficiently accurate traffic volume estimate. Including additional factors and leveraging more advanced machine learning would likely improve accuracy.

The proof of concept was instrumental in pointing toward the potential and challenge of harnessing probe-vehicle data at scale for the creation of highly dynamic and granular traffic data such as volume estimates and O&D patterns of travelers, and suggested a viable technical path toward real-time traffic volume estimates.

FHWA Consideration of Non-Traditional Methods for Reporting AADT

In 2016, as a byproduct of the MAP-21 legislation, the Highway Safety Improvement Program (HSIP) Final Rule required states to have 'access to AADT for all public paved roads by 2026[5]. A March 2020 publication by FHWA[6] summarized this change in reporting requirements as follows:

> *State Departments of Transportation (DOTs) are required to report AADT every year to the Highway Performance Monitoring System (HPMS) for the full extent of mainlines, samples, and ramps on all Federal-aid facilities. In addition, the 2016 Highway Safety Improvement Program (HSIP) Final Rule requires States to have access to AADT along with other Model Inventory of Roadway Elements (MIRE) Fundamental Data Elements (FDE) for all public paved roads, including non-Federal aid-system (NFAS) roads, by year 2026. According to the HSIP Final Rule: The MIRE FDE are beneficial because collecting this roadway and traffic data and integrating those data into the safety analysis process would improve an agency's ability to locate problem areas and apply appropriate countermeasures, hence improving safety. The NFAS includes roads that are functionally classified as:*
>
> - *Minor collectors in rural areas (6R).*
> - *Local roads in rural areas (7R).*
> - *Local roads in urban areas (7U).*
>
> *According to 2016 Federal Highway Administration (FHWA) Highway Statistics, these functional classes together account for more than 75 percent of the total roadway mileage in the United States.*

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[5] Federal Highway Administration, Highway Safety Improvement Program Final Rule, Docket No. FHWA-2013-0019. Federal Register, Vo. 81, No. 50, March 15, 2016. https://www.federalregister.gov/documents/2016/03/15/2016-05190/highway-safety-improvement-program

[6] https://safety.fhwa.dot.gov/rsdp/downloads/fhwasa20064.pdf

Due to this substantial increase in the requirement to report AADT, states were faced with the possibility of expanding their volume count system. If AADT was estimated using traditional methods, they would need to deploy significantly more temporary count stations and some additional permanent count stations to better characterize these lower volume roads. This threatened to significantly increase the cost to gather HPMS data as requested by FHWA.

In response to this concern, which is referred to as the MIRE 2026 requirements, and bolstered by evidence of the ability to reflect accurate typical volumes through probe-based data sources, the FHWA sponsored a multi-state pooled fund study entitled *'Exploring Non-Traditional Methods to Obtain Vehicle Volume and Class Data'*. This study was launched in 2018 and lasted through 2021, and produced a series of reports that are documented, archived and accessible at https://www.fhwa.dot.gov/policyinformation/travel_monitoring/pubs/aadtnt/. This pooled funded study included 19 state DOTs, who contributed funding and participated in the advisory committee research, and assessed the accuracy with which probe-based data could accurately estimate AADT for purposes of future 2026 MIRE reporting requirements.   Though this effort was with respect to AADT, a planning level measure, and not real-time volume, the initiative was notable and instrumental for several reasons:

- Although there was evidence that estimating volumes through non-sensor-based means was technically feasible, work in this area was mainly undertaken by researchers and academics. Vendors showed little interest in developing such products, as they were not convinced that there would be sufficient market demand to support them. The pooled fund initiative by FHWA combined with the increased MIRE reporting requirements that would impact DOT budgets starting in 2026 brought probe-based volume estimation from academic interest to mainstream, validating the market demand.
- Even though technically, estimating volume on average for an entire year (AADT) is theoretically less demanding than real-time tracking of unexpected fluctuations in traffic, the accuracy requirements for AADT were better understood and defined and the academic research funded through MCOMP was equally applicable. Also, the core data sets used to estimate planning level measures such as AADT were the same or similar to that which would support real-time estimates.
- FHWA developed accuracy benchmarks for non-traditional AADT estimates based on the idea that they should be at least as accurate as factored 48-hour counts. This benchmark and the resulting methods for validating the accuracy were a product of the pool-fund study, providing 'goalposts' for estimating planning level volumes from probe vehicle data.
- Likely most important, the rule making from MAP-21 resulting in the MIRE reporting requirement caused demand for more cost-effective and scalable methods to estimate volume, thus creating a market for probe-based volume data.

Although, from an application and use perspective, volume estimation to support AADT estimates for planning applications and that needed for real-time operations applications are significantly different; even so, the initiative from FHWA was a significant trigger that prompted industry to invest in probe-based volume estimation products.

2022 The Eastern Transportation Coalition Transportation Data Marketplace

TETC developed and deployed the Transportation Data Marketplace (TDM) beginning in 2008, in which member agencies pooled resources and created a corridor-wide traffic monitoring system which remains the largest of its kind in the US. At its inception in 2008, the data was limited to travel time and speed data and the procurement was awarded to a single vendor. The 2008 TDM procurement was the first of its kind using specifications-based accuracy requirements for speed and travel time data, a validation program to test and measure accuracy, penalties if the data fell below accuracy requirements, confidence indicators to reflect times when probe data was not abundant enough for high quality travel-time and speed estimates, and a common data use licensing allowing states to share procured data -- both with adjoining states and sub-jurisdictions.

In 2014 the TDM entered Phase II and was rebid with the idea of bringing multiple vendors into the marketplace, allowing member states to select from pre-approved vendors for travel time and speed. Three probe data vendors were awarded contracts in 2014. In 2022, the TDM entered its third phase. It kept all the tenets from Phases I and II and added multiple core data areas. In addition to travel time and speed, five other data categories were added: volume, origin-destination, waypoint data, freight, and conflation services. The volume data specifications spanned planning level measures such as AADT, ADT, and AHDT, granular measures including daily traffic and hourly traffic for specific roadway segment as specific times, and real-time data feeds that provided the granular data delivered with minimal latency to support TSMO applications. Multiple vendors responded and were awarded contracts to deliver various traffic volume products, but no vendor was able to deliver any real-time volume products. At the time of this report, TDM contains planning level volume products, highly granular volume (daily and hourly) estimates, but still lacks real-time volume estimates as a core product.

Though lacking a real-time element, the third phase of the TDM set the benchmark for procuring volume data for planning purposes. Similar to other data areas in the TDM, TETC's validation program has been testing and monitoring the quality of the volume data feeds -- beginning in 2023 with a study in North Carolina, and again in 2024 with a comprehensive study in Georgia. At this time, the primary market intertest within the coalition is for planning applications, particularly for MIRE reporting, as previously described. The validation provides special emphasis on testing the data consistent with FHWA guidelines for meeting the MIRE AADT reporting requirement on all public roadways but also tests daily and hourly volume data more suited for TSMO performance metric applications.

2024 TomTom TRB Paper on the Accuracy of Volume Estimates

At the Transportation Research Board Annual Meeting in January of 2024, the paper titled “Network-Wide Traffic Volume Estimation Based on Probe Vehicle Data” was presented by Kia Eisinga and Stefan Lorkowski, both associated with TomTom, a provider of global traffic data. TomTom is also a data supplier to multiple traffic data vendors in the TDM. The paper “proposed a method for estimating traffic volumes on all roads of the network, … by combining large-scale probe-vehicle data with stationary detector data, this method builds a model to estimate the probe-vehicle penetration rate at road level, which then allows for traffic volume estimation.”[7] This paper is notable and referenced herein not because it was first or extremely unique with respect to technical approach, as academic research papers that preceded it employed similar methods. The TomTom paper itself cited many of the research papers funded through the MCOMP grant funding as well as others. Rather, the TomTom paper is notable in that the association and data used in the paper came from a major transportation data network supplier, and it confirmed and validated the research work of its predecessors using the vast amount of base data available through the TomTom traffic data system.

Using probe data from the Netherlands with penetration rates of 20% to 30% percent for motorways (equivalent to interstates or freeways in the US), and 10% to 25% on other roads (roughly equivalent to FRC 3 through 5 in the US), the authors developed a model to primarily estimate volumes. The model considered measured probe penetration rates as calculated from the volume counters on the network, and various factors that influence the penetration rates such as road class, time of day, number of lanes, etc. -- an approach similar to previous studies. The accuracy of the resulting probe-based volume estimates was largely a function of the accuracy of the measured probe penetration rate estimates and their consistency over time and location, constrained by the statistical limits of sampling theory. Using a country wide model for the Netherlands, the authors demonstrated the capability of estimating volumes with a mean absolute percentage error (MAPE) of 25% within a two-minute time reporting interval for motorways, and 7% within the day. For non-motorways, the maximum accuracy was limited to about 12% MAPE with significantly longer time reporting intervals. The results were consistent with the expected accuracy as illustrated in Table 1.

The above description of initiatives and research leading towards the availability of real-time volume estimates is not intended as an exhaustive literature review; rather, it provides a sketch of significant contributions that puts industry on the precipice of acquiring and integrating real-time volume data into the TDM to support TSMO applications.

[7] Eisinga, K., & Lorkowski, S. (2025). Network-Wide Traffic Volume Estimation Based on Probe Vehicle Data. Transportation Research Record, 0(0). https://doi.org/10.1177/03611981241289408

Real-Time Volume Applications & Stakeholder Engagement

The development of a viable real-time volume product within the TDM is reliant on two factors. The first is the technical viability of the process and the capacity of industry to supply data and processing to establish the products. The second is sufficient market demand to justify the investment to bring the products to market. In the case of speed and travel time from probe data, the market demand in the late 2000s were from two primary applications: travel time on changeable message signs and traveler information delivered through 511 systems and agency sponsored web sites (noting this predated the smart phone revolution and the modern navigation apps of today). Agencies were investing financial resources in travel time and speed sensor deployments even though hardware base sensor solutions were expensive and maintenance intensive. The business use case for travel time and speed through probe data was evident, and quantifiable. If the probe-based speed were of sufficient quality, agencies could avoid costly sensor deployments.

The business use case for real-time volume information is not as evident as for real-time travel time and speed data. While probe-based non-traditional sources of AADT information received a significant boost from MIRE reporting requirements of AADT on all public roads, no similar federal mandate nor single TSMO application has spurred development of real-time TSMO applications for volume.

To assess market demand, the REVEAL project developed a list of potential TSMO applications for which real-time traffic volume data may provide return on investment. Using this list of applications, the project team surveyed Coalition members to rank the applications and provide input on needed accuracy and other technical specifications.

TSMO Value-Added Applications

Ten TSMO applications were identified as outlined in the list below. This enumeration of potential TSMO applications was seeded by previous MCOMP research, and further refined through stakeholder engagement with state DOT representatives to the Coalition.

TSMO applications to benefit from real-time volume data include:

- Traffic Signal Timing and Performance Metrics:
    - Signal Re-timing
    - Traffic Signal Performance Measures
    - Adaptive Signal Operation (automatically changing plans based on demand)
    - Before and after studies for signal retiming
    - Low volume intersections
    - Identify inoperable sensors
- Special Event Management
- Impacts of Incidents

- Detour planning and management
- Construction and maintenance allowable work hours for lane closures
- Work zones
- Variable Speed Limits and Hard Shoulder Running
- Traveler Information
- Parking Lot Occupancy (truck parking or park and rides)
- Performance Metrics
- Winter Weather Recovery Times

Coalition Member Agency Stakeholder Engagement

Following the identification of key TSMO applications that could benefit from real-time volume estimates from probe data, the project team developed a survey to engage with Coalition member agencies. The survey was web-based, and asked agency representatives to rank the various application use cases identified in the previous section, and comment on the type and form of volume data needed for each. A copy of the user survey administered through web service is provided in the appendix.

The survey was circulated to the TDM Leadership Committee that oversees the validation activities. The committee was briefed in December 2024 on the results of the most recent volume validation that reflected the accuracy and quality of higher granularity daily and hourly estimates of probe-based volumes (a summary of which is provided in section 'Current Industry Capacity'). The briefing familiarized Coalition representatives of current industry capacity to report roadway volumes for TSMO applications. After the briefing, representatives were requested to rank applications for which data of this nature, delivered in real-time would provide benefit. The results of the survey have been tabulated and summarized in the tables following.

Four agencies responded to the survey. Those responding to the survey on behalf of their agencies included personnel with expertise in data science, transportation planning, intelligent transportation systems (ITS) & TSMO, and emerging technology.

Agencies were asked to identify and rank the priority of the identified applications. The project team followed up with participants to clarify their top three ranked applications. The table below contains the tally of the votes for ranking of 1st, 2nd, and 3rd priority. Operations performance measures and traffic signal applications consistently fell in the top three applications for real-time data. Special event management garnered two votes, and incident impacts, detour planning and management, and allowable lane closure hours garnered one vote each.

	1st	2nd	3rd
Special Event Management		1	1
Incident Impacts		1	
Detour Planning and Management		1	
Allowable Lane Closure Hours	1		
Work Zone Impact Analysis			
Variable Speed Limits or Hard Shoulder Running			
Traveler Information			
Parking Lot Occupancy			
Operations Performance Measures	2		1
Traffic Signal Applications	1	1	2

With respect to traffic signal applications, respondents were asked to identify what aspects of traffic signal management would benefit from real-time volume estimates. These results are compiled in the table below. Performance metrics, signal retiming, and before and after studies were traffic signal management functions identified consistently as benefitting from real-time volume data.

Traffic Signal Applications to Benefit from Real-Time Volume	Totals	%
Signal Retiming	3	75%
Traffic Signal Performance Measures	4	100%
Adaptive Signal Operations	2	50%
Before and After Studies for Signal Timing	3	75%
Low Volume Intersection Management	1	25%
Identify Inoperable Sensors	0	0%

Respondents were requested to identify existing sources of volume data that currently support the various TSMO applications. The existing volume choices included Factored AADT, Data from Nearby Sensors, of Average Volume Profiles by Roadway Type. The results are provided in tabular format below. The letters a, b, c, d correspond to a specific agency respondent (note that agency c did not provide information in this category). The high priority applications identified by the agencies are shaded in blue.

Existing Source of Data

	Factored AADT	Nearby Sensors	Average Volume by Roadway Type
Special Event Management	abd	bd	
Incident Impacts	a	bd	
Detour Planning and Management	a	bd	bd
Allowable Lane Closure Hours		abd	bd
Work Zone Impact Analysis	a	bd	bd
Variable Speed Limits or Hard Shoulder Running		abd	b
Traveler Information	d	bd	
Parking Lot Occupancy		d	
Operations Performance Measures	abd	abd	abd
Traffic Signal Applications	bd	bd	

Agency representatives were questioned about whether Absolute Volume estimates or some type of Volume Index would be acceptable for various TSMO applications. Absolute Volume refers to numerical values for volume, whereas a volume index could be a percentage of nominal traffic, or categorical such as "light", "medium", or "heavy" compared to nominal traffic conditions. The results are tabulated below with priority applications highlighted in blue. Operations performance measures and traffic signal applications both require absolute volume estimates, while the other priority applications may also benefit from volume index measures.

Absolute Volume Estimate or Volume Index

	Absolute Volume	Volume Index
Special Event Management	c	abc
Incident Impacts	c	abc
Detour Planning and Management	bc	ac
Allowable Lane Closure Hours	bc	ac
Work Zone Impact Analysis	abc	
Variable Speed Limits or Hard Shoulder Runnin	ac	b
Traveler Information	c	ab
Parking Lot Occupancy	abc	c
Operations Performance Measures	abc	
Traffic Signal Applications	abc	

Agencies were also queried with respect to latency and granularity. Granularity refers to the time reporting interval or time binning of the data. Time reporting interval choices included 1 min, 5 min, 15 min and one hour. Latency refers to acceptable delay, that is how quickly does the data need to be delivered after the period of interest. Choices for latency were < 2 min, < 5 min, < 15 min, and < 1 hour. Prioritized applications had responses for time reporting intervals centered roughly around 5 minutes. The responses for maximum latency were varied.

	Granularity - Time Reporting Interval			
	1 min	5 min	15 min	1 hour
Special Event Management	a	bc	d	
Incident Impacts	abd	c		
Detour Planning and Management		abd	c	
Allowable Lane Closure Hours	d	b	a	c
Work Zone Impact Analysis	bd	a	c	
Variable Speed Limits or Hard Shoulder Running	ab	c	d	
Traveler Information		bd	ac	
Parking Lot Occupancy	b	ad		c
Operations Performance Measures	d	bc		a
Traffic Signal Applications	b	ac	d	

	Latency			
	<2 min	<5 min	<15 min	<1 hour
Special Event Management	ab	c	d	
Incident Impacts	abd		c	
Detour Planning and Management	bd		ac	
Allowable Lane Closure Hours		b		acd
Work Zone Impact Analysis		b	c	ad
Variable Speed Limits or Hard Shoulder Running	ab	c	d	
Traveler Information	b	ad	c	
Parking Lot Occupancy		abd		c
Operations Performance Measures		b	c	ad
Traffic Signal Applications	b	ac		d

The last area queried in the survey was with respect to accuracy requirements, with results shown below. The high priority applications tended to cluster around 5% to 10% accuracy. Note that the survey did not define accuracy metrics such as with respect to absolute volume (as in MAPE) or with respect to capacity or maximum observed flow (ETCR or EMFR), but rather open to interpretation.

	Accuracy within ...				
	2%	5%	10%	20%	30%
Special Event Management		ab	cd		
Incident Impacts		ab	cd		
Detour Planning and Management		b	c	ad	
Allowable Lane Closure Hours		b	d	c	a
Work Zone Impact Analysis		b	acd		
Variable Speed Limits or Hard Shoulder Running	a	bc	d		
Traveler Information		b	d	ac	
Parking Lot Occupancy	ab		d	c	
Operations Performance Measures	a	bc	d		
Traffic Signal Applications	b	a	cd		

Assessment of Current Industry Capacity

The assessment of industry capacity is reflected in activities over the past 12 months that provide objective information on the current capacity of vendors to provide real-time volume products capable of accurately reflecting volume flows for operations purposes. This report summarizes two such activities.

