TDM Validation Activity: Low Volume Travel Time Study Stowe, Vermont

TETC Transportation Data Marketplace Data Validation

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Low Volume Travel Time Study
Stowe, Vermont
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Validation activity for TDM Validation program, focusing on low-volume scenario with recreational congestion in Stowe, VT

TDM-VAL-04

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Executive Summary

This report describes a Transportation Data Marketplace (TDM) data validation effort conducted by The Eastern Transportation Coalition (TETC) data validation team focused on one of the six data items available in the TDM) probe-based Travel Time/Speed data. This activity was conducted in Stowe, VT, and targeted rural/low volume roadways that have historically experienced severe congestion during special events (winter ski weekends).

Although Travel Time/Speed probe data has been well-studied in previous Coalition validation activities, prior attempts to evaluate data quality in rural or low-volume roadways have been limited by an inability to capture traffic congestion, making it challenging to fully evaluate vendor performance. Based on renewed Coalition interest in understanding vendor data quality on rural / low-volume roadways, the validation team, in coordination with the Technical Advisory Committee (TAC), proposed several strategies to capture slowdowns on rural/low volume roads: (i) identifying locations that experience congestion during special events, (ii) planned maintenance activities, and (iii) inclement weather. Ultimately the special event approach was selected, and Stowe, VT was identified as the study area based on conversations with Vermont Agency of Transportation (VTrans) and the location's track record of severe congestion on holiday weekends during ski season – particularly President's Day weekend.

The study area consisted of 10 road segments along VT-100 (between I-89 and downtown Stowe) and VT-108 (between downtown Stowe and the ski resort), shown in Figure 1. These segments were chosen with the expectation of capturing resort-related traffic over President's Day – a weekend that has historically produced hour-plus delays. Reference data was collected between Jan 16-23, 2023, using wireless re-identification traffic monitoring equipment (i.e., Bluetooth detectors) and corresponding travel time vendor data was provided by four of the five vendors. One vendor was unable to prepare data for review in this round.

Vendor data feeds were assessed by visually inspecting speed and travel time plots for each segment in comparison to the reference data, focusing in particular on periods where congestion was observed. In contrast to most TETC travel time validation efforts, this study does *not* include summary error metrics, as the low-volume roads did not provide large enough sample sizes to calculate the traditional error metrics to appropriate levels of confidence. Rather, visual analysis of the time series plots provided rich insights into vendor data quality and showed that **all vendor feeds reflected slowdowns that were observed in the reference data**. The visual analysis was similar to the arterial method of ability/inability to capture slowdowns. The following points summarize the key observations:

- **Congestion to/from the ski resort was less severe than it has been historically, but significant enough to meaningfully assess vendor data.** After several prior attempts to capture congestion on rural/low-volume roads, this marks the first real opportunity to evaluate vendors' ability to capture slowdown events in such conditions. However, compared to historical conditions in Stowe – especially over President's Day weekend – the congestion was milder, and did not result in traffic diverting to secondary routes or spilling back to I-89. Nonetheless, the observed congestion signatures provided ample opportunity to evaluate vendor performance with delays on these roadways reaching appropriately 15 to 20 minutes at peak travel demand to and from the ski area.

- **All vendors reflected the slowdown patterns observed in the reference data.** There were some differences between vendors in terms of the magnitude and duration of slowdown events reported, but in general, *this validation activity demonstrated that industry was able to identify congestion on rural and low-volume roads* – including road segments along VT-108 that are not coded to Traffic Message Channel (TMC) locations, the location referencing system for which probe data has traditionally been reported.

- **Vendor data converged during peak travel times and diverged during off-peak periods**. Due to the rural, low volume nature of this study area, overnight and off-peak hours had minimal traffic, meaning that vendors had to produce data with little to no real-time information. The observed divergence between vendors during these periods is likely due to method or policy each vendor handles this scenario. For example, one vendor may report prevailing speed limit, while another a free flow speed based on observed traffic statistics. In contrast, during daytime and peak periods, higher traffic flows enabled vendors to report speeds based on real-time information, which resulted in much closer agreement between vendors.

This validation provides initial evidence that industry can accurately reflect traffic conditions in a rural / low volume context. The TETC validation team recommends continuing to monitor this scenario, and where possible, identifying further opportunities (special events, inclement weather, or planned maintenance activities) to evaluate vendor data on low-volume roads that experience congestion.