2024 TDM Volume Validation Study in Georgia

In 2024, as part of its TDM program, TETC conducted a volume validation exercise in the state of Georgia. The validation activity, which targeted April 2024 as its core evaluation period, concentrated on planning level measures of AADT, ADT, and AHDT. However, the validation also included highly granular reporting of volume data for specific roadways at specific times for daily and hourly time aggregations. Reference (or ground-truth) data was taken from continuous count stations and temporary coverage counts in the state of Georgia as illustrated to the right, covering all functional road classes (1-7) on the state highway system.

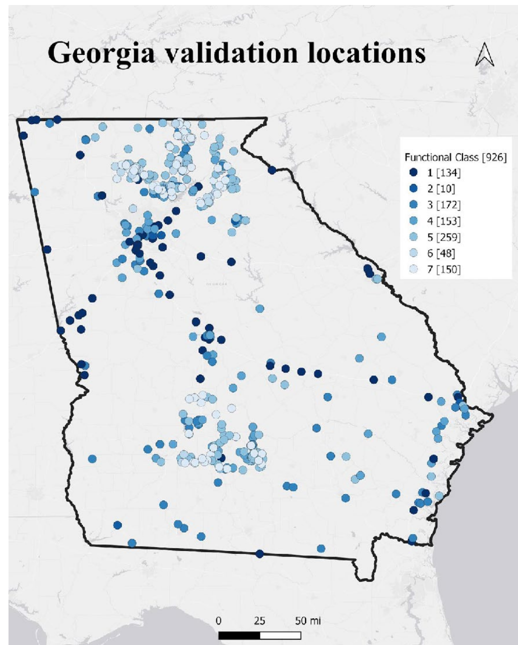


Figure 3 Georgia Volume Validation Sites

Of the five industry vendors that participated in the volume validation exercise, three were able to provide granular estimates of volume for specific days and hours on roadways. The performance of these three industry participants is considered representative of industry capacity to deliver highly granular spatial estimates of roadway volumes as of April 2024. Note, this data was not delivered in real-time, but rather several weeks after the time period of investigation. The results of the granular volume measures provide insight into the time granularity currently available from industry, but not the ability to deliver with low-latency, real-time APIs. The participation rate of vendors (3 out of the overall 5) is indicative both of industry's current focus on planning level measures (for which all five vendors provided volume estimates), as well as the fact that vendors were in the process of recovering from data supply chain disruptions that occurred in ~2023 post-pandemic period.

The first granular volume measure validated were daily volumes for a specific segment of roadway, for specific days (as opposed to an average day as provided by planning level measures of AADT and ADT). Data from both continuous count stations (traffic recorders that have the capability to record traffic flow 24/7/365) and 48-hour temporary counts (counts taken with portable sensing equipment) were compared to data submitted by the three vendors. Each 24-hour period at each site created a signal data point.

The performance of the three vendors for Daily Volumes is depicted in the Figure below, with error distributions plotted across different volume ranges, and +-15% error boundaries shown in dashed blue lines. The box and whisker plots depict the median (center vertical black line), mean (red X), inter-quartile range (shaded region), and approximated 95th percentile (whiskers). Note the estimate of a Daily volume generally worsens with decreasing volume as would be anticipated with a constant sampling or penetration rate. However, there are some exceptions. High volume ranges for Vendor A do not follow this trend, and low volumes for vendor C and D also are larger than the trend would predict. (Note, the errors at high volumes from Vendor A were investigated and found to be an issue in the conflation roadway locations between the vendor's internal base maps and the geo-referencing protocol used in the validation and were subsequently corrected.)

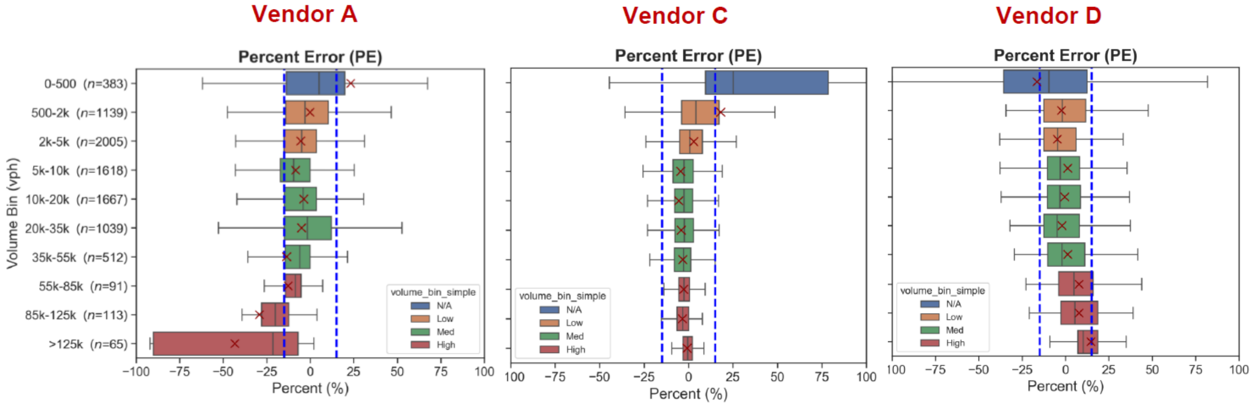


Figure 4 Vendor Performance for Daily Traffic Counts

The above results contain both data from continuous counters and temporary counters. The number and distribution of continuous counters versus temporary count sites are shown in the Figure below, to the left. Note that continuous count stations tend to be located on higher class roadways (FRC 1 through 5) and less representative of lower volume roads (FRC 6 and 7). In contrast, temporary count sites are clustered in lower road classes (FRC 3 through 7). High volume roadway classes (FRC 1 and 2) are nearly exclusively covered by continuous counters, whereas extremely low volume roadways (FRC 6 and 7) are nearly exclusively reported on by temporary count sites. The common process for training machine learning (ML) to estimate volumes is dominated by data from continuous count stations. As such, better performance would be expected in roadway classes one through 5, where significant continuous count data exists for training AI and ML models.

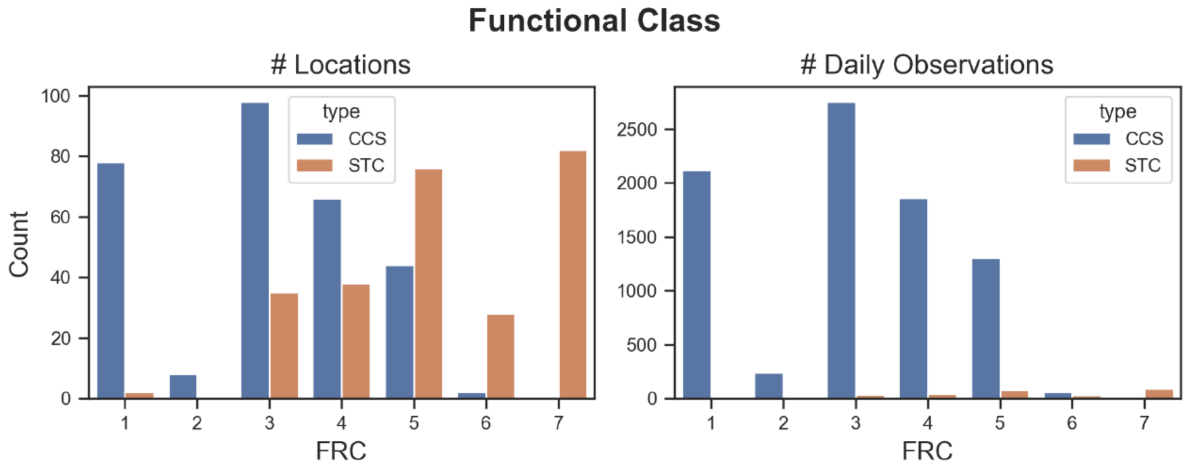


Figure 5 Distribution of Continuous and Temporary Volume Counts by Roadway Classification

As a test and reflection of the ability of these new data sources to accuracy report volumes on roadways beyond that which was used for training, validation performance is separated into that for continuous count stations (where vendors had access to historic data to train the models) and temporary count stations (where vendors likely did not have access to the data for training the models). The graph to the right in the above Figure shows the relative size of each data set in actual data points, noting that since temporary counts only collect 48 hours of data as compared to 24x7x365 for continuous counts, the number of records in each data set differs substantially in size.

The results for Daily Volumes separated into continuous counters versus temporary counters are reflected in the graphs below. In all cases the performance on the temporary count sites is worse than on the continuous count sites, as would be expected based on the ML principles because historic data from the continuous count stations were likely included in the training data sets (though not for the time periods tested). Road classes 3 through 5 were common to both continuous count stations and temporary count stations. For Vendor A and D the difference in performance within these classes were similar between continuous count stations and temporary count stations, though performance at temporary count sites were slightly worse (as would be anticipated). Performance for roadway classes 6 and 7 were substantially worse, suggesting that there may not have been sufficient training data in these classes for good performance. Note that the results for Vendor C were substantially worse across all roadway classes for the temporary count data, suggesting either overlearning of the training data set from continuous counters, or perhaps a processing irregularity for temporary count stations.

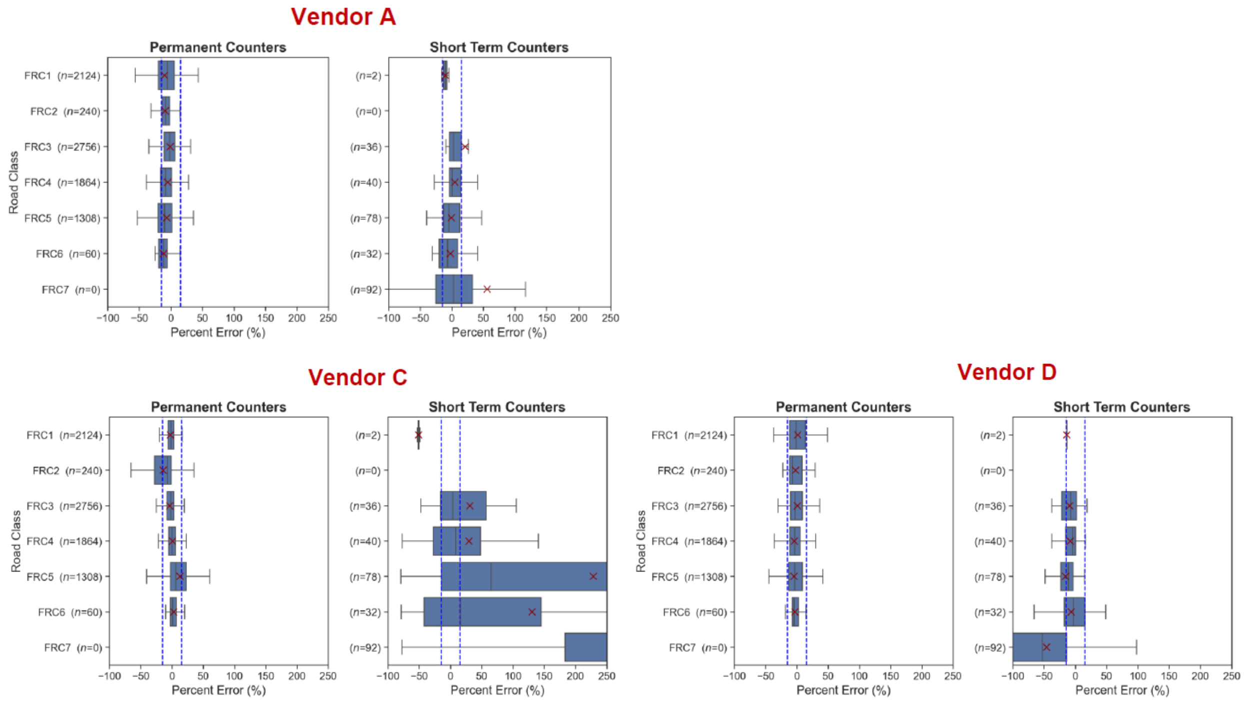


Figure 6 Daily Volume Estimate Percent Error

For the Daily Volume validation: (a) all three of the participating vendors were able to produce reasonable daily estimates of traffic volume, (b) vendor A and D show similar though slightly degraded performance for temporary count stations as compared to continuous count stations, particularly in road classes 3 through 5 which were well represented in both data sets, (c) performance for temporary count stations as compared to continuous count stations in road classes 6 and 7 were much higher, noting that training data from continuous count stations for these road classes were significantly lacking, (d) vendor C performance at short term count locations was substantially degraded from continuous counts, suggesting overlearning of the training data set or some type of irregularity or error in processing of the temporary count sites.

The final validation exercise evaluated the accuracy of reported Hourly Volumes on an hour-by-hour basis of the volume for a specific roadway segment. The same three vendors that provided data for Daily Volume estimates also provided Hourly Volume estimates. Reference data was similar as that for Daily Volume validation, including both continuous count stations (CCS) and short-term count stations (STC), though at hourly intervals. At hourly time levels a time series plot and analysis provide insight into vendor capacity. One such time series plot is shown in the Figure below. In these plots the reference data from with the CCS or STC is shown in black, and the vendor supplied volume estimates are shown in red. The relative agreement can be visually inspected across the timeline. The representative plot below depicts the vendor data closely following the reference data provided from a CCS. However, note that hourly volumes are predictable for time of day and day of week, and no atypical traffic behavior is visible.

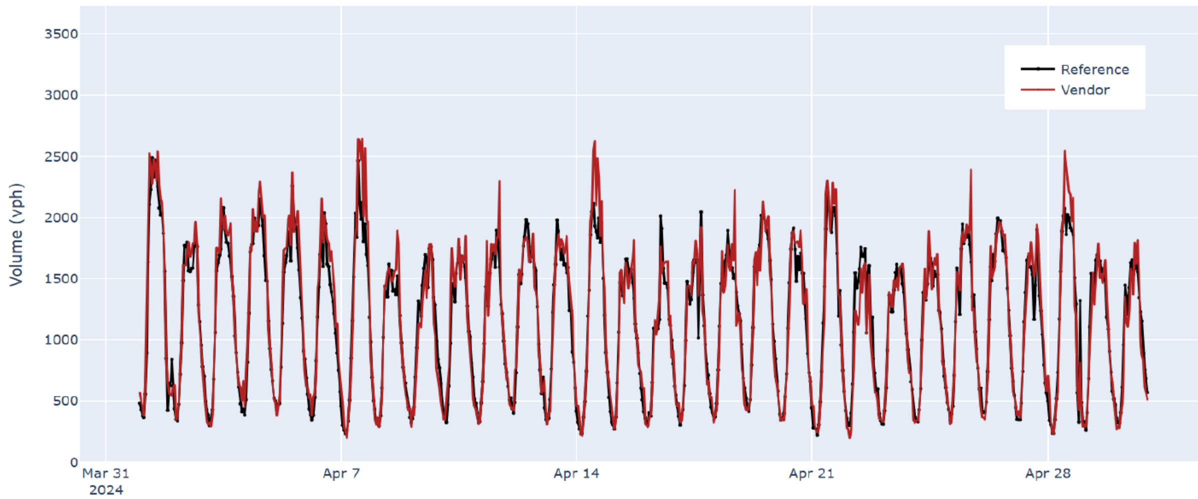


Figure 7 Example Hourly Volume Time Series Plot

Operations applications are concerned primarily with atypical traffic conditions. If traffic were typical, then AHDT for the specific hour and day of week would result in reasonable estimation of real-time hourly volumes, a common method for estimating traffic for specific day and time in lieu of real-time volume data. On roadways without AHDT, the AADT can be factored to hourly estimates based on time-of-day and day of week template based on a nearby CCS station in the region for a similar road class. A better test of the quality of hourly real-time volume data for TSMO applications is to observe performance during a typical period or event.

The validation methodology consisted of searching the reference data for atypical roadway volumes and observing the volume estimates from the vendors during those periods. One such example is depicted in the examples that follow. The map on the right in the Figure below shows the location of CCS P060 on a roadway class 3 for April 5-7.

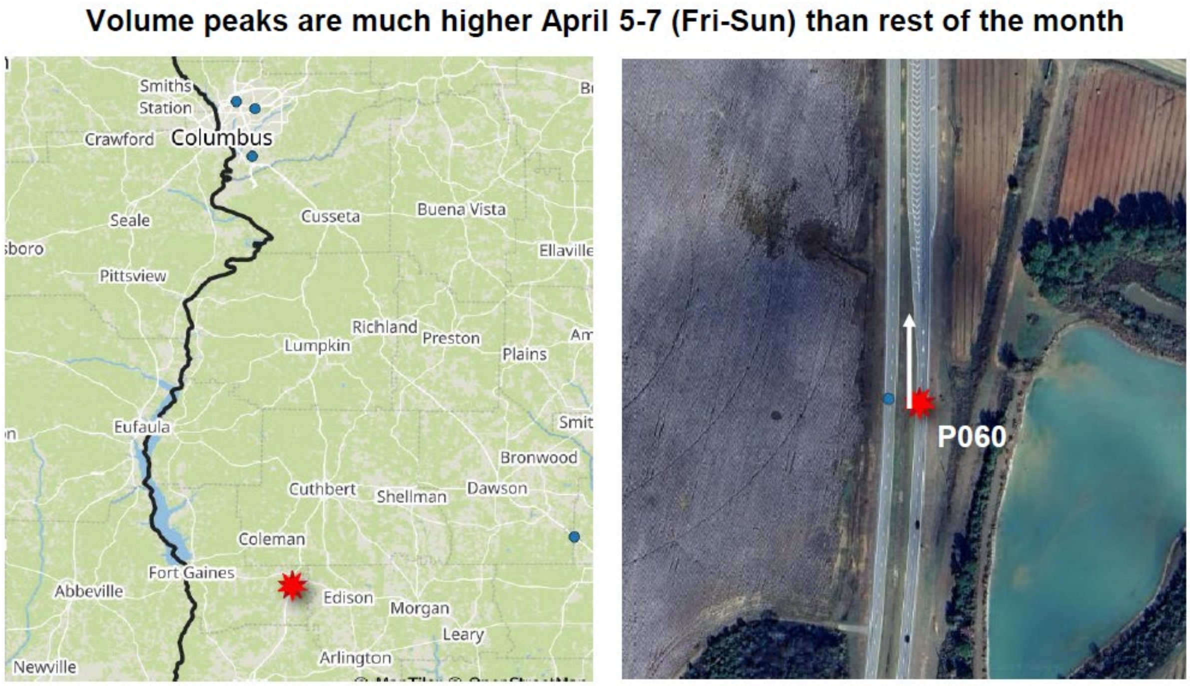


Figure 8 Location of atypical Volume Demand from CCS P060 on April 5-7

The time series analysis for this location and time for Vendor A is shown in the Figure below, with the reference data from the CCS depicted in black, and the vendor data depicted in red. Note that Vendor A did not register any unusual traffic volumes during the April 5-7 time period. A close inspection of the vendor reported data indicate that similar, if not identical, volume estimates for April 5-7 as it did for April 12-14. Vendor A performed similarly for the several anomalous volume incidents assessed in the validation data set from Georgia in the month of April 2024 indicating that the volume feed was not sensitive to atypical volume demand but rather employed either AHDT or a template method for AADT.