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Introduction

Transportation data sold through the Eastern Transportation Coalition (TETC) Transportation Data Marketplace (TDM) is procured from private industry based on contract specifications. The intent of the Coalition’s validation program has evolved from a highly prescriptive methodology of the original Vehicle Probe Project (VPP) validation to one with more freedom to explore the fidelity and accuracy of the data feeds across six data categories in various contexts. The TDM now has the flexibility to adjust to the needs of the Coalition members as the market evolves and data needs expand. The validation process is overseen by a technical advisory committee that sets general direction and reviews results. The TDM includes both quantitative and qualitative analysis of datasets available through the marketplace as appropriate for each data type. The marketplace currently contains six core data items: Travel Time/Speed, Volume, Waypoint, Origin-Destination, Freight, and Conflation, with all but one (Travel Time/Speed) being sold through the marketplace for the first time. As such, the validation team, under the guidance of the TETC Validation Technical Advisory Committee (TAC), is beginning to establish standards and methods for effectively evaluating data quality and value across these six types of data sets.

This report evaluates one of the products sold in the TDM: Travel Time/Speed data, which was the core product from VPPII. Although Travel Time/Speed data has been well-studied in previous Coalition validations, most evaluation activities focused on freeways and mid-to-high volume signalized arterials. Prior attempts to evaluate data quality in rural or low-volume roadways have been limited by an inability to capture traffic congestion, making it challenging to characterize vendor performance in such roadways. Based on renewed Coalition interest in understanding vendor data quality on low volume/rural roads, the validation team, in coordination with the Technical Advisory Committee (TAC), proposed targeting this scenario.

As part of the validation study, reference Travel Time datasets were collected and used as the basis for evaluating reported vendor data. Vendor data feeds were assessed by visually inspecting speed and travel time plots for each segment in comparison to the reference data, focusing in particular on periods where congestion was observed. In contrast to most TETC travel time validation efforts, this study does *not* include summary error metrics, as the low-volume roads did not provide large enough sample sizes to produce such measures to high level of statistical significance. However, visual analysis of the time series plots of vendor data provided rich insights into the ability to capture slowdowns (similar to the ‘slowdown analysis’ for signal-controlled arterials) and was useful for drawing conclusions about industry capabilities on rural and low volume roads.

Data Vendors

All vendors selected through the TDM RFP process in the Travel Time category (Carto, HERE, INRIX, Iteris, Timmons) were invited to participate in the validation study. In keeping with the inaugural TDM validation activity, the validation team used the CATT Works Georeferencing Protocol (CWGP) to describe validation locations but relaxed the requirement for data to be submitted in real time. Due to the failure of previous attempts to capture congestion on low volume rural roadways, reference data was first collected and analyzed to ensure that adequate congestion was captured before directing vendor to provide data.

Four of the five Travel Time/Speed vendors (Carto, HERE, INRIX, Iteris) successfully submitted data in the travel time evaluation, while one (Timmons) was unable to prepare data for review. All vendor data deliveries were timely and compliant with requested data formats.

Study Area

The study area for this validation activity focuses on two rural / low-volume corridors in Stowe, VT: Vermont Routes 100 and 108, which have AADTs of 9k-13k and 2k-9k, respectively. These roadways were chosen in coordination with the validation technical advisory committee and Vermont Agency of Transportation (VTrans) in an effort to identify congestion induced by special events on low volume/rural roadways.

Figure 1 shows the geographic scope of the study area in the context of the region (upper left image) and within the state (lower left image). The town of Stowe is located in Northern Vermont just north of interstate I-89 between Burlington and Montpelier, about 200 miles NW of Boston, MA. Stowe is well known for its ski resort and outdoor recreation activities, which have historically caused major congestion during weekends and holidays, including President's Day week in 2022[1].

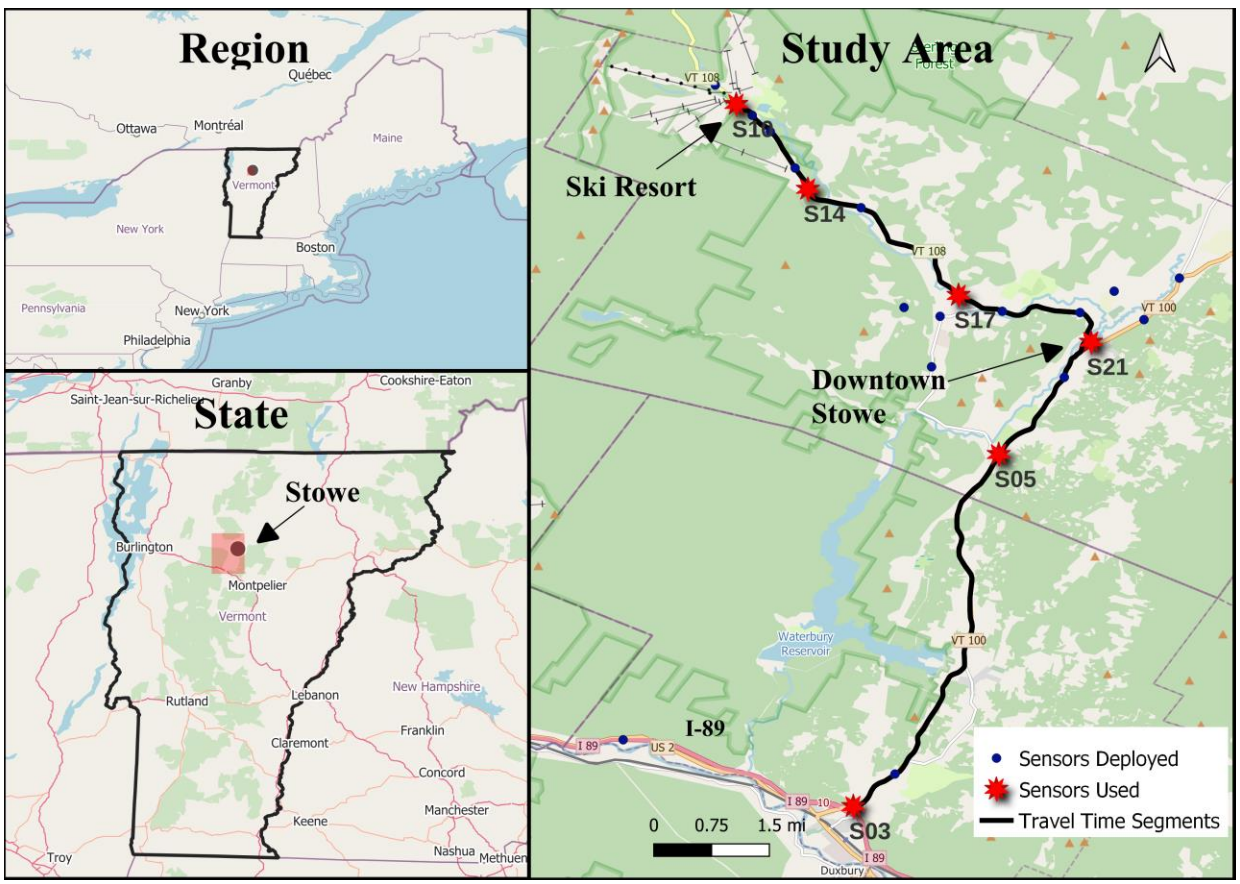

Figure 1 – Validation roadways shown relative to state/region (left) and zoomed in (right)

[1] Stowe VT 100 and VT 108 Congestion (arcgis.com)

The right image in Figure 1 shows the locations where Bluetooth re-identification sensors were deployed (blue dots), encompassing VT-100 (connecting I-89 to downtown Stowe), VT-108 (connecting downtown Stowe to the mountain resort), and several additional locations chosen to understand vehicle routing patterns in case of traffic diversions due to severe congestion. Based on an initial review of the reference data, it was determined that the data from the additional sensors would not be utilized in the travel time analysis, as severe congestion (greater than one hour delay) was not experienced. As such, a subset of sensors -- indicated by red stars on the map – were selected and used to divide the corridors into logical segments (also referred to as paths) of at least 1 mile in length. VT-100 was split into two segments in each direction (sensor pairs S3-S5, S5-S3, S5-S21, S21-S5 in Figure 1), while VT-108 was divided into three segments in each direction (S10-S14 and S14-S10 by the ski resort, S14-S17 and S17-S14 midway between downtown Stowe and the resort, and S17-S21 and S21-S17 near Stowe), resulting in 10 total directional segments.