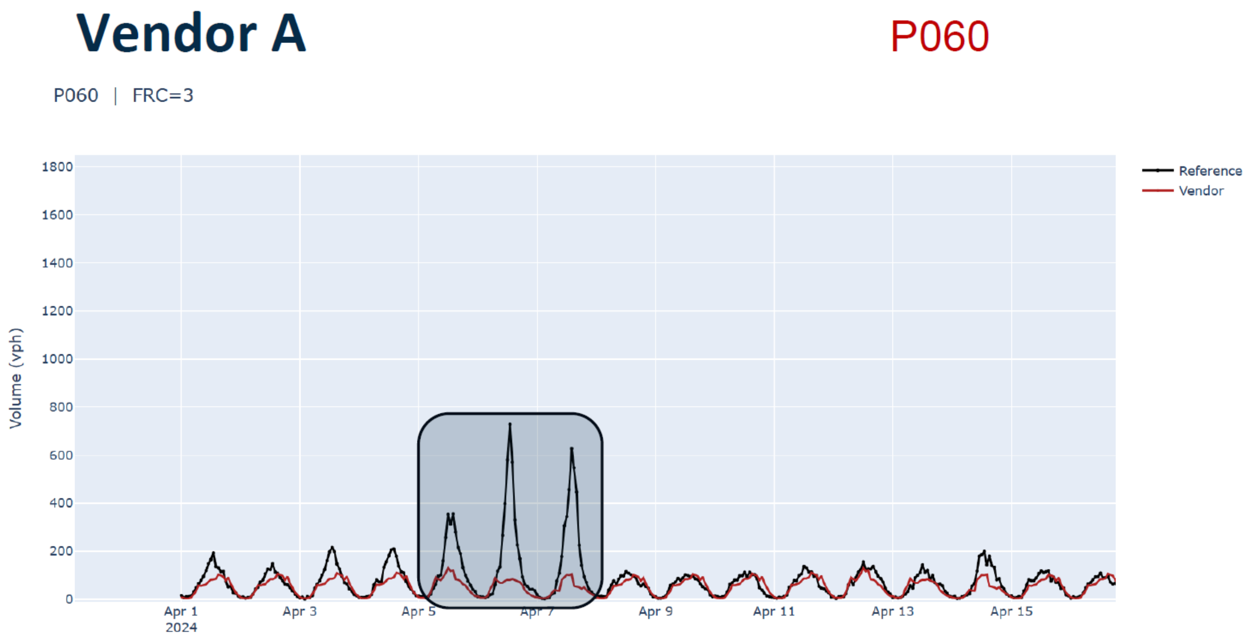


Figure 9 Vendor A performance at CCS P060 during atypical volume demand

The performance for Vendor C is depicted in the Figure below. Note that Vendor C was able to capture the anomalous event, with relatively high accuracy, reflecting the ability to capture fluctuations in traffic for TSMO applications. Similarly Vendor D, below, also was able to detect the anomalous volume fluctuation over this period, though the magnitude of the reported volumes were approximately twice that of the reference data from the CCS.

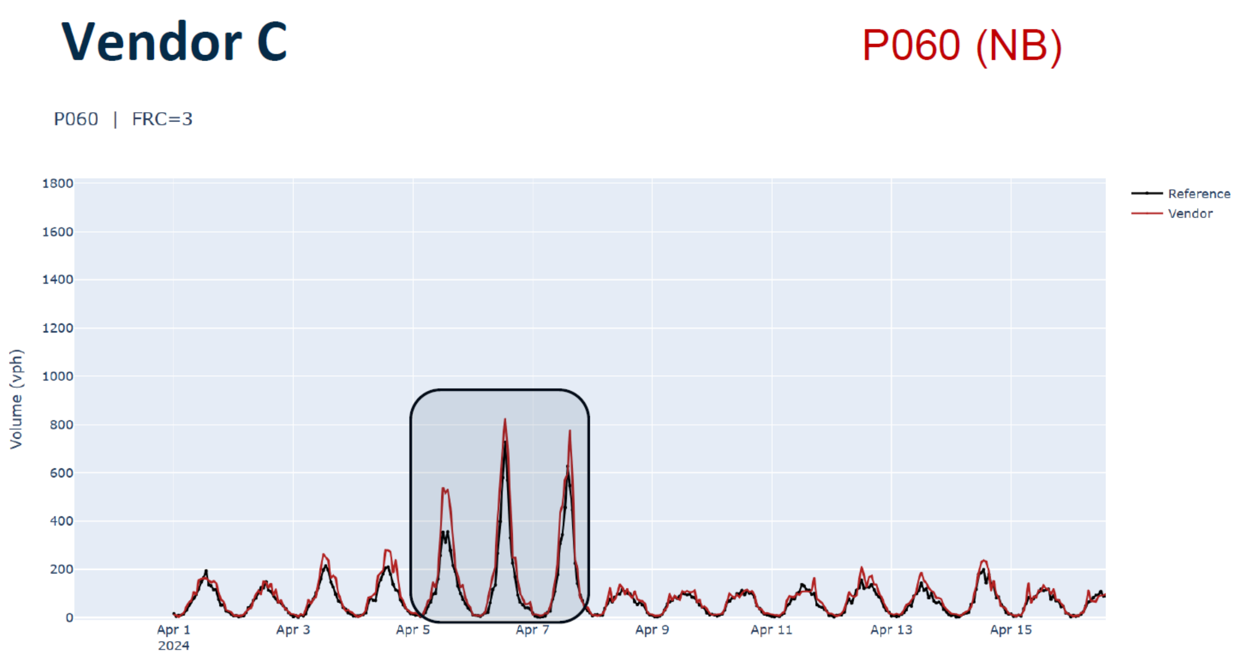


Figure 10 Vendor C performance at CCS P060 during atypical volume demand

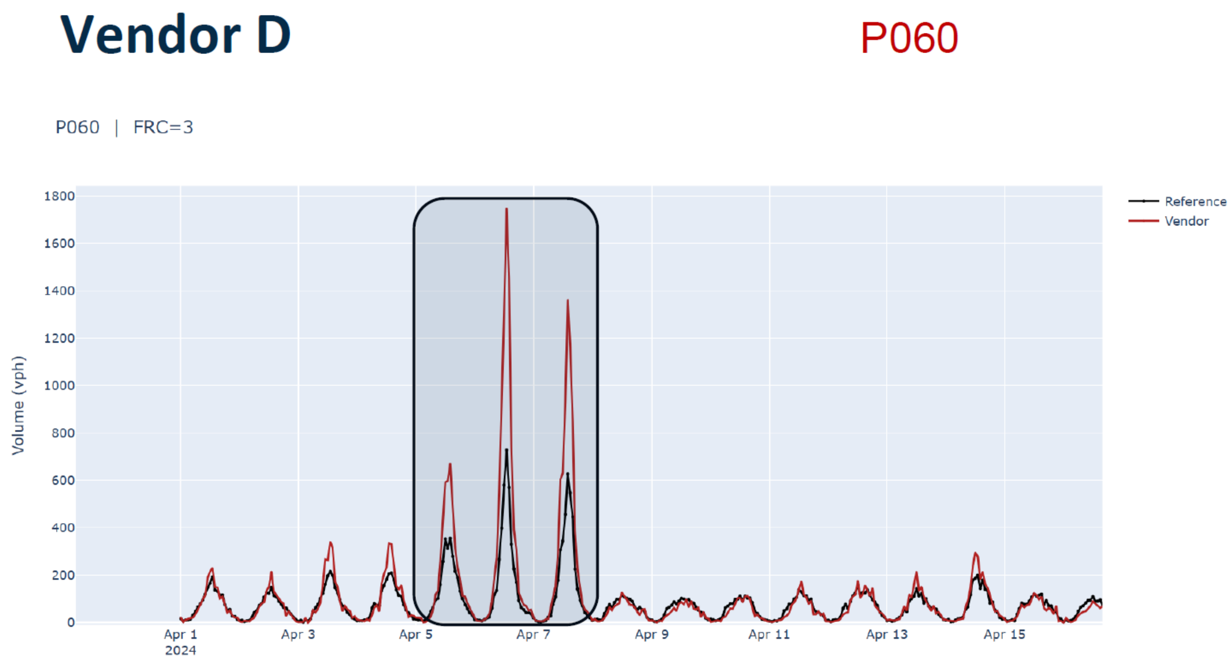


Figure 11 Vendor D performance at CCS P060 during atypical volume demand

A second example of an unusual traffic volume event is depicted in the following Figures below. This example is from the same time period as the previous example, but at a different CCS.

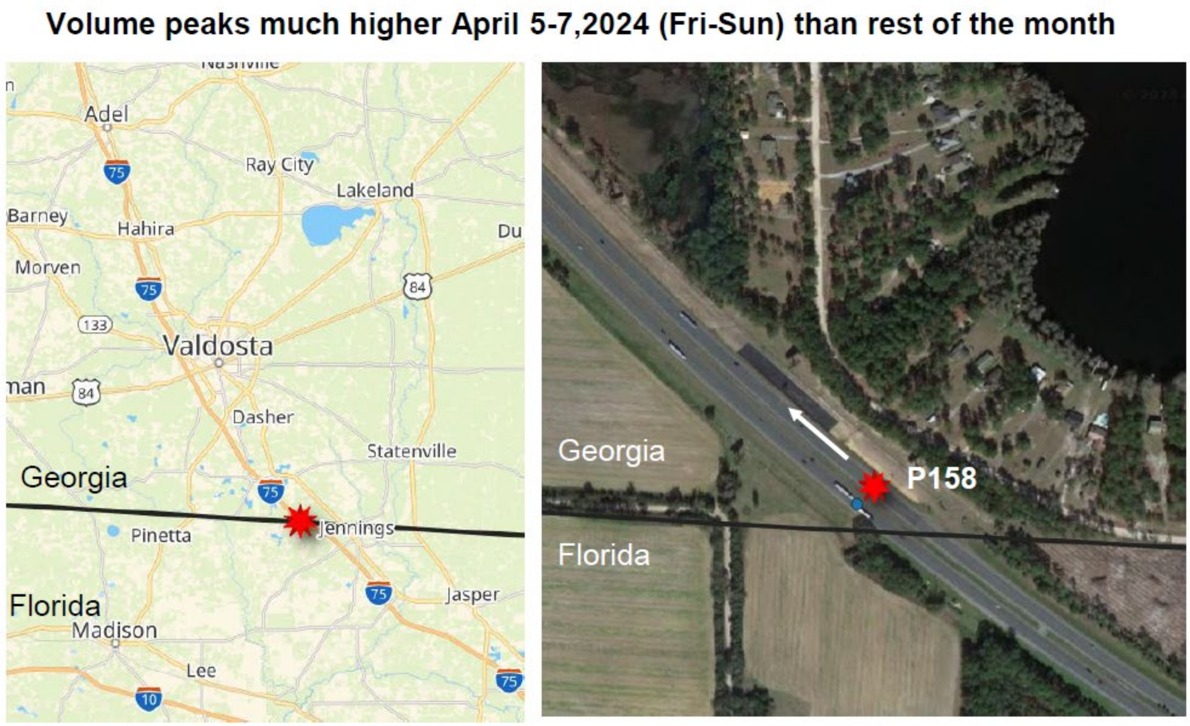


Figure 12 Location of atypical Volume Demand from CCS P158 on April 5-7

The volumes reported from Vendors A, C and D are provided in the Figures that follow. Similar trends are reflected as in the first example. Vendor A was not sensitive to any fluctuations in traffic volumes. Vendor C accurately captured the first day of the heightened volume (April 5) but then failed to capture any unusual volume on April 6 and 7. Vendor D reflected the unusual volume event, but over-estimated its magnitude.

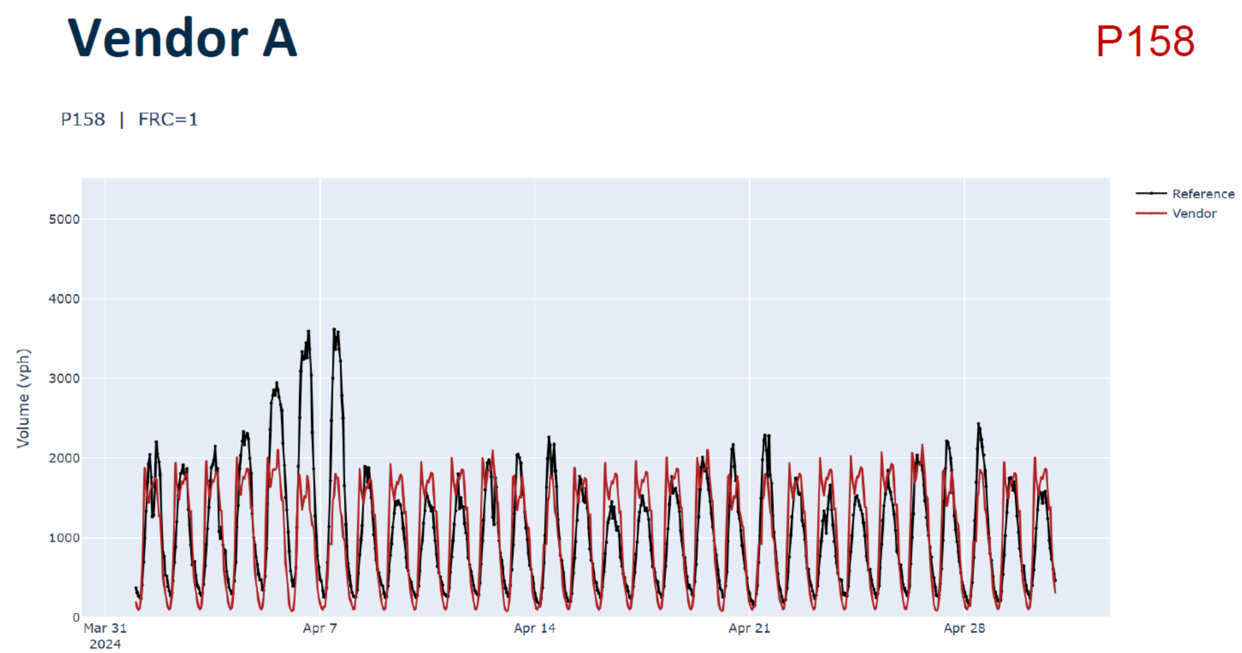


Figure 13 Vendor A performance at CCS P158 during atypical volume demand

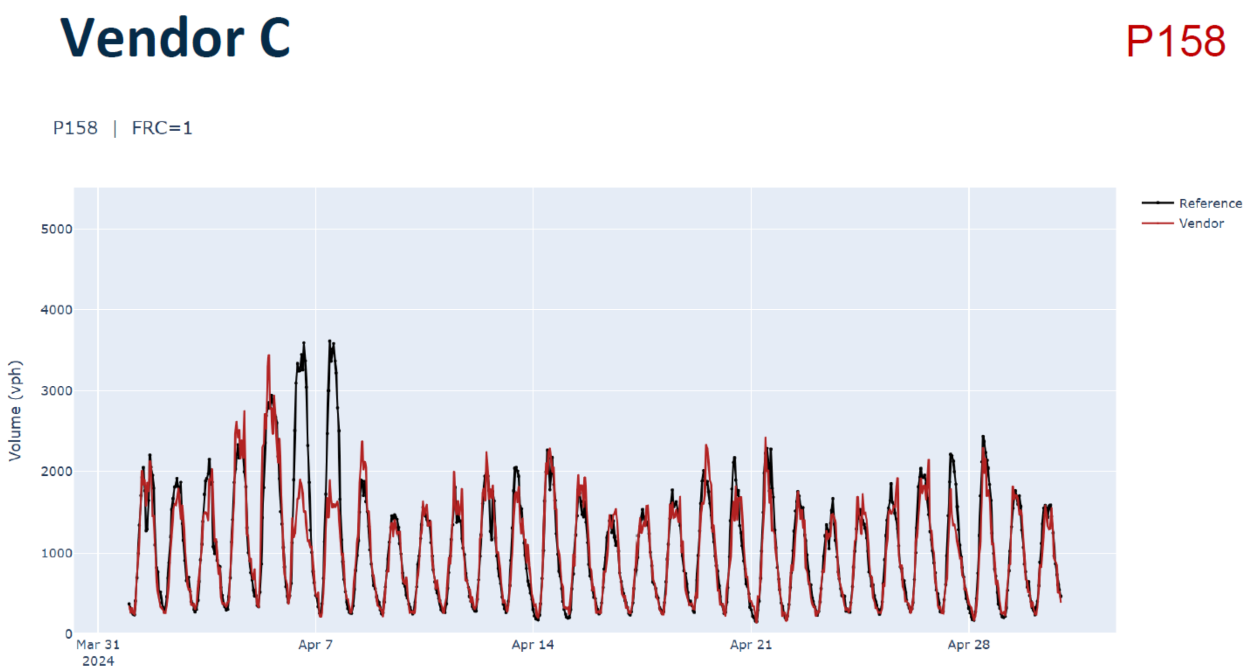


Figure 14 Vendor C performance at CCS P158 during atypical volume demand

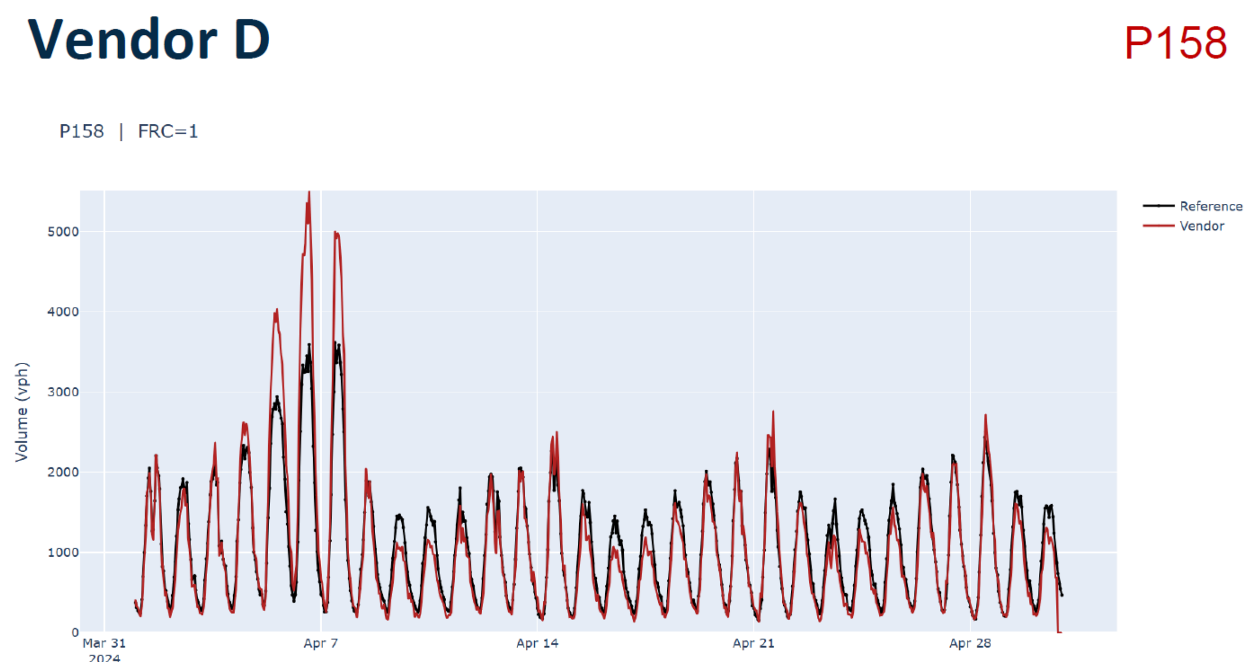


Figure 15 Vendor D performance at CCS P158 during atypical volume demand

A third, and last example, is depicted below, coming from a 48-hour STC site on a low volume roadway. However, this time series does not include an anomalous event (as did the previous two examples).