Table 1 shows the key attributes used to communicate the validation segment locations to vendors via CWGP. This information was shared with vendors as a GeoJSON file with MultiPoint coordinate geometry (representing the start and end points of each segment) so that it could be readily processed with a computer or displayed via web or Geographic Information System (GIS) tools.

Table 1 - CWGP attributes for travel time validation segments

ID	Start Location	Start Heading	End Location	End Heading	Road Name	Road Class	Length (Miles)
P01	-72.74979 44.34389	78	-72.71155 44.43583	32	VT-100	3	7.08
P02	-72.71155 44.43583	33	-72.68742 44.46543	81	VT-100	3	2.47
P03	-72.68742 44.46543	261	-72.71155 44.43583	213	VT-100	3	2.47
P04	-72.71155 44.43583	212	-72.74979 44.34389	258	VT-100	3	7.08
P05	-72.68742 44.46543	342	-72.72238 44.47744	316	VT-108	4	2.39
P06	-72.72238 44.47744	326	-72.7615 44.50543	343	VT-108	4	3.04
P07	-72.7615 44.50543	343	-72.78059 44.52748	298	VT-108	4	1.83
P08	-72.78059 44.52748	118	-72.7615 44.50543	163	VT-108	4	1.83
P09	-72.7615 44.50543	163	-72.72238 44.47744	146	VT-108	4	3.04
P10	-72.72238 44.47744	136	-72.68742 44.46543	162	VT-108	4	2.39

Data Collection

Reference Data

Reference travel time samples were collected along the 10 directional validation paths from August 31 to September 9, 2022. Bluetooth re-identification sensors were deployed by a contractor that specializes in field collection, and the resulting raw data was processed by the

Coalition Validation team using the approach outlined in Section 3 the Data Validation Program document[2] to obtain travel time measurements.

Vendor Data

Vendors were instructed to report the average travel time/speed values for all validation segments (as specified by the validation team using CWGP, not TMCs or other native segments) during each minute of the collection period plus two additional weeks. Data from additional dates were requested in an effort to capture possible severe winter weather events. Although vendors are usually required to deliver data in real-time, that requirement was not relevant for this study because reference data was first collected and analyzed to ensure sufficient congestion was captured before deciding to proceed with the activity.

Four of the five Travel Time/Speed vendors (Carto, HERE, INRIX, Iteris) successfully submitted data in the travel time evaluation, while one (Timmons) was unable to prepare data for review. All data deliveries were timely, used the specified georeferencing protocol, and followed the requested data formats.

Evaluation Methodology

Vendor data feeds were assessed by visually inspecting speed and travel time plots for each segment in comparison to the reference data, focusing in particular on periods where congestion was observed. In contrast to most TETC travel time validation efforts, this study does *not* include summary error metrics, as the low-volume roads did not provide large enough sample sizes to provide meaningful statistical comparisons. However, visual analysis of the time series plots provided rich insights into vendor data quality. This process has similarities to the “Slowdown Analysis” used previously to score vendors’ ability to capture congestion events on signalized arterial facilities.

Results and Discussion

The primary intent of the travel time validation was to identify congestion along the rural/low volume roadways and assess each vendor’s ability to reflect these events in their data feeds. As such, the validation team prepared time series plots comparing reference and vendor data for each segment as interactive HTML files for visual inspection. Representative plots for two segments – one on VT-100 and the other on VT-108 -- are presented in this section and are used to illustrate the key findings. The full archive of interactive plots for each path is available for download at the following link.

Please note that all plots include both speed and **estimated traffic flow** data. *To be clear, **flow** is not actually measured at a count station or based on a vendor’s volume product**;*** instead, it is estimated by assuming that our Bluetooth sensors capture 5% of traffic, thus providing a useful proxy for the amount of traffic. The intent is to add an additional dimension to the analysis and identify periods when there are no or very few vehicles on the road. If Bluetooth sensors detect zero or just a handful of vehicles during overnight periods, then there is probably minimal traffic on the road and probe vendors will also have limited probe vehicles to use for reporting speed/travel time.

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[2] The Eastern Transportation Coalition Transportation Data Marketplace Data Validation Program Overview (link)

Example 1 -- Segment P01 (S3-to-S5) along VT-100

The first segment, path P01 (S03-to-S05), is shown in Figure 2 and located along VT-100 in the Northbound direction just North of the I-89 interchange. It is approximately 7 miles in length with an AADT of about 9k-12k (bidirectional, so approximately 4.5k-6k in the Northbound direction). Figure 3 is a screenshot of the HTML file for P02, showing an overview of reference travel times across the data collection period (top subplot), as well as corresponding estimates of flow (bottom subplot) based on an estimated 5% penetration rate of Bluetooth data. It highlights that speeds (and thus travel times) are quite stable around 35-45 mph (~10-12 minutes of travel time), with a single congestion event on February 19 producing a larger drop in speeds. The flow plot highlights that traffic volumes are extremely low, close to zero, during overnight hours.

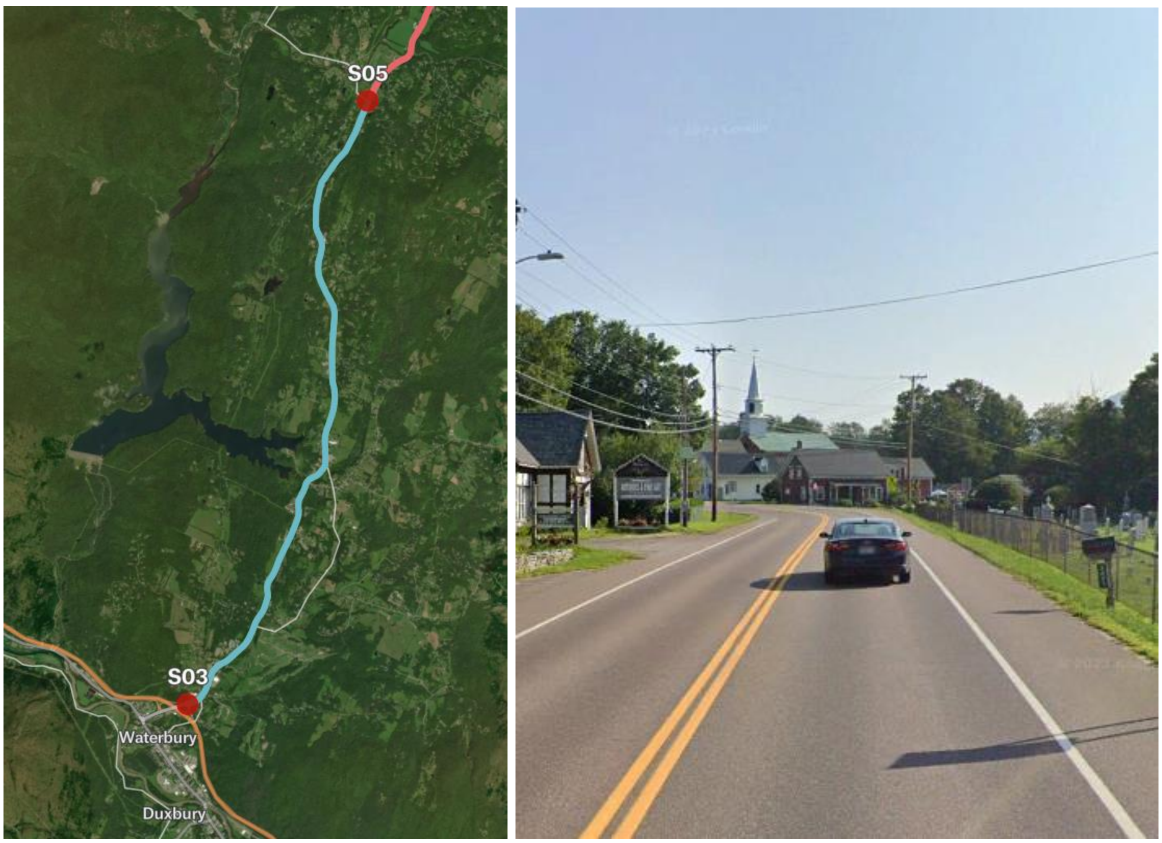

Figure 2:   Segment boundaries and screenshot for segment P01 (S03-to-S05) along VT-100