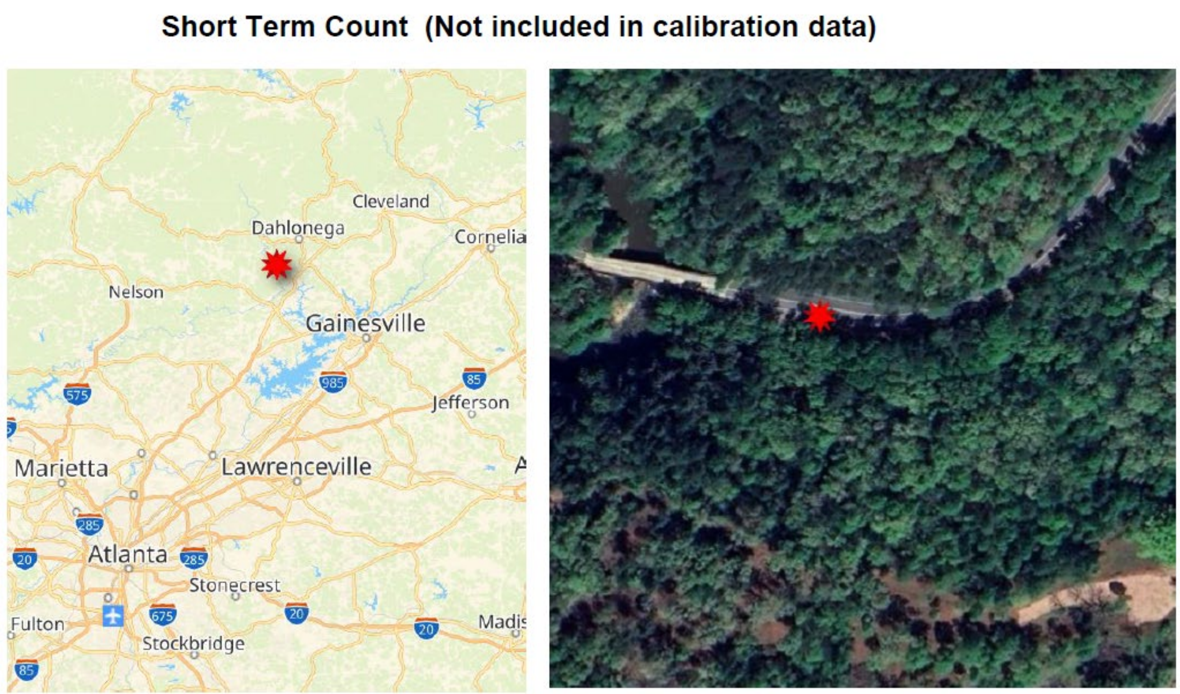


Figure 16 Location of hourly volume example from a low volume road (FRC6)

The results from vendors A, C and D are shown in succession in the Figures that follow. Vendors A and D reflect the hourly volume to a reasonable degree of accuracy, whereas Vendor C reported volumes that were 2 to 3 times the reference volume. These results are consistent with the Daily Volume accuracy results for low-volume, short term counters.

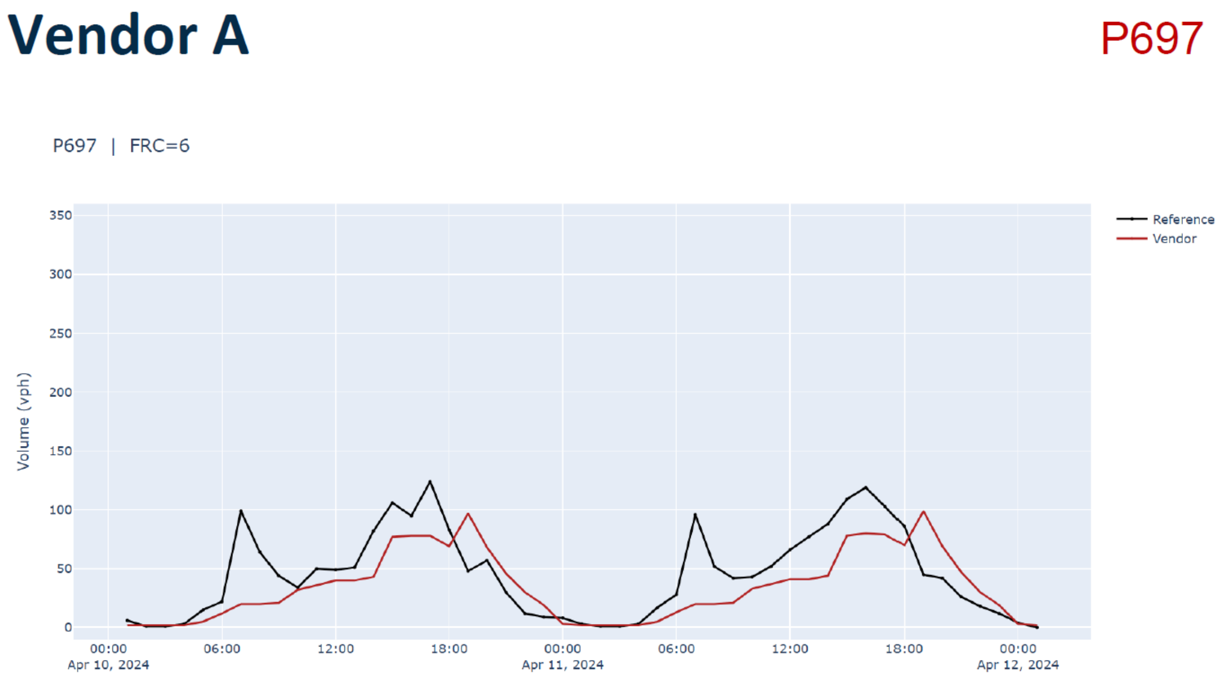


Figure 17 Vendor A performance on a low-volume roadway

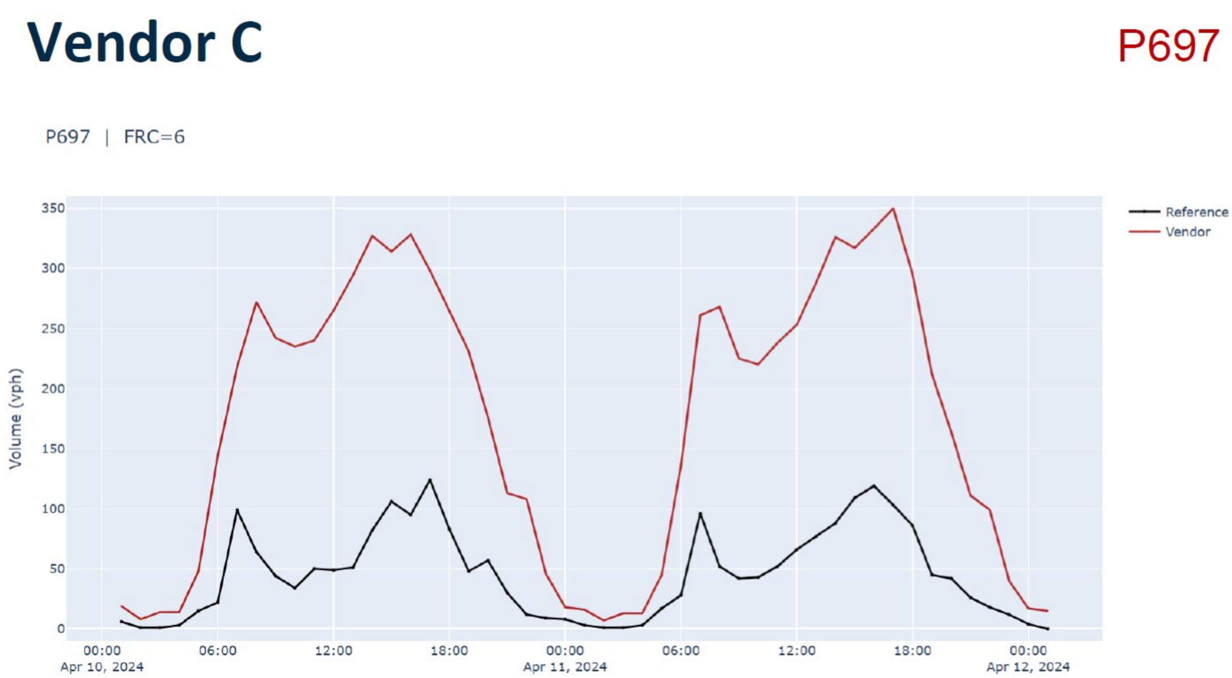


Figure 18 Vendor C performance on a low-volume roadway

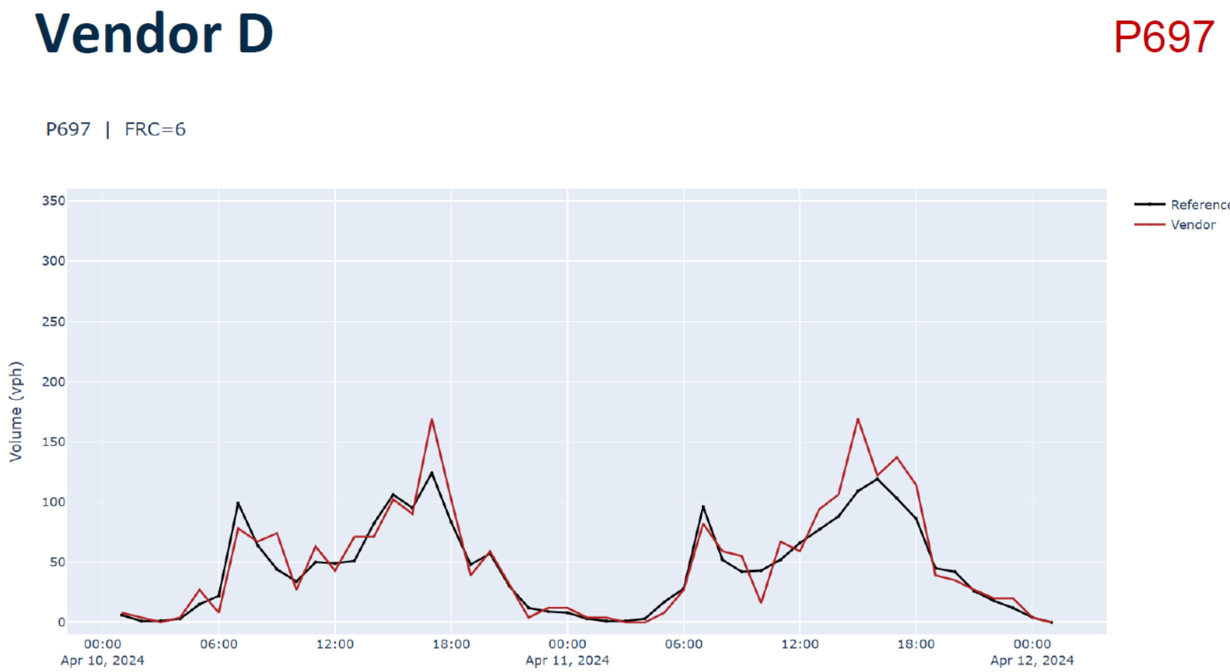


Figure 19 Vendor D performance on a low-volume roadway

The statistical error distributions for the Hourly Volume validation for the three vendors are depicted in the graphs below, segregated into CCS and STC similar to the results for Daily Volumes. The trends revealed follow those for Daily Volumes. Note, these statistical results include periods and location reflecting both typical and atypical volumes, and the typical volume demands are in the super-majority of all the data.

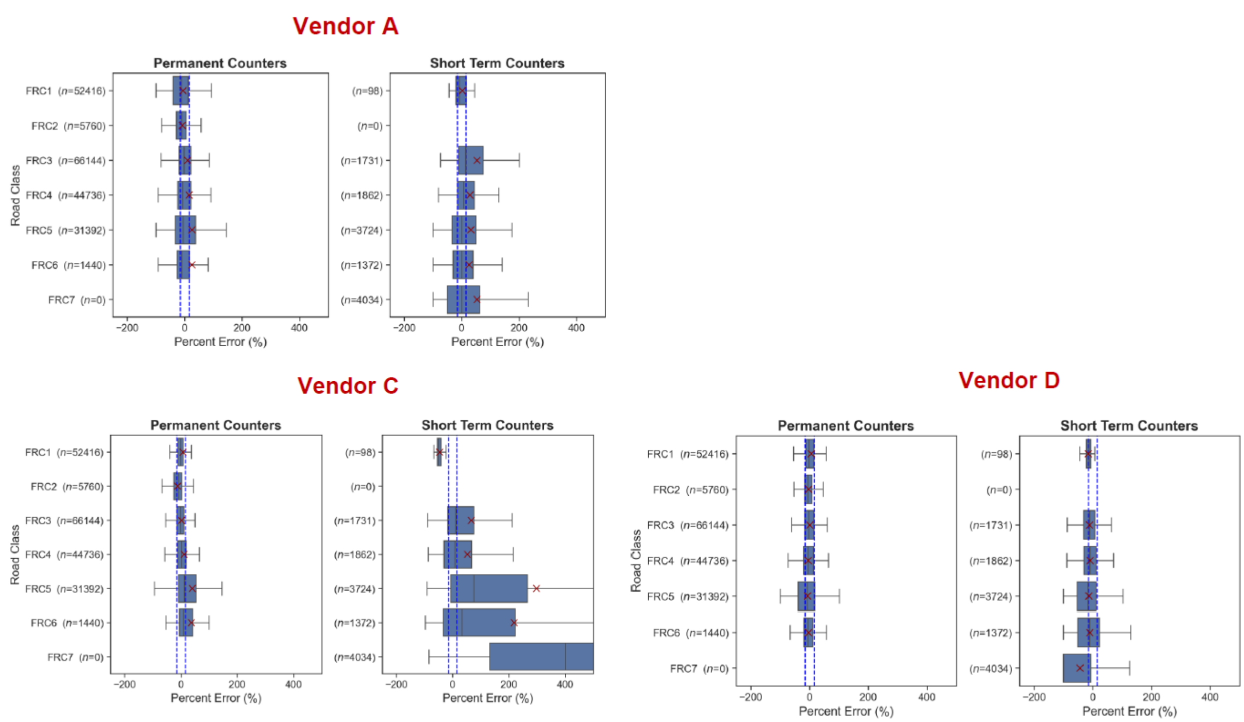


Figure 20 Daily Volume Estimate Percent Error

The results of the Daily and Hourly Volume estimates from April 2024 TDM validation activities are the most recent broad industry testing available and reflect the emerging ability to report and capture highly granular estimates of volume on a daily and hour-by-hour basis. These results provide no indication of the capacity of industry to provide real-time volume data in an API or other interface, only the accuracy of highly granular volume estimates (daily and hourly). The validation was conducted shortly after the pandemic, and during a period of time in which data supply chains were significantly disrupted due to failing businesses and policy changes from cellular carriers. The results are encouraging that perturbations in traffic are reflected in some data feeds, but also indicate that refinement of process and data is still needed to accurately capture these trends. Note that only two of the five vendors provide volume data at the hourly level capable of capturing atypical hourly fluctuations (Vendors C and D). Vendor A reported hourly, but using an older methodology similar to AADT factoring.

FDOT's High-definition Engineering Intersection Data via Integrative modeling (HEIDI) project

The second activity dates from late 2024 and was sponsored by the Florida DOT to assess the viability of obtaining valid turning movement counts at signalized intersections as part of their Regional Integrated Corridor Management initiative. This is the first known (by the project team) attempt at assessing volume estimation (turning movement) volume products specifically for low-latency applications.