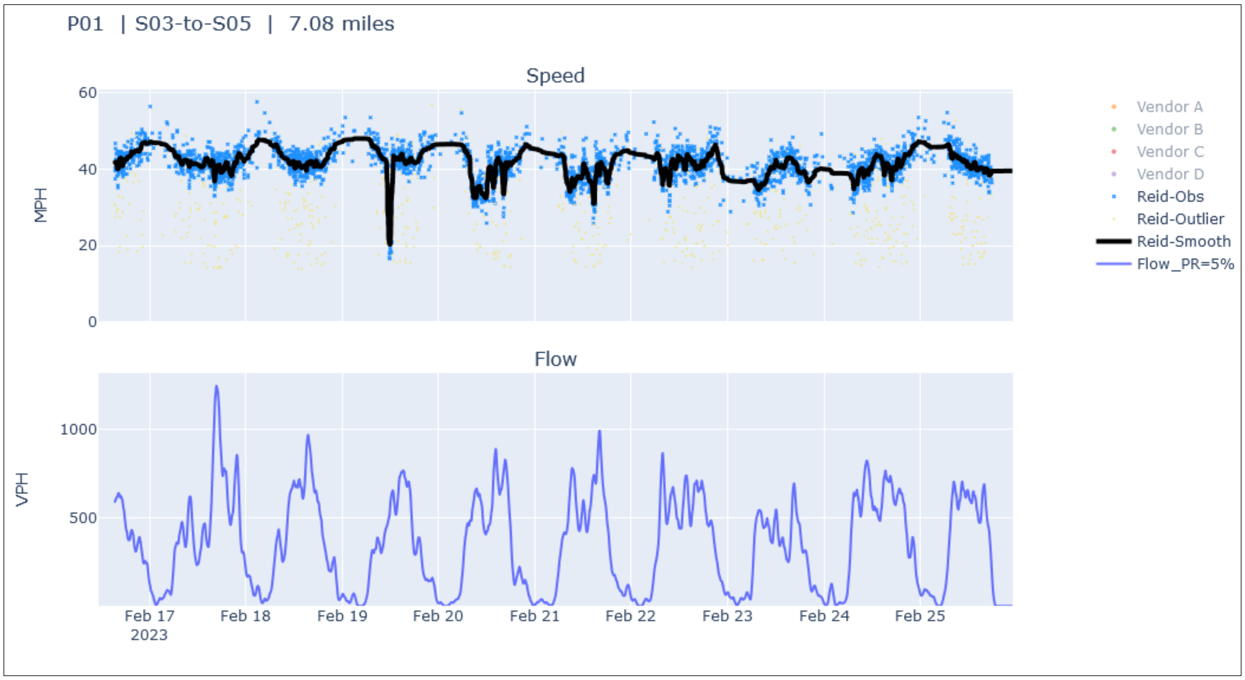

Figure 3: Reference travel times /speeds observed along segment P01 during study period

Figure 4 focuses on the single congestion event present on this segment. This plot is the same as Figure 3 but includes the speed traces for each of the four vendors (labeled A-D in the legend, where Vendor A = Carto, B = HERE, C = INRIX, D = Iteris), and is zoomed in to show just February 19 and 20. This plot highlights several observations:

- **All 4 vendors reflected the slowdown event**, albeit with different levels of fidelity. This is encouraging because the event was non-recurrent, meaning that it would not have been identifiable using historical patterns.
  - All vendors identified the onset of congestion at about the same time, with vendors A-C showing an abrupt drop in speed closely matching with reference mean speeds (black line) and D showing a more smoothed/gradual decrease and smaller reduction in speed. All vendors also showed speeds recovering to pre-slowdown levels at about the same time, with similar sharp increases for vendors A-C and smoothed/gradual increases for D. Although the reference data line (black line) takes longer to recover than the vendor data, it should be noted that it represents the *average* of individual Bluetooth observations. Visual inspection indicates that some individual Bluetooth speeds recover sooner than the average line, consistent with what the vendors are reporting. Note, the slowdown traffic event depicted on February 19 appears consistent with that of a momentary traffic incident such as a vehicle crash, or other type of incident that impacts flow for a short period of time.
- **Vendor speeds tended to converge during daytime hours** when vehicles were observed on the road (flow values show presence of vehicle detections)

  Vendor speeds showed more divergence during overnight and off-peak periods when minimal vehicles were detected (flow values at or approaching 0). Refer to the overnight hour of mid-night to 6 AM on February 20. Further investigation of vendors' "status flag" field indicated that reported values during these periods was often not based on real-time information. This suggests that the observed divergence between vendors during these periods may be due to how each vendor produces data when real-time information is unavailable, and free-flow travel speeds are assumed. The divergence appears to be the result in different methods of reflecting free-flow travel in the absence of data.

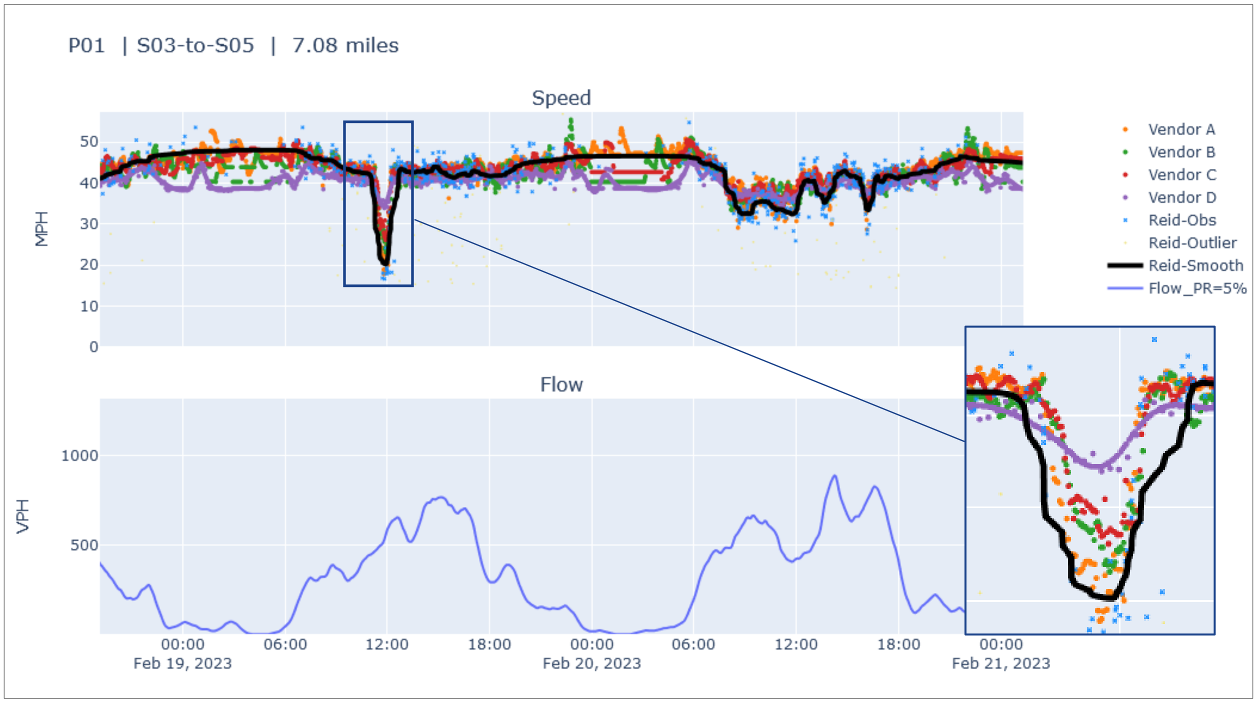

Figure 4: All vendors' travel times /speeds observed along segment P01 during study period

Example 2 -- Segment P10 (S17-to-S21) along VT-108

The second segment is path P10 (S17-to-S21), shown in Figure 5 and located along VT-108 (Mountain Road) in the Eastbound direction, ending in downtown Stowe. It is approximately 2.4 miles in length with an AADT ranging from 2k-9k (bidirectional, so approximately 1k-4.5k in the Eastbound direction). P10 was chosen as it reflected the most significant slowdown in the dataset, however, slowdowns were observed generally on all segments (P05 through P10) between the town of Stowe and the ski resort.

Figure 6 shows a brief overview of reference travel times across the data collection period, highlighting a pattern of recurrent congestion in the PM period from vehicles returning from the ski resort to the town of Stowe. During off-peak periods, average travel times are generally around 5 minutes, but increase during the afternoon/early evening (9-12 minutes on normal weekdays, and about 15 minutes during President's Day weekend).