The goal of FDOT's High-definition Engineering Intersection Data via Integrative modeling (HEIDI) project was to investigate fusing crowd sourced and field device sensor data to improve the quality and availability of arterial turning movement count volume data for traffic operations. This was a three-phase contract awarded to a commercial vendor, Flow Labs. Phase 1 was a pilot project to assess the viability that the fusion of the two sources is an acceptable approach. Two very different corridors were selected to evaluate this theory. One was Lake Mary Blvd in Seminole County, FL, which is highly urban and has a significant amount of roadway infrastructure in the form of vehicle detection and count data. The other is a rural corridor along US 301 in Sumter County, FL that has digital communication to signals but limited additional data availability with respect to infrastructure sensors. The urban and rural scenarios were chosen to investigate the impact probe data availability on the process. FDOT is currently in the final stages of validation testing for Phase 1. If testing is successful, then the project progresses to Phase 2 (district wide scale-up), and then Phase 3 (service).

FDOT was able to share results of Phase I (draft report issued in February of 2025). Consistent with other studies, the results indicated greater accuracy with increased volume. The FDOT study was unique in that it assessed accuracy as a function of both latency as well as time interval. The time interval is the summary interval over which volume is reported, such as 5-minute, 10-minute, 15-minute, or 30-minute periods. Whereas latency refers to when that data is delivered relative to the time interval. A 15-minute latency for a 30-minute time interval implies that the estimate for volume for a designated 30-minute interval arrives 15 minutes after the interval closes.

These accuracy results, summarized in the chart below, indicate the performance of two approaches, that of using probe data alone for estimation of turning movement counts, and the accuracy of fusing of probe data with infrastructure data – and the impact of the selected time Interval and latency with respect to accuracy. A volume-weighted Mean Absolute Percentage Error (MAPE) was employed to ensure that accuracy metrics were not disproportionately affected by the high number of low-volume periods in the dataset. Ground truth was determined through manually assessed video counts of the roadways

- **Types of Estimates Generated:**
    - **Probe-Only Estimates**: Solely based on real-time high-penetration probe data (TomTom), without the use of historical data or detection-based adjustments.
    - **Integrated Estimates**: Derived by combining real-time probe data with infrastructure-based detection data, applying correction factors to account for detection inaccuracies and turning movement percentages.
- **Time Intervals Analyzed:** Estimates were generated at 1, 3, 5, 15, 30, and 60-minute aggregation levels, assessing accuracy at different levels of granularity.
- **Latency Intervals Analyzed:** Estimates were assessed at 1, 3, 5, 10, 15, 30, and 60-minute delays, evaluating the effect of real-time processing constraints.

The results indicated the impact of latency and time interval on reporting accuracy. Overall observations from the results depicted in the tables from the Figure below indicate:

- Accuracy increased as time interval duration increased (as is predicted in probe data sampling)
- Accuracy increased as latency increased for probe data only solutions, but did not heavily influence the fused, integrated solution

The first result is consistent with probe sampling theory and is predicted by previous theoretical work. The second result validates information provided during vendor interviews informing that probe-data from source suppliers arrives at different frequencies or delays to the vendor that aggregates the data for end customers. The longer the latency, the higher the number of samples (or observations) are received, thus increasing the penetration rate with higher latency, and thus increasing the accuracy of volume estimation.

Interval-Latency Accuracy Levels - Probe Only - MAPE

		Time Interval (minutes)					
		1	3	5	15	30	60
	1	100.00%	107.27%	89.49%	24.68%	10.59%	7.28%
	3	103.22%	96.23%	62.61%	24.33%	9.79%	7.63%
	5	94.84%	73.28%	46.12%	19.25%	9.86%	7.87%
	10	89.17%	44.64%	26.87%	15.11%	8.93%	7.50%
	15	32.74%	21.72%	18.15%	13.33%	8.58%	7.46%
	30	32.18%	21.33%	18.25%	13.25%	8.36%	7.29%
Latency (minutes)	60	32.22%	21.34%	18.31%	13.29%	8.37%	7.29%

Interval-Latency Accuracy Levels - Integrated - MAPE

		Time Interval (minutes)					
		1	3	5	15	30	60
	1	35.09%	16.61%	13.82%	9.84%	7.71%	5.80%
	3	35.09%	16.61%	13.81%	9.57%	7.52%	5.95%
	5	35.09%	16.59%	13.62%	9.35%	7.08%	5.87%
	10	35.04%	16.48%	13.48%	8.53%	5.88%	6.14%
	15	34.07%	15.61%	11.93%	7.83%	6.07%	6.36%
	30	34.08%	15.54%	11.94%	7.90%	5.96%	6.27%
Latency (minutes)	60	34.08%	15.54%	11.95%	7.90%	5.97%	6.28%

Figure 21 Results of High-definition Engineering Intersection Data

The ‘sweet spot’ revealed by the FDOT phase I exercise points toward a 15-minute time interval at 15 minutes latency. For probe only testing, this resulted in 12.15% MAPE. Note that MAPE is relative to absolute volume, this is likely well within the 10% accuracy target for error to maximum theoretical capacity ratio (ETCR) or error to maximum observed flow ratio (EMFR).

Industry Stakeholder Engagement

Industry engagement was conducted with vendors within the Coalition's Transportation Data Marketplace (TDM) with volume data products (offering historic volumes such as AADT), as well as other vendors associated with the TDM either through ancillary products, or sub-contractor arrangements with core vendors. Engagement included an informal interview asking the vendors to describe the status of the industry as outlined below, as well as any publicly accessible documentation volunteered by the vendors.

The interviews requested feedback from the vendors in these areas:

- What are your firm's current volume data products offered in the traffic data market?
- What has the reception to these volume data products in the market been relative to your other traffic data products?
- What are your firm's current or future planned data products or applications with respect to real-time volume data feeds?
- Have you received any direct customer feedback related to need or demand for real-time volume or products?
- Are there any data supply chain issues or peculiarities with respect to real-time volume products relative to planning level (historical) data products?
- What role can the Coalition play to facilitate advancement of real-time volume or its associated applications?

A summary of the stakeholder engagement for each vendor interviews is provided below:

HERE/Bentley

HERE/Bentley currently supports the TETC TDM through various volume related products such as AADT, ADT, AHDT, and daily and hourly volumes, and has been a consistent participant in the Coalition's volume validation activities since the validation for volume products was initiated in 2022. With respect to volumes, HERE/Bentley shared that 'it is an interesting time', the advancement in data science and core data supply chains have made volume products available, but relative to other products (such as travel time and speed), they are harder for DOT planning departments to utilize and integrate into productive workflows. AADT is the most commonly requested product. Having AADT disaggregated by day of week and hourly distributions has also been productive for our customers. The customer base has been primarily the planning community and their associated planning applications. Request for seasonal data is heard often, particularly with respect to tourism. There is an occasional request for month specific data, but not that often.

Most transportation agencies have committed to the concept of probe-based volume data but are only in the first stages of either procuring or integrating it into applications. The newness of such data streams has many agencies on 'information overload', attempting to sort out the marketing noise from the actual value of the various products. Agencies are ready to engage in this space but are struggling to get up the learning curve. They have progressed to the point of acknowledging that probe-based volumes are viable and available in the market but are now in the process of sorting out the market.

Current volume products from HERE/Bentley are for planning level applications. We (HERE/Bentley) are continually considering the state market adoption, however, the progression and inquiry into real-time volume data is too big of a leap at the present time. Real-time volume appeals to our ITS and operations customers, while most of the experience with current historic volumes are with planning practitioners. The HERE/Bentley data team monitors the space and have neither ruled out nor made plans for real-time products. If the data quality is there from the data supply chain for real-time volume products AND if the market presents demand, we would move into that space. There has been an occasional inquiry for location and time specific volumes typically related to a large event such as hosting the Olympics or the World Cup, but not a consistent request from customers for real-time volume data of this nature.

HERE/Bentley perceives that higher granularity volume data (even real-time) is currently feasible in certain areas, and on certain facilities where adequate base level data would support such a product. In contrast to travel time and speeds, the data supply chain is not yet mature to develop a nationwide model that would produce quality results generally across any geographic area and on a variety of (upper level) road classes. Real-time is possible for a corridor or limited geographic scale application in which a process to acquire data, build a model, and process can be efficiently managed. However, translating it to a nationwide deliverable is not viable at this time as there is inadequate data for a real-time model at that scale. If a state DOT is interested in real-time volume data, it is recommended at this time to have geographic specific discussion with suppliers including the identification of specific corridors, road types, and/or regions in mind.

INRIX

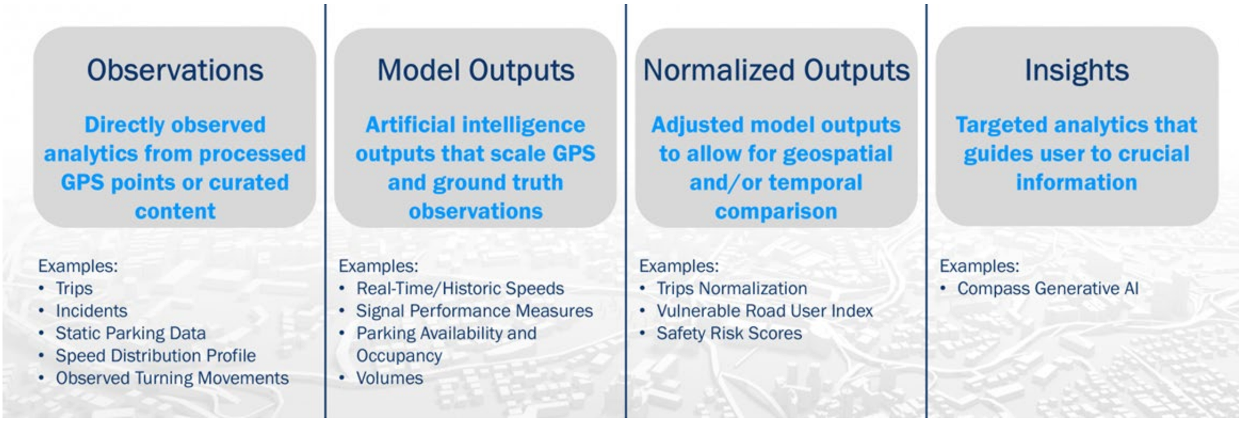
INRIX has participated in the Coalition TDM with respect to volume estimation since its inception in 2022, including the volume validation exercises that commenced in 2022. Even prior to the current TDM, during the VPPII (the previous phase of the TDM which ran from 2014 to 2022), INRIX supported an ancillary volume product that provided expected volumes for roadways modeled after factored AADT (sometimes referred to as the TTI method). This process produces anticipated volumes for a roadway based on the time of day and day of week for nominal traffic conditions.

Products in the INRIX portfolio currently provide absolute volume estimates and align with the historic planning applications that need AADT, ADT, or AHDT. These products help serve the need to provide average volume estimates on all public roadways as per MIRE requirements beginning in 2026 (as previously discussed). It is important to note that AADT, ADT, and AHDT taken from traditional sources such as pneumatic tubes are also modeled calculations. Also volume estimates for particular day/hour can fluctuate greatly, whereas AADT, ADT, and AHDT are single values over long periods of time (typically a year or quarter) reflecting nominal traffic conditions.

INRIX has several volume-related products for TSMO in the pipeline and some even on the market. The biggest impediment in the marketplace to real-time volume and the associated TSMO applications is that the concepts and language with respect to volume estimation (moving to real-time volumes) are often obscure and muddled. Defining terminology and providing education to the industry on various approaches to volume estimation is needed, and a role that the Coalition can play. INRIX defines various volume related products within the following construct:

- *Observations*: This is the number of probe vehicles that pass a point or were observed on a segment for a given time period. INRIX can provide this today with low latency and marketplace customers receive this data on a monthly basis. Whether observed number of vehicles is provided in real-time or with higher latency, such as hours or days later, is determined primarily by the requirements of the application. For low-latency real-time volume applications, the penetration rate of the probe data source (and thus the number of observed probes) is impacted by latency requirements. The longer you are able to wait for data, the more data sources can report (as reinforced by other vendors). Some data providers provide probe observations to INRIX with low latency (such as under every 5 minutes) while others will provide observations every 15 minutes, every hour, or days later (inducing a possible 15 minute to one hour latency). The longer the allowable latency, the higher the penetration rate as more data becomes available.
- *Scaled Volumes*: Scaled volumes take into account both the observed number of vehicles as well as the penetration rate of the probe-vehicle data to provide an estimate of absolute volume. Penetration rates are hyper-geographic with significant variations from region to region, by time of day or longer temporal periods, and across various roadway types. This makes it difficult to generalize scaled volumes across large regions and obtain reasonably accurate estimates of absolute volume at scale. Additionally, on lower volume roads scaling factors can be challenging as the variability can be significant with minor changes (i.e. - +/- 100 vehicles per day have a bigger impact with AADT is 500 vs 50000). The availability (and variability) of probe source data is also a critical factor in volume data quality. Scaled volume estimates need to be sensitive to, and continuously monitor for, the availability of all contributing source data streams.
- *Model outputs*: Modeled volume estimates provide expected volume for a roadway for a particular location and time period based on planning style models of the roadway network and associated demand. Such models typically run periodically, such as quarterly, and can be informed by probe-data, but are still primarily modeled output reflecting nominal conditions for planning level applications. These outputs can be attached to a real-time data feed such as travel time and speed, but do not reflect impacts during atypical situations such as incidents, events, or roadway construction.
- *Normalized Volumes* is a term INRIX used to reflect an adjusted observed volume taking into account the variability of available probe sources over time. Normalized volumes provide a way to compare observed probe counts over long periods of time without worrying about which data providers are included and the scale of their probes.

INRIX provided the following graphics to better illustrate this construct:



The federal government is both an enabler and a hindrance to volume data products. The MIRE requirements spurred interest in probe-based volume estimates, however the current policy of the federal government to allow for 'non-traditional sources' of volume data is still in an experimental basis, slowing adoption. Also, there is discussion, perhaps debate, in the industry on whether volume data should be a standalone product or integrated into existing travel time and speed APIs, and TSMO specific applications.

The industry demand for volume data, as measured by product inquiries, is low relative to other traffic data products from INRIX. Of the inquiries received for highly granular probe-based volumes, requests are dominated for the need for turning movement counts at intersections, particularly from local jurisdiction who have responsibility for maintaining signal timing plans.

With respect to the role the Coalition can play to advance probe-based volume estimates, inconsistent nomenclature is an issue in sorting out the many products coming online from various probe-based vendors. For example, some customers use the term 'trips' and 'volumes' interchangeably, whereas internally at INRIX they refer to distinct products, thus causing confusion. The Coalition can assist in education and moving the industry to standardize terminology and minimize market confusion. INRIX recommended that the Coalition sponsor a webinar or symposium geared specifically toward education, providing vendors opportunities to explain processes, terminology, and discuss limitations of volume estimation technology.

With respect to real-time volume estimates, INRIX can support observed turning movement counts in near real-time, while scaled turning movement counts remains problematics due to the issues cited previously. Planning level volume estimates, such as AADT, continue to evolve in response to customer feedback. INRIX is moving to a quarterly product to reflect seasonality.

Iteris

Iteris is a core data vendor for volume products in the TDM and has participated in volume validation exercises since its inception in 2022. Iteris's current capacity with high granularity volume data is best exemplified with their client in Ventura County, CA, where 15-minute volume data is integrated into the Clear Guide software product to allow transportation practitioners to view sub-hourly traffic in relation to various other performance metrics. Though not generated in real-time, the sub-hourly granularity of volume estimates allows for high accuracy performance metrics related to total hours of delay. This proved an effective tool to observe the shifts in traffic patterns when a bridge on the I-10 corridor in LA was disabled due to a fire.

Work zone analytics within Clear Guide utilizing high granularity volume estimates is a valuable application showing how much traffic is being diverted as a result of construction activities. Volume data also allows practitioners to better analyze traffic incidents analysis and after-action reports in conjunction with other measures of congestion.

It has been Iteris' experience that integration of volume data into existing applications provide for better customer adoption. It allows them to grow into the new data and assess what it can do for them. This type of exposure allows more people to become familiar with and understand the product and process, and its limitations. The need for volume data may be dictated by local rules and regulations. For example, in CA, any capital project cannot raise VMT, and data is needed to validate compliance to this regulation.

Currently Iteris calculates granular volume estimates for a full year and then populates the associated applications (such as Clear Guide) with sub-hourly volume estimates. This is the same process used to generate volume estimates for TETC validation process.

Further, Iteris has emphasized and developed visualization tools both for its highly granular volume estimates as well as planning level AADT and ADT estimates. One example is the application of volume data estimates to calculate wasted fuel cost due to construction induced congestion. Current volume products are limited to the TMC network, but Iteris is moving to include all functional road class 5 and above, part of the HERE linked network of roadways.

Technically, moving from high-granularity estimates (sub-hourly) to real-time is on the horizon, but needs to be market driven. Although there are technical issues, the primary issue is market demand sufficient to justify the investment in product development.

Iteris does expose some relative measures of volume in real-time in the form of observed counts displayed in Clear Guide, with no effort to calibrate or normalize. Although magnitude of penetration rates (also referred to as sampling rates) are touted as key elements in volume estimation, Iteris has found that consistency and stability of penetration rates are equally important for quality volume estimates. A national volume model could be created; however, it would need a national buyer to make the economics viable.

With respect to the role of the Coalition, Iteris would encourage studies that validate minimum sampling rates and impact of penetration rate stability on quality of volume estimates.

TomTom

TomTom (https://www.tomtom.com/) does not directly provide volume estimates within the Traffic Data Management (TDM) framework; rather, it collaborates with several partners in its data supply chain to offer a range of traffic products, including volume estimates. One of TomTom's key offerings is the 'Traffic Stats' product, a historical traffic database that not only includes the number of observed probes but also provides valuable insights into road speeds and travel times (https://www.tomtom.com/products/traffic-stats/). Many of TomTom's partners leverage the Traffic Stats product to generate value-added volume estimates for planning purposes.

At the TRB annual meeting in 2025, TomTom introduced its Historical Traffic Volumes product (https://www.tomtom.com/products/historical-traffic-volumes/), which grants users access to essential metrics such as Annual Average Daily Traffic (AADT), Annual Average Daily Hourly Traffic (AADHT), Average Daily Traffic (ADT), and Average Daily Hourly Traffic (ADHT). Customers and partners can access the Historical Traffic Volumes product through an API, batch delivery, and TomTom Traffic Insights, with plans to offer it soon as a map layer and via the TomTom Move portal (https://move.tomtom.com/).

What sets TomTom's Historical Traffic Volumes product apart in the market is its foundation on extensive probe data and high penetration rates. In addition, TomTom's expertise in mapping allows for the consideration of crucial attributes such as roadway capacity, resulting in highly accurate volume estimates across a vast network.

The high penetration rate was further validated in a study comparing historical ground truth counts from the Maricopa Association of Governments (MAG) with TomTom data. This study revealed an average penetration rate of 29.1%, consistent across various times of day and traffic volumes. For more details on this study, please refer to this link.

Real-time volume estimates are a key feature of TomTom's product, 'Junction Analytics' (https://www.tomtom.com/products/junction-analytics/), which is designed for managing signalized intersections. This tool provides a real-time volume metric that estimates the number of vehicles passing through a junction per hour. In addition to the real-time volume metric, Junction Analytics offers several other metrics, including Delay, Usual Delay, Queue Length, Travel Time, Stops, Historical Data, Turn Ratios, and Accumulated Probes. While all these metrics are available in real time (updated every minute), a historical archive of the data is also provided. The product is user-friendly, accessible via a web UI and an API, and assists road authorities, traffic managers, and engineers in optimizing traffic light performance. It is also accessible in the TDM through partner FlowLabs as an ancillary product under GeoTab.

Regarding TomTom's Historical Traffic Volumes product, it is still early to gauge market reception. However, there was significant interest at recent events, including the TRB and the Consumer Electronics Show (CES). TomTom anticipates that demand will grow as these products are integrated into their standard offerings, namely TomTom Orbis Maps and TomTom Traffic Analytics.

As for TomTom's Real-time Volumes, this feature has been in production within the Junction Analytics product for several years and is experiencing strong interest. TomTom is viewing the demand for real-time volumes mainly in traffic signal operations space, where it can be utilized for turning movement counts and for calculating performance metrics such as delay time, safety, emissions, and noise levels. The signal control industry traditionally relies on sensor-based data but recognizes that scaling this data can be challenging due to costs and maintenance concerns. By combining existing sensor data with probe data and potentially leveraging AI, there is a promising pathway to enhance intersection intelligence in a cost-effective manner. The confidence in probe-based volume estimates has been bolstered by the publication of a 2024 TRB paper (https://journals.sagepub.com/doi/10.1177/03611981241289408), which compared and validated theoretical volume data estimates against ground truth data.

In summary, TomTom anticipates strong interest in their new Historical Traffic Volumes product. Meanwhile, the real-time volumes offered in the Junction Analytics product are already being utilized by numerous customers within the traffic signal operations sector. TomTom believes this area represents the most relevant application for real-time volume data. With regards to the role of Coalition, TomTom sees value in benchmarking probe-based signal optimization products including the real-time volume metrics used in these products.

Streetlight

Streetlight has been a core volume data vendor within the TDM since 2022 and has participated in all the validation activities. Streetlight was one of the first vendors (if not the first) to provide historic volume products based on probe data sources to support various planning applications. Streetlight has witnessed market demand for their products being driven by volume estimation products, even more than from origin & destination information which was Streetlight's original market entry product. Discussions with clients may be initiated by MIRE reporting requirements, but historical volume estimates are used not only for AADT reporting, but for a variety of transportation planning purposes.

Streetlight was acquired by Jacobs two years ago, and concurrently started a product focus on operations and TSMO applications evolving from their core expertise in the planning space. While StreetLight's planning level products offer monthly updates of volume estimates and other traffic data like speeds, StreetLight's operations and TSMO level products are distinguished by a focus on providing more frequent updates with less latency, for certain types of data. This includes what StreetLight describes as "near-real-time" data updated daily with 24-48 hours of latency, and "real-time" data updated minute-by-minute with 2-3 minutes of latency.

With respect to real-time products in support of traffic management for atypical demand patterns such as those induced from major incidents, special events, or road construction activities, market feedback has been to incorporate some type of volume measures (either absolute or relative) alongside travel time and speed in a single feed or programming interface or dashboard.

For construction planning, data from the previous month is timely enough to determine appropriate times for road closure as well as for restricting work zone hours so as not to impede on peak traffic times. Such applications require absolute volume estimates.

Near real-time data, defined as volume estimates with latency between 24 to 48 hours, support a variety TSMO applications. Many near real-time uses of volume estimates can operate on relative volume estimates, as opposed to absolute volume estimates. Some probe data sources can take up to half a day to report, so the lower the latency, the lower the penetration rate. Streetlight is currently producing monthly absolute volume estimates, and near real-time relative volume estimates, with a roadmap to near real-time and real-time absolute volume products.

Streetlight utilizes two types of data sources for its real-time and near-real-time applications. One source is connected vehicle data, which is typically provided by vehicle OEMs and comes in the form of GPS trajectory traces. This data is delivered in real-time, and currently licensed in its native form to DOTs for application development. State DOTs that license this data are typically supported by partnership with a University to leverage this data to productive applications. The second major data supply chain source to Streetlight is pre-aggregated probe data in the form of vehicle count and associated speed, not vehicle trajectories. The second source of data is currently driving Streetlight TSMO specific products, such as the development of their near-real time and real-time offerings in their dashboard.

Streetlight notes that there is a fuzzy line between planning and operations, perhaps ‘planning for operations’, for which the near-real time is bridging to TSMO applications. These include applications to support Vision Zero and Safety concerns when multi-modal data is needed across the entire network to screen for hazard levels for people walking and biking.

With respect to the Coalition role, Streetlight suggested that any webinar or symposium include actual member use cases for vendors to respond to while discussing their volume products. StreetLight also encouraged the Coalition in its effort to standardize terminology across the industry, as both different members and vendors may have small differences in what is meant by “real-time”. One use case’s real-time data update frequency and latency requirements may be a different use case’s “ancient history”.

Flow Labs

Flow Labs participates in the TDM through two ancillary products as a subcontractor to GeoTab. These products both contain and integrate probe-based volume estimates as described further below.

Traffic Signal Operations Solutions: This product provides member agencies with a tool kit for management of signalized intersection and consists of three components (1) signal optimization (2) probe-based signal performance measures (PBSPMs), and (3) probe based measures integrated with sensor based automated traffic signal performance metrics (ATSPMs) – a hybrid approach called Integrated Signal Performance Measures (ISPMs). Probe based metrics include real-time turning movement counts for signalized corridors along with speeds, travel times, queue length, stops and delay, emissions and fuel consumption. Volumes estimates may be based wholly on probe data, or a hybrid of probe data and available sensor data. This allows for utilization of sensors when available in the field, while still providing valid estimations when neither sensors nor connectivity exists at the intersection, creating an ‘Infrastructure Agnostic’ approach. Flow Labs partners with TomTom for provision of the base probe data, with processing methodologies unique to Flow Labs.

Roadway Safety Management – This product integrates data from multiple sources, creating outputs not possible from a single source. Input data includes probe vehicle data for volumes (though not in real-time) and speeds, crash data and fatal crash data, and connected vehicle data for hard braking, aggressive acceleration, phone handling, suspected unreported crashes, and high-speed events. The volume data integrated in the Roadway Safety Management platform includes historical volumes such as AADT and VMT, from historical probe traffic data from TomTom and data from count studies and continuous count stations (CCS).

Flow Labs has additional products that incorporate probe-based volume estimates such as Mobility Management Solutions, that incorporates various volume estimates (both historic and real-time) along with traditional travel time and speed measures – however, this product is not currently accessible in the TDM.

Overall, interest from customers for real-time volume information is relatively low as compared to historical planning level volume measures. Improved and expanded volume data for planning applications directly improves decision making providing return on investment. Flow Labs has observed that real-time volume for operations may inform situational awareness but does not significantly enable or impact the decision space for operations management. Integrated corridor management system (ICMS) is a notable exception, and the FDOT exploration of real-time turning movements (as previously described) exemplifies this. Within ICMS, better volume data enables decisions with respect to signal timing plans or signage in response to atypical traffic patterns. Real-time volumes, when combined with location detection, also enable calibration and validation of sensors, providing the ability to detect and correct sensor drift biases that can grow over time.

Understanding how penetration rates vary with time is critical to make accurate absolute volume estimates (as attested by several vendors). Penetration rates change for a number of different reasons, and an integrated approach that utilizes both historical and continuous count data (from sensors) is required to scale observed vehicle counts to accurate absolute volume estimates.

The Coalition's validation studies are critical to the industry. These validations have traditionally compared probe data-based volume estimates with sensors-based counts from either continuous count stations using primarily inductive loops or temporary counts using primarily pneumatic tubes. Flow Labs recommends the validation also include manual counts from video to assess and account for detection device error, as Flow Labs experience has indicated that sensor error can be significant. Flow Labs also recommends opening the validation activities to additional vendors outside the Coalition to encourage new data feeds and technology. Providing an onboarding path for new technology, as well as a pricing model to allow DOT's to 'dip their toe in the water' before committing, would help advance new data and applications such as real-time volumes.

Replica

Replica has participated in the TDM beginning in 2022, providing planning level volume estimates, accessible as an ancillary product. Replica is somewhat unique in that their volume products are best described as model driven by field data. Any vendor in this space uses a combination of probe observations combined with some type of algorithm or model to provide an estimate of volume, and the extent to which volumes are modeled or data driven is a continuum. On that continuum, Replica is more model centric but informed by and validated against field observations. Using this approach, Replica provides two volume data products. The first is Network Link Volumes that provide seasonal volume estimates for typical week and weekend travel. This model is run twice per year, once in the spring and once in the fall. The outputs are multi-modal in nature, informing (estimating) private auto trips, commercial trips, transit, bicyclist, pedestrian and taxi & TNCs. Replica also supports an AADT product, updated annually which includes estimated vehicle AADT, single unit trucks and combination trucks as well. The AADTs are disaggregated into hourly estimates using an hourly volume profile, which is an expected distribution of hourly volumes based on the road type and other factors. AADTs are provided for a wide variety of roadway classes, noting that the lower roadway class, the less accurate the estimate. Accuracy is a function of the number of samples of probe data observed, which scales with roadway volume, and the proximity of the road to the nearest continuous counter in order to have a more accurate estimate of probe penetration rate. Replica's coverage for various road classes is detailed at the following web resource: https://documentation.replicahq.com/docs/annual-average-daily-traffic-aadt

Source data security continues to be a concern for the industry. Even though the industry is past the upheaval from 18 months ago related to policy changes from Apple and Google with respect Location Based Services data, as well as the disruption due to the insolvency of Wejo, the industry is not 'out of the woods' yet with respect to privacy concerns, and the industry could still impacted by the availability of data supply chains moving forward due to PII policy.

With respect to future volume products that serve TSMO application, Replica is actively investigating but has not committed to a product at this time. If such a product is developed, the underlying model would be lighter than that for Network Link Volumes product and rely more heavily on field observations. Real-time volumes would be more vulnerable to supply chain volatility than volume estimates for planning applications. Whereas planning level estimations can tolerate a momentary absence of data (perhaps for a few days or even weeks) while still creating quality products, in contrast, a real-time volume estimate is directly exposed to any outages in the data supply chain.

Overall, market reception for Replica's volume products for planning applications has been positive. Communicating the approach Replica takes, that of combining a model with field observations has been challenging at times, though in general that market is responding favorably. The rate of adoption could be increased with greater collaboration between the private sector vendors and the agencies either procuring or developing the specifications for the data, with specific reference to the use of such data for HPMS reporting (MIRE 2026). The Coalition continued validation efforts with industry helps to build trust both in the data products and in the data science processes that support the products. Also, the Coalition role as a convener between industry, states, and FHWA in exposing the quality and value of volume estimates though probe-base data sources is also extremely valuable.

Geotab

Altitude by Geotab has been available through the TDM since 2022, with particular emphasis on freight data. Altitude by Geotab has developed and supports a comprehensive AADT traffic product providing traffic estimates across six million road segments (covering motorway, trunk, primary, secondary, and tertiary roads) nationwide. The product offers three distinct vehicle groupings: heavy-duty commercial vehicles (over 26,001 lbs.), medium-duty commercial vehicles (10,001-26,000 lbs.), and universal (all vehicles). The medium and heavy duty AADT volume estimates leverage Altitude by Geotab extensive network of fleet telematics data, while the universal estimates incorporate sophisticated machine learning models tailored to each road type, achieving high accuracy rates (R-squared values of 85-96% depending on road type). The models integrate HPMS data through advanced mapping techniques to ensure reliability, with transparent methodology documentation.

The AADT product is currently available for 2022, with 2023 data in final production stages. The Altitude development path includes reducing data latency to make yearly estimates available shortly after year-end, followed by more frequent updates (monthly or quarterly) with minimal delay.

The medium and heavy duty AADT products fill a critical market gap, as many planning functions have relied heavily on inference and factorization for truck volume estimation. Customers are using these products for freight planning, infrastructure investment decisions, sustainability initiatives, and strategic site selection. Altitude by Geotab has established strong relationships with consulting partners who directly service DOTs for modeling and specialized projects. Altitude by Geotab's roadmap includes a rolling archive of medium and heavy-duty truck volume estimates. While real-time capabilities remain a longer-term goal, the company acknowledges technical challenges including sample sizes, latency, and privacy considerations. Altitude by Geotab maintains a privacy-first approach with comprehensive data aggregation and de-identification protocols.

The role the Coalition can play is to facilitate conversations about use cases and priorities for freight volume estimates, particularly in helping establish accuracy specifications and validation methodologies for medium and heavy-duty volume data.

Recommended Real-Time Volume Data Specifications

Procurement specifications for volume data from the latest phase of the TDM awarded in 2022 are included in Appendix B. These are provided as reference only, as they form the basis for building on existing TDM practice moving forward. The TDM specifications listed in Appendix B include both those for travel time and speed data (section 1.0) as well as that for volume data (section 2.0) as many of the volume data specifications reference specifications for travel time and speed data with respect to attributes (such as the inclusion of a confidence score) as well as location referencing. Note that the TDM awarded in 2022 included specifications for real-time volume, but no vendor proposed a real-time volume product. Rather, the volume data that was proposed and is now included in the TDM are historical volume data, primarily for planning applications. Even so, the format and specifications from 2022 are used as a basis for possible future procurement of real-time volume data in the TDM. Based on the information gleaned from REVEAL, the following recommendations for future TDM real-time volume include:

Recommendations from REVEAL:

Types of Volume Estimation

The 2022 procurement specified absolute volumes, which estimate the number of vehicles on the roadway similar to what would be reported by a sensor. Feedback within the Coalition as well as from the vendors indicated multiple approaches to reporting volume. Such approaches include:

Absolute volume: Absolute volume is an estimation of the flow rate of vehicles either in vehicles per hour (vph) or absolute number of vehicles for the time period.

Observed vehicles: This is the number of probe vehicles observed in the probe data for the specified time period. Note that in the 2022 TDM, specification 1.1.6 from the Travel Time and Speed requested (as a desirable attribute) the number of samples. This is equivalent or synonymous with the number of observed vehicles.

Modeled volumes: This method uses a regional flow model with a roadway network and demand patterns informed by probe-data to estimate primarily planning level measures of volume. The result is typically an absolute volume estimation for a roadway under nominal conditions.

Scaled Volumes: A scaled volume estimate used observed volumes as a basis and factors up based on known penetration rates to obtain an estimate of absolute volume. Scaled volumes must take into account penetration rates and variation in penetration rates to achieve accurate results.

Relative Volume or Volume Index: Relative volume (or proportional volume) estimation is a percentage of traffic relative to normal/expected volume flow for the time period. Relative volumes require less calibration and can be achieved as a ration of the observed vehicles to the expected number of observed vehicles based on the time of day and day of week. A volume index would report volumes in a simplified scale such as opposed to percentages. The scale may be as simple as above average, average, and below average, or +- deciles to nominal volume.

Roadway Type

Roadway types are defined in the 2022 TDM (see 2.5.1 to 2.5.8), borrowing from travel time and speed specifications from section 1. With the known issues related to penetration rate and penetration rate variability, and the impact of overall volume flow to accuracy, it is recommended that future specifications be with respect to absolute volume flows as well as with respect to functional class and associated applications. For example, for volume flows that are above 4000 vph, the accuracy specification may be 5%, or accuracy within 200 vph, where as volume flows below 400 vph may have an accuracy specification 20% or 80 vph.

Applications Supported

The 2022 TDM envisioned volume data feeds would be provided similar in concept to travel time and speed APIs. Stakeholder engagement with Coalition members and vendors revealed strong application dependency with respect to market demand as well as technical specifications. Leading applications included turning movement counts for intersections, atypical volumes associated with major incidents, large events and severe weather activity, volumes for operations performance measures, and volumes for management of lane closures. Specifications for quality and delivery should be provided by or indexed to the application categories as cited previously.

Confidence Attribute

Accuracy of volume estimates is well understood, being a function of penetration rate, volume (penetration rate x volume = sample size) and penetration rate variability. The larger the sample size, the higher the accuracy. A confidence indicator, similar in concept to that used for travel time and speed, is needed in volume as well. However, the form has not been specified.

Time Reporting Interval

Reporting interval refers to binning volume data into time increments such as 5 min, 15 min, or 1 hour. Current evidence points toward 15 minutes to 1 hour reporting intervals as the highest that can be achieved with reasonable accuracy. However, as time improves, this may decrease.

Latency

Latency refers to the delay in time between the receipt of the observed volume (or absolute or scale volume estimate) and the end of the corresponding reporting interval. Current evidence points toward a 15-minute latency to allow for maximum penetration rate.

Update Frequency

Update frequency refers to how often a volume estimate is created and delivered. Modern travel time and speed data feeds provide updates once every minute. The update frequency must be greater than the time reporting interval. For example, if the time reporting interval is 5 min, the update frequency must be at least once every 5 minutes. However, the update frequency, can (and often is) greater than the time reporting interval. For example, if the time reporting interval is 15-minute volumes, the update frequency can still be one minute. Each minute, a new estimate of 15-minute volume is provided.

Accuracy

Different applications require varying accuracy. See discussion on applications supported. The general target of 10% accuracy measured either in absolute difference (MAPE) or relative to either capacity (ETCR) or maximum observed volume (EMFR) observed in early research from surveys appears consistent with current stakeholder feedback.

Location Referencing

Standardization of API calls is recommended to continue to evolve the TDM to highly flexible, vendor agnostic data services. Volume flows differ from travel time and speed conceptually with respect to location referencing. Travel time and speed data at its basis requires a segment definition with vehicles entering and departing in order to establish a valid travel time (or speed derived from the travel time). However, volumes can be established at any point along the roadway as the number of vehicles passing a screen line in a specific direction.

Location referencing should include any accepted location referencing as designated in the 2022 TDM AND evolve to include a required standardized API call that is map agnostic similar to the CWGP introduced in the 2022 TDM.

Validation

Validation in the TDM for real-time will evolve within current volume validation procedures in which an independent source of volume counts can be obtained (the reference volume) and compared to the vendor provided volume estimates for accuracy, latency and other attributes. One vendor noted that reference volume (ground-truth volume) should include manual vehicle counts through video to assess sensor error.

Summary and Recommendation

In 2025, three years into the third phase of the TETC TDM, this REVEAL project has assessed the technical capacity of industry to begin to provide real-time volume data, the applications for which such data would provide benefit, and the pathway toward achieving real-time probe-based volume estimation capability. The foundations for achieving this capability were laid through previous research (MCOMP-II), development of planning level volume estimates in the form of AADT, ADT, and AHDT spurred from MIRE reporting requirements, and accelerated through USDOT 'non-traditional volume measures' initiative. The ability to acquire quality planning level volume estimates is attested by the 2022 TDM and its multiple vendors that provide such data to Coalition members and participate in TDM validation activities. The TDM validation also assesses daily and hourly volumes quality for a specific roadway segment, the results of which indicate that industry is on the verge of delivering highly granular volume data (not in real-time) of sufficient quality to support date and time specific performance metrics reflecting atypical traffic flows. Further assessment by Florida DOT indicates that real-time turning movements at intersections are beginning to become available with adequate accuracy to support integrated corridor management.

A survey of Coalition member revealed that the leading applications or market demand are for traffic signal operations, operations performance measures, and various TSMO applications for incident management, special event management, detour planning and management, and allowable lane closure hours. Interviews with vendors currently supporting some type of volume product affirmed the feedback from Coalition members with respect to application specific use cases as the market driver. Vendor interviews also provided insight into industry capacity, market demand, and constraints. Several vendors are either providing, or positioned to provide, some form of real-time volume estimates in a dynamic form, but at limited geographic scale.

Latency in current planning level volume products range from one month to one year. 'Real-time' refers to data delivered within 5 minutes to one hour after the reporting time interval , and 'Near Real-Time' refers to 24 to 48 hours after. Various volume measures may benefit TSMO applications such as absolute volume, volumes relative to nominal conditions, reporting of number of observed vehicles, or a volume index. Absolute volume are the most difficult to achieve accurately at scale, whereas relative volumes or a volume index may be feasible in the near term on a broad geographic scale. Vendors agreed that real-time volumes for specific corridors, intersections or regions, on roadway with significant vehicle demand is currently the state of the practice. However, the market for real-time volume data remains uncertain, and an evolutionary path to ever increased scale and fidelity appears to be emerging as the preferred path. At this time, industry does not have the capacity to produce absolute real-time volume estimates from probe data at large geography scale to a high degree of accuracy. This is largely due to variations in probe vehicle penetration rates which can vary significantly across geography, time, and road class.

As a result of the findings in this report, the Coalition makes the following generalized observations.

- Volume estimations for planning measures such as AADT, ADT, and AHDT are available from multiple vendors, and the quality appears to be maturing quickly based on TETC validation results. Data supply chain disruptions that occurred 18 to 24 months ago, appear to have been resolved. Currently planning volume estimation products are finding a ready market for a variety of planning functions, which continues to drive investment by the industry.
- Highly granular volume data (not in real-time) is currently within the TDM market and is tested yearly as part of the TETC validation. However, the maturity of these products and their ability to be refined into productive applications are still in development. Only two vendors were able to produce hourly volume estimates that were sensitive to atypical demand in April of 2024. The vendors that captured atypical volumes, however, varied in their ability to estimate it accurately.
- Application specific volume estimation for signalized intersections and integrated corridor management are beginning to emerge as witnessed by the Florida assessment activity. Turning movement counts was ranked consistently in the top three applications by Coalition members for real-time volume estimation. This is also consistent with vendor feedback that real-time volume at limited geographic scope for specific corridors and applications can now be considered.
- Broad-based volume monitoring for all highways similar to how state DOTs are accustomed to ingesting travel time and speed is not available on the market at this time. Some evidence exists and points toward this level of capability in the future as data supply chains mature, grow and become more stable, AND demand for such data on a large geographic scale emerges. This will likely first emerge as relative volumes or as a volume index.
- There are four forms of basic traffic flow data that crowd-sourced probe data may someday be able to provide universally and reliably: how *fast* things are moving (speed data); how *many* things are moving (volume data); *where* they are coming from and going to (O/D); and the pathways they are taking (*routes with travel times*). While several vendors noted a reluctance to invest heavily in volume reporting capabilities in the face of lukewarm demand from agencies, Streetlight noted how their volume capabilities are driving demand even more so than their legacy O/D capabilities; and Iteris noted how their users highly prefer data that have been expanded to represent all traffic. Evidence suggests that when there are flow products with proven accuracy, reliability and consistency, agency demand for such products will emerge.

This report makes the following recommendations for incorporating and encouraging continued development and refinement of real-time traffic volume and supporting applications within in The Eastern Transportation Coalition Transportation Data Marketplace. These recommendations were gleaned from the evidence presented and informed by interviews with vendors and stakeholder engagement with Coalition members. It is recommended that …

- The Coalition continues volume validation activities, rooted in planning level volume measures, but evolving to more granular and time dynamic measures (ultimately real-time). The pace for evolution should match the evidence in the market of the capacity of data vendors as it presents itself.

- The Coalition should provide opportunity for new products/vendors to participate in the validation activities, particularly with respect to emerging capabilities such as real-time volume with paths enabled to inclusion in the TDM.
- The Coalition should invest in education such as webinars and symposium. These not only provide opportunities for vendors to share capability but also helps to normalize/standardize the vocabulary and lexicon in this space, avoid market confusion which slows adoption, and assist agencies to 'sort out the market' and shorten the learning curve. This also allows Coalition members to share use cases for such data for which industry can respond.
- The Coalition should investigate reasonable technical guidelines for specifications for real-time volume such as data reporting intervals, latency, accuracy with respect to targeted applications as an integral part of their ongoing validation. Real-time volume specifications should build on prevailing volume specifications from the TDM, though customized and modified as needed.
- The Coalition should encourage DOTs to 'dip their toe in the water' with respect to these emerging capabilities through support by the Coalition staff as well as appropriate pricing mechanisms in the TDM that allow for 'try before you buy' approaches.

The Eastern Transportation Coalition (TETC) has been a national leader in research and demonstration of the feasibility of volume estimates from outsourced/probe data. As an outcome, historical volume estimates such as AADT, ADT, and AHDT are now available through the Transportation Data Marketplace (TDM). However, real-time volume data has yet to be commercially available. Evidence from TETC research, namely the TETC's Southeast States Hurricane Evacuation Monitoring pilot, as well as the most recent TETC Volume Validation from Georgia in April of 2024 point toward the viability of acquiring volume estimates from probe data in a dynamic fashion to support TSMO related applications in the near future.

The objective of REVEAL is to accelerate the availability of real-time volume data by developing a procurement strategy specifically targeted at volume data that would support TSMO applications of interest within the TETC. Real-time volume data refers to volume estimates on a roadway for a specific date and time, rather than an average or typical condition – AND delivered in a timely fashion, with minimum latency as opposed to the planning level estimates that are delivered from a week, to a quarter, to a year after the fact. REVEAL will develop specifications for inclusion into the TDM, and facilitate the discussion between practitioners and industry providers on the attributes of new volume products to support agency needs.

This questionnaire is developed to enable TSMO practitioners within the Coalition to provide feedback on applications of real-time or near-real time traffic volume data. This questionnaire uses the term 'real-time' to reflect volume estimates on specific roadways provided through a data feed from an industry vendor in a timely fashion. Real-time can be delivered near instantaneously with delay as little as seconds, or may be delivered with a 15 min, 30 min, or even an hour time lag. Depending on this time lag and accuracy of data, targeted TSMO applications may or may not be feasible. The goal of the REVEAL initiative is to encourage and foster the dynamic delivery of accurate volume estimates to support TSMO applications. The questions below begin to provide a basis for how such data would be used to help guide industry to value-added data products.

Contact Stan Young at seyoung@tetcoalition.org or at 301-792-8180 for any questions

Please provide contact information

Agency or Institution Name	
Name	
Position	

Role within Agency or Institution

Email Address

Would real-time volumes (such as through movements and turning movement counts) be useful or valuable for

- [ ] Signal Retiming
- [ ] Traffic Signal Performance Measures
- [ ] Adaptive Signal Operation (automatically changing plans based on demand)
- [ ] Before and after studies for signal retiming
- [ ] Low volume intersections
- [ ] Identify inoperable sensors
- [ ] Other

How quickly does volume data need to be provided in time (latency) for each application below?

	Real Time (<2 minutes)	< 5 mins	< 15 mins	< 1 hour
Special Event Management	○	○	○	○
Incident Impacts	○	○	○	○
Detour Planning and Management	○	○	○	○
Allowable Lane Closure Hours	○	○	○	○
Work Zone Impact Analysis	○	○	○	○

	Real Time (<2 minutes)	< 5 mins	< 15 mins	< 1 hour
Variable Speed Limits or Hard Shoulder Running	○	○	○	○
Traveler Information	○	○	○	○
Parking Lot Occupancy	○	○	○	○
Performance Measures	○	○	○	○
Traffic Signal Applications	○	○	○	○
Other (Indicate Below) [ ]	○	○	○	○

How granular does volume data need to be for each application below?

	1 min bin	5 min bin	15 min bin	1 hour bin
Special Event Management	○	○	○	○
Incident Impacts	○	○	○	○
Detour Planning and Management	○	○	○	○
Allowable Lane Closure Hours	○	○	○	○
Work Zone Impact Analysis	○	○	○	○
Variable Speed Limits or Hard Shoulder Running	○	○	○	○
Traveler Information	○	○	○	○
Parking Lot Occupancy	○	○	○	○
Performance Measures	○	○	○	○
Traffic Signal Applications	○	○	○	○

	1 min bin	5 min bin	15 min bin	1 hour bin
Other (Indicate Below)	○	○	○	○

How accurate does volume data need to be for each application below?

	Within 2%	Within 5%	Within 10%	Within 20%	Within 30%
Special Event Management	○	○	○	○	○
Incident Impacts	○	○	○	○	○
Detour Planning and Management	○	○	○	○	○
Allowable Lane Closure Hours	○	○	○	○	○
Work Zone Impact Analysis	○	○	○	○	○
Variable Speed Limits or Hard Shoulder Running	○	○	○	○	○
Traveler Information	○	○	○	○	○
Parking Lot Occupancy	○	○	○	○	○
Performance Measures	○	○	○	○	○
Traffic Signal Applications	○	○	○	○	○
Other (Indicate Below)	○	○	○	○	○

What existing data sources do you use for each application below (click all that apply)?

	Factored AADT	Data from Nearby Sensor Stations	Average Volume Profiles by Road Type
Special Event Management	☐	☐	☐
Incident Impacts	☐	☐	☐
Detour Planning and Management	☐	☐	☐
Allowable Lane Closure Hours	☐	☐	☐
Work Zone Impact Analysis	☐	☐	☐
Variable Speed Limits or Hard Shoulder Running	☐	☐	☐
Traveler Information	☐	☐	☐
Parking Lot Occupancy	☐	☐	☐
Performance Measures	☐	☐	☐
Traffic Signal Applications	☐	☐	☐
Other (Indicate Below)	☐	☐	☐

Do you need a volume estimate (100 vph) or would a volume index (typical volume, more/less volume than usual, double the usual volume) be appropriate for each application below (click all that apply)?

	Volume Estimate	Volume Index
Special Event Management	☐	☐
Incident Impacts	☐	☐

	Volume Estimate	Volume Index
Detour Planning and Management	☐	☐
Allowable Lane Closure Hours	☐	☐
Work Zone Impact Analysis	☐	☐
Variable Speed Limits or Hard Shoulder Running	☐	☐
Traveler Information	☐	☐
Parking Lot Occupancy	☐	☐
Performance Measures	☐	☐
Traffic Signal Applications	☐	☐
Other (Indicate Below)	☐	☐

What is your agency's top priority for real-time volume data that you would benefit from?

	First Priority	Secondary Priority	Third Priority
Special Event Management			
Incident Impacts			
Detour Planning and Management			
Allowable Lane Closure Hours			
Work Zone Impact Analysis			
Variable Speed Limits or Hard Shoulder Running			
Traveler Information			
Parking Lot Occupancy			

	First Priority	Secondary Priority	Third Priority
Performance Measures	☐	☐	☐
Traffic Signal Applications	☐	☐	☐
Other (Indicate Below)			
☐	☐	☐	☐

Would you be willing to discuss the survey results with the TETC?

◯ Yes

◯ No

Appendix B: Technical Specifications for: The Eastern Transportation Coalition Traffic Data Marketplace

Traffic Data Requirements for Travel Time & Speed Data, Volume Data, and Conflation Services

The following section contains the baseline system specifications in the form of a matrix. Priority codes are given for each specification in the matrix. The definition of each priority code is defined below.

Priority Codes:
Y/N: Respond Yes or No

M: Mandatory Specification (The Vendor shall verbiage . . .)
The Offeror must respond to any and all *M* within the Core Data category(s) for which the Offeror is responding. Failure to respond to an M specification is cause for determining a proposal non-responsive.

HD: Highly Desirable Specification (The Vendor may . . .)
The Offeror is highly encouraged to respond to all *HD* specifications within the Core Data category for which the Offeror is responding. Failure to respond to an HD will indicate that the Offeror cannot support the *HD* specification.

D: Desirable, also considered Optional, Specification (The Vendor may . . .)
The Offeror is encouraged to respond to *D* specifications for which Offeror has an applicable product. Failure to respond to a *D* specification will indicate that the Offeror cannot support the *D* specification.

The response for a Specification should affirm or deny the Offerors ability to meet the specification. Additionally, supporting information to verify ability to meet the specification should be provided. If the space in the matrix is not sufficient for a response, please append additional material, and references in the matrix. If additional space is required for further explanation, or if supporting material is appended, directly reference the additional or supporting information within the corresponding cell within the matrix (for example: “see Attachment XX, page Y for a detailed explanation”).

Six Core Data categories are specified below. A vendor must respond to at least one of the six Core areas for consideration. A vendor may provide a proposal for one or more of the Core Data Categories response areas. A response that does not address the minimum mandatory (*M*’) requirements of at least one Core area, will be dis-qualified. For any Core Data category, a vendor shall address all specifications within the matrix as described above for ‘*M*’, *HD*’, and ‘*D*’ specifications as outlined in the description of the Priority Codes above. For expediency and efficiency of review, if a vendor is not responding to one of the Core areas, please indicate so, and omit any associated matrix responses.

If a vendor's response spans two or more Core Data categories, the vendor is requested and encouraged to consolidate material to the extent possible. For example, if the vendor is responding to Core Data items 1 & 2 (Travel Time and Volume data) with the same product, individually address the response matrix for each section, but consolidate any product specific information in attachments.

Item	Description	Priority	Respondent Comments
CORE TRAFFIC DATA – ITEM 1			
REAL TIME TRAFFIC SPEED AND TRAVEL TIME DATA REQUIREMENTS			
Objective: Speed and Travel Time data are at the heart of the Traffic Data Marketplace (formerly the Vehicle Probe Project), providing both real-time and historic travel time and speed estimates on a link basis for various roadway types in the coverage area. Speed refers to the space-mean speed, NOT the instantaneous vehicle speed. Speed, for the purpose of this RFI, refers to the observed time rate of traversal of a segment, defined as the length of the segment divided by the travel time.			
	1.0 Real-Time Travel Time & Speed Data		
1.1.0	DOES VENDOR INTEND TO RESPOND TO IS CORE TRAFFIC DATA ITEM	Y/N	If ‘No’ proceed to ITEM 2.0. If ‘Yes’, respond to all cell entries that follow
1.1. **Base Real-Time Data Elements of Travel Time & Speed for all Roadways**			
1.1.1	**Mean Travel Time** The Vendor shall report Travel Time to the nearest whole second (or equivalent such as decimal minutes)	M	
1.1.2	**Mean Speed** The Vendor shall report Speed to a precision of the nearest 1 mph or greater.	M	
1.1.3	**Status Flag** The Vendor shall provide a status flag(s) per segment for each reported Travel Time / Speed record to indicate the following: ● Normal system operations with sufficient probe density to estimate travel times accurately. ● Periods of low-traffic flow, travel time may need to be imputed from a combination of real-time data combined, historical data, and adjacent roadway segments	M	

	Real-time probe data is not available, travel time is imputed based on historical data and/or adjacent roadway segments • An example of existing status flag are scores of '30', '20' and '10' to indicate whether data feed is based on real-time data ('30'), combinations of real-time and historical data ('20') and assumed free flow ('10'). This is only an example. Any status flag that reflect similar information is acceptable.		
1.1.4	**Historic/Anticipated traffic data** The Vendor may provide anticipated travel time and speed based on historic travel time and speed data representative for the time of day and day of week.	HD	
1.1.5	**Quality Indicator** The Vendor may provide a numerical score that reflects the confidence or anticipated error in the estimate of the mean Travel Time & Speed. The intent is to provide a measure similar in concept to the standard error in the estimate of the mean. The method used to generate a numerical score for quality may be dependent on the type of technology and type of processing. Vendor should provide explanation of the quality metric.	HD	
1.1.6	**Sample size** The Vendor may provide the sample size (such as the number of base probes) for a given time frame (such as the number of observed probes in a 15-minute period).	D	
1.2. Additional Data Feed Elements or APIs for all Roadways			
1.2.1	**Posted speed limit for the roadway segment**. The Vendor may provide this attribute as part of the travel time data feed or as static information as part of the Base Map.	HD	

1.2.2	[Combined into 1.2.1]		
1.2.3	**Congestion alerts/alarms** The Vendor may provide a configurable data feed to inform members when a specified segment exceeds a defined maximum travel time or minimum speed threshold	D	
1.2.4	**Congestion alerts/alarms** The Vendor may provide a data feed to inform members when a group of segments exceed a customizable maximum travel time or minimum speed threshold	D	
1.2.5	**Incident alerts/reporting** The Vendor may provide a data feed to inform members when roadways within a specified region are exhibiting customizable abnormal travel characteristics (such as slowdowns or congestion)	D	
1.3 Deleted			
1.4. Travel Time and Speed Data Quality and Latency on Freeways and Arterials See document the *Eastern Transportation Coalition Data Validation Program*, available at https://app.box.com/s/o7q6z16xoq0bpbt40wfjg3bhqosuinr4 for more details on the ETC Validation Program.			
1.4.1	**Average Absolute Speed Error (AASE) for Freeways** Speed data for shall have a maximum average absolute error of 5 MPH in each of the following speed ranges: (all in MPH) 0-30, 30-45, 45-60 and > 60	M	
1.4.2	**Speed Error Bias for Freeways** Error bias is defined as the average speed error (not the absolute value) in each speed range. Speed data for Freeways shall have a maximum average error of +/- 4 MPH in each of the following speed ranges: 0-30 MPH, 30-45 MPH, 45-60 MPH and > 60 MPH.	M	
1.4.3	**Average Absolute Speed Error (AASE) for Arterials**	M	

	Major Arterials (arterials with flow exceeding 20,000 AADT) shall have an AASE of 8 mph or less in the speed ranges defined as 0-15 MPH, 15-25 MPH, 25-35 MPH and > 35 MPH.		
1.4.4	**Speed Error Bias for Arterials** Major Arterials shall have a maximum speed error bias of +/- 4 MPH in each of the speed ranges defined as 0-15 MPH, 15-25 MPH, 25-35 MPH and > 35 MPH.	M	
1.4.5	Accuracy requirements shall be in effect for hours when vehicle flows exceeding 500 VPH for Freeways.	M	
1.4.6	Accuracy requirements shall be in effect for hours when vehicle flows exceeding 500 VPH of through traffic for Arterials.	M	
1.4.7	Maximum data latency shall be less than or equal to eight (8) minutes.	M	
1.4.8	Maximum data latency may be less than or equal to five (5) minutes.	HD	
1.4.9	Arterial data shall be subject to 'Slowdown Analysis' as outlined in the Eastern Transportation Coalition Data Validation Program, with Failure to Capture < 15%.	M	
1.4.10	Arterial data may be subject to 'Slowdown Analysis' as outlined in the Eastern Transportation Coalition Data Validation Program, with Fully Captured > 70%.	HD	
1.4.11	Vendor shall support the CATT Works Georeferencing Protocol (CWGP) for submission of data to the validation program. The CWGP can be accessed at: https://app.box.com/s/s1mkogrpbun2k2jk3ejekzume3dil821 Alternatively, validation locations and associated data can be communicated between Vendor and the ETC Validation Team via OpenLR. The OpenLR version that will be supported by the ETC Validation team is based on the method documented in the publicly available whitepaper (https://www.openlr-	M	

	association.com/fileadmin/user_upload/openlr-whitepaper_v1.5.pdf)."		
1.5. Temporal Reporting			
1.5.1	Traffic data shall be provided 24 hours per day, 7 days per week.	M	
1.5.2	Allowance shall be made for up to 40 hours of scheduled system maintenance per year during off-peak hours.	M	
1.5.3	The Vendor shall report/update traffic conditions at least once every 1 minute.	M	
1.6. Spatial Reporting and Link Definitions Data may be requested for the defined roadway types anywhere within the Coverage Area. Procurement of data shall be implemented via task orders specific to the requested area. Based on the Coverage Area, Proposers shall indicate the extents to which data can be provided on the roadway types listed below. Vendor shall provide maps, direct Coalition to electronic web resources, or describe in sufficient detail the extent of coverage for each roadway type in the Coverage Area. See Definitions for description of roadway types. Vendors shall/map provide Travel Time & Speed Data on :			
1.6.1	Freeways	M	
1.6.2	Major Arterials (arterials and state highways > 20000 AADT)	M	
1.6.3	Minor Arterials (arterials and state highways between 5000 and 20000 AADT)	HD	
1.6.4	Interchange Ramps	M	
1.6.5	Segregated Special Use Lanes (See Definitions)	M	
1.6.6	Non-Segregated Special use lanes (See Definitions).	HD	
1.6.7	Local roads	HD	
1.7. Spatial Referencing These specifications refer to the encoding of information relative to a Base Map or other Georeferencing system The Vehicle Probe Project originally standardized on Traffic Message Channel (TMC) codes for the delivery of Travel Time & Speed data. Later, proprietary Base Maps were used from vendors to convey data in a more highly granular formats. Open Street Maps (OSM) has emerged as an open			

source Base Map standard that rivals or exceeds that of TMC, and is non-proprietary requiring no license fee.			
1.7.1	Traffic Data shall be reported using Traffic Message Channel (TMC) codes as specified by the Traveler Information Services Association (TISA), including both internal and external nodes reported separately. More information on TMC codes are available at http://tetcoalition.org/wp-content/uploads/2015/02/TMC_White_Paper-Final.pdf	M	
1.7.2	Traffic Data may be reported using Open Street Map (OSM) segmentation *See note above It is highly desirable for vendor to natively support OSM. At a minimum, vendor data shall be licensed to be conflated to OSM segmentation. Vendors should provide documentation with respect to OSM segmentation support (either current or planned) as part of the RFP response.	HD	
1.7.3	The Vendor may provide finer granularity link definitions – suggested granularity of one mile for freeways, and up to 0.3 miles for complex urban arterials. Vendor response should fully describe any higher definition segmentation, the extent to which such segmentation is open-source, uses static or dynamic referencing, and frequency of map updates.	HD	
1.7.3	The Vendor may provide data in a member provided Base Map that conforms to the CWGP or the OpenLR protocol	D	
1.7.4	Ramps shall be reported as separate links	M	
1.7.5	The Vendor shall provide traffic data for new or improved facilities within six (6) months of roadway open to traffic. Vendor shall describe process for obtaining/reporting such data as part of RFP response.	M	
1.7.6	The Vendor may provide traffic data for new or improved facilities within four (4) weeks of roadway open to traffic. Describe process for obtaining.	HD	

1.7.7	The Vendor may provide traffic data for new or improved facilities when roadway opens to traffic. Describe process for obtaining.	D	
1.7.8	The Vendor shall provide Link definitions for any network segmentation supported which shall, at a minimum, contain ● Beginning and ending latitude and longitude, identifying the centerline of the lane (or group of lanes) being reported. Freeway / Interstate class roadway segments will report separately for each direction of travel. ● Beginning and ending heading ● Segment length ● Direction of travel (unidirectional or bi-directional) ● Common name or route number ● A unique identifier.	M	
1.7.9	The Vendor may provide Link definitions which shall contain preceding and following segment/s	HD	
1.7.10	The Vendor may provide a GIS shapefile of any base map supported by the vendor	HD	
1.7.11	The Vendor shall not update base map more frequently than once every quarter (three (3) months). Note: Reporting on new roadways as per specification 1.7.6 or 1.7.7 may be accomplished in separate API	M	
1.7.12	Any Base Map update provided by the Vendor shall contain deltas from the previously supported Base Map. Segments shall be identified that have changed. ● Traffic Message Channel (TMC) updates shall contain a list of TMCs that have changed	M	
1.7.13	The Vendor shall support a base map for at least 12 months from issuing a subsequent base map update.	M	
1.7.14	Base map updates may be no more frequent than once every six months	HD	

1.7.15	Base map updates may be no more frequent than once per year	D	
1.8. Availability and Reliability Reliability refers to the ability of the system to produce traffic data estimates consistently for each link at all times. Data reliability is measured simply as the percentage of measurement intervals (combination of space and time) when traffic data estimates are delivered.			
1.8.1	Note: Valid traffic data estimates occur only when sufficient base level data exists to support an estimate of the mean travel time or mean speed for a particular time period. Estimates based purely on imputation (for example, the historical average) are not considered a valid estimate in terms of the availability requirement. Periods of low flow (<500 VPH) are excluded. The Vendor shall provide Traffic data for at least 98 percent of all covered links at all required time reporting intervals, whenever minimum flow volumes are exceeded.	M	
1.8.2	**Availability:** The Vendor shall provide Data subscription services that shall maintain at least 99.5 percent availability, determined as percent uptime of the data service excluding any scheduled system maintenance (as per 1.5.2).	M	
1.8.3	The Vendor shall document and report Availability on a monthly basis.	M	
1.9. Data Formatting, Packaging and Access			
1.9.1	The Vendor shall provide Data as a fully documented API interface consistent with industry standards. Vendor to fully document.	M	
1.9.2	The Vendor shall allow for selective content subscription so that various states and road authorities may subscribe only to the state geographic area of interest.	M	
1.9.3	The Vendor may allow for selective content subscription so that various states and road authorities may subscribe only to the county geographic area of interest.	D	

1.9.4	The Vendor shall provide hardware, software and network capacity sufficient to initially support up to 50 concurrent data subscriptions, with the capability to scale to 100 data subscriptions as needed. It is the responsibility of the contractor to provide sufficient capacity to service all subscription demands.	M	
1.9.5	Vendors shall archive data purchased by Coalition members for a minimum of one (1) year. The archive must contain data in the same format (same fields reported in the live feed and same temporal and spatial granularity) as it was originally delivered in real-time and accessible via an API, FTP site, S3 bucket, or equivalent interface.	M	
1.9.6	The Vendor may provide a tiling service for travel time and speed for integration into agency traveler information websites, apps, or ATMS platforms as an alternative data access method.	D	
1.9.7	The Vendor may provide a tiling service of historical speed (expected speed for the current time of day and day of week) as an alternative data access method. User may specify color, pen width and speed ranges.	D	
1.9.8	The Vendor may provide a tiling service of the comparative speed (current speed as compared to historical speed for time of day and day of week) as an alternative data access method.	D	
1.10 Visualization Tools and Analytics			
1.10.1	The Vendor may provide a password-protected web-based tool to view real-time traffic data delivered to Coalition Member (not the general public) for the purpose of monitoring the traffic data feed, and validation of conformance to contract specifications. The monitoring service is for use only by the Coalition and its members primarily for administration purposes. Preferences for the service includes: ● Capacity to support up to five (5) concurrent users	D	

	● Viewing of live traffic data in map-based format ● Viewing of archive traffic data in map-based format ● Segments can be selected and data viewed		
1.10.2	Other analytic tools and software Although the primary purpose of this procurement is to obtain the highest quality traffic data for the Coalition and its Members, Vendors may, and are encouraged to, provide value added products available through this contract, These product may be part of the core data offering (if they do not add substantially to core data pricing) or as ancillary products which are separately priced. This may include visualizations and analytics that utilizes the core data, archive and historic data tools for viewing and retrieval, and other types of analytics software that leverages the core data.	D	

Item	Description	Priority	Respondent Comments
CORE TRAFFIC DATA – ITEM 2			
VOLUME DATA REQUIREMENTS			
Objective: Traffic Volume data is the second dimension of traffic vital to obtain a complete understanding of traffic flow and is a priority in the Traffic Data Marketplace (formerly the Vehicle Probe Project). The Coalition intends to procure both historic and, possibly, real-time traffic volume data on a link basis for various roadway types in the coverage area. The Coalition has been a leader in research and development of methods to obtain accurate volume estimates from probe-based data. The results of that research indicate that probe density and consistency is such to support traffic volume products and expects the extent of available products to grow into the future to cover more road classes, and to evolve from aggregated historic measures such as AADT and ADT, to real-time estimates across the entire network. Volume refers to the number of vehicles that traverse a segment in a specified time frame, NOT the number of observed traffic probes. Vendors interested in providing base data from which volume can be estimate should respond to the Waypoint Data section. **Note: The various traffic volume estimates below marked mandatory (M) reflect the products for which the Coalition desires service. A vendor must be responsive to one (1) or more of the data items marked as 'M' to be considered compliant.**			
	2.1.0 Base Data Elements for all Roadways		
2.1.0	DOES VENDOR INTEND TO RESPOND TO THIS CORE TRAFFIC DATA ITEM.	Y/N	If 'No' proceed to section 3.0. If 'Yes', respond to all cell entries that follow
2.1 Base Data Elements for Historic Volume Estimates			
2.1.1	Vendor shall provide historic estimated volume data reported as estimated Average Annual Daily Traffic (AADT)	M	
2.1.2	Vendor shall provide historic estimated volume data reported as estimated Average Daily Traffic (ADT) for • day or week, • month of year, • season, • weekday/weekend, • a specific day of the year.	M	

2.1.3	Vendor shall provide historic estimated volume data reported as hourly (as opposed to daily) estimated Average Hourly Daily Traffic (AHDT) ● for day or week, ● month of year, ● season, ● weekday/weekend Example – estimated volume for Mondays from 2-3 PM is 3468 vehicles	M	
2.1.4	Vendor shall provide historic estimated volume data reported as estimated Hourly Volumes Flows specific ● to the day of year and ● to the hour of the day. Example – estimated volume for June 5, 2019 from 2-3 PM is 3468 vehicles	M	
2.1.5	NOTE: For any mandatory traffic volume estimates, vendor shall provide date range for which traffic volume estimates are available. Example: 'Historic AADT estimates are available for calendar year 2018 forward.'	M	
2.1.6	Vendors may provide Hourly Volume Flows available in real time. In response to this RFP, vendor shall indicate future plans to provide a real-time volume feed (if any).	HD	
.1.7	Vendor may provide historic Sub-Hourly volume flows (ex: 5, 15, 30 minutes) specific ● to the day of the year and ● to the hour of the day. Example – estimated volume for June 5, 2019 from 2:00-2:15 PM is 900 vehicles	HD	
2.1.8	Vendors may provide real time Sub-Hourly volume flows	HD	
2.2. Status Flag and Error Estimates			
2.2.1	Status Flag The Vendor may provide a status flag(s) per segment for each reported Traffic Volume record	HD	

	to indicate whether sufficient data is available to estimate traffic volumes.		
2.2.2	Quality indicator The Vendor may provide a numerical score that reflects the confidence or error in the estimate of the volume parameter. The intent is to provide a measure similar in concept to the standard error in the estimate of the mean. A suggested method is to use anticipated error derived from Cross-Validation techniques.	HD	
2.2.3	Vendor may provide a flag for low traffic volume situations	HD	
2.3. Additional Data Feed Elements or Services for all Roadways			
2.3.1	The Vendor may report estimated volume separately by vehicle class	D	
2.3.2	The Vendor may report estimated volume separately by groupings of vehicle class (i.e. light duty, heavy duty).	D	
2.4. Volume Data Quality and Latency It is the intent of the Coalition to perform validation of Traffic Volume data provided through this TDM similar in scope and extent as the validation of travel time and speed data. However, the methodology, frequency, and other parameters of the Traffic Volume validation program are not yet established. Any such methods will be consistent with published research in the area, and subject to the resources available through the Coalition. The validation committee of the ETC will provide overall guidance and review. Any vendor that provides data to the ETC or any of its Members, will be required to participate in the Traffic Volume validation program. Due to required calibration, submission of data for validation of Traffic Volume will only be required for the geographic regions for which a vendor is under task order to provide data, though any vendor may submit data (voluntarily) for regions outside of their contracted region. **NOTE: All accuracy specifications below are designated as Highly Desirable or Desirable, not Mandatory. This acknowledges that traffic data volume services is an emerging field, and established metrics for quality are still evolving.**			
2.4.1	For AADT, accuracy specifications, at a minimum, may be consistent with findings from the FHWA pooled fund project titled **'Non-Traditional Methods to Obtain Annual Average Daily Traffic Evaluation and Analysis Project'.** These accuracy specifications reflect current fidelity of 48 hour counts relative to measured AADT.	HD	

2.4.2	**Minimum Accuracy Hourly Volume Specification: SMAPE** – Minimum accuracy may be expected in the following ranges: 10-15% for High Volume roadways (Freeways) 20-25% for Mid Volume roadways (Arterials) 30-50% for Low Volume roadways (Local Roads)	HD	
2.4.3	**Minimum Accuracy Hourly Volume Specification: Coefficient of Determination (R^2) as reported against the calibration data set.** Minimum R^2 accuracy may be expected for the following 90% for High Volume roadways (Freeways) 80% for Mid Volume roadways (Arterials) 70% for Low Volume roadways (Local Roads)	HD	
2.4.4	Error to Capacity Ratio (ETCR) – Freeways of less than 10%	HD	
2.4.5	Error to Capacity Ratio (ETCR) – Freeways of less than 5%	D	
2.4.6	Error to Max Flow Ratio (EMFR) – Non-Freeways of less than 20%	HD	
2.4.7	Error to Max Flow Ratio (EMFR) – Non-Freeways of less than 10%	D	
2.4.8	Error to Max Flow Ratio (EMFR) – Local Roads of less than 20%	HD	
2.4.9	The Vendor shall report performance using Cross Validation with the number of training bins (n) greater than or equal six, and less than or equal to ten, chosen at random.	M	
2.4.10	Specification 1.4.11 is included by reference for the submission of Traffic Volume validation data	M	
2.5. Spatial Reporting and Link Definitions			

	The Vendor shall provide volume estimates on the following facilities denoted as 'M'. The Vendor may provide volume estimates on the following facilities marked at 'HD' or 'D'		
2.5.1	Freeways	M	
2.5.2	Major Arterials	M	
2.5.3	Minor Arterials	HD	
2.5.4	Interchange Ramps	HD	
2.5.5	Segregated Special use lanes	HD	
2.5.6	Non-Segregated Special use lanes	D	
2.5.7	Intersection Turning Movements	HD	
2.5.8	Local Roads	HD	
2.5.9	Vendors shall provide a matrix of Traffic Volume Estimate type (as described in 2.1.1 to 2.1.8) indexed by road category (as described in 2.5.1 to 2.5.8). Vendors shall respond in the RFP reflective of their current ability to provide accurate traffic volume estimates.	M	
2.6. Spatial Referencing – See section 1.7			
Section 1.7 is included by reference for Volume Estimates			
2.7. Data Formatting, Packaging and Access			
2.7.1	The Vendor shall provide Data using prevailing industry standard formats, packaging, etc. (e.g. APIs, FTP site, S3 bucket, or similar). Vendor to provide description in response.	M	
2.8. Visualization Tools and Analytics			
2.8.1	Specification 1.10.2 is included by reference	D	