Figure 7 focuses on a 2–3-day period over President's day weekend to illustrate the congestion patterns. This plot is the same as Figure 6 but includes the speed traces for each of the four vendors (labeled A-D in the legend, where A = Carto, B = HERE, C = INRIX, D = Iteris), and is zoomed in to show just February 21-23. This plot highlights several observations:

- **All 4 vendors captured the congestion events during the PM peak periods.** There are fewer differences between vendors here than in Example 1. **All vendors reflected the patterns observed in the reference data closely**, adequately capturing the magnitude and duration of the speed drop and recovery. The results from path P10 were representative of all the slowdowns observed on this route, in that all vendor adequately captured and characterized the slowdowns.
- As with Example 1, **vendor speeds showed strongest agreement during daytime and peak periods**. This corresponds to times when estimated flow is much greater than zero (i.e., when there are vehicles on the road).
- **Vendor speeds diverged during off peak and overnight periods when estimated flow was very low**.   These results are consistent with Example 1, but the divergence appears particularly pronounced because the speed values are lower. Again, this is the likely result of differing methods of establishing assumed free flow speeds / travel time during periods of low traffic flow. As in the in first representative sample, the vendors data feeds were also accompanied by flags that indicated lack of real-time data (and thus inferred speeds / travel times) during these periods.

Figure 5:   Segment boundaries and screenshot for segment P10 (S17-to-S21) along VT-108

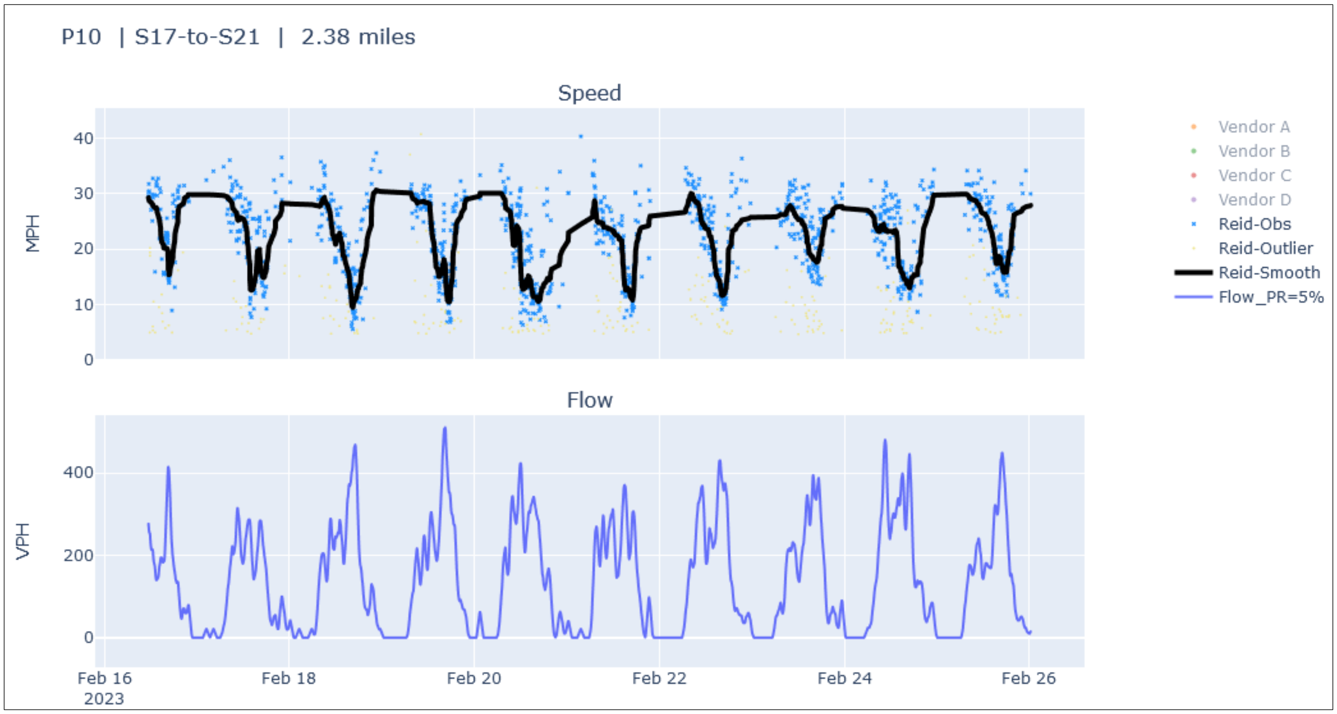

Figure 6: Reference travel times /speeds observed along segment P10 during study period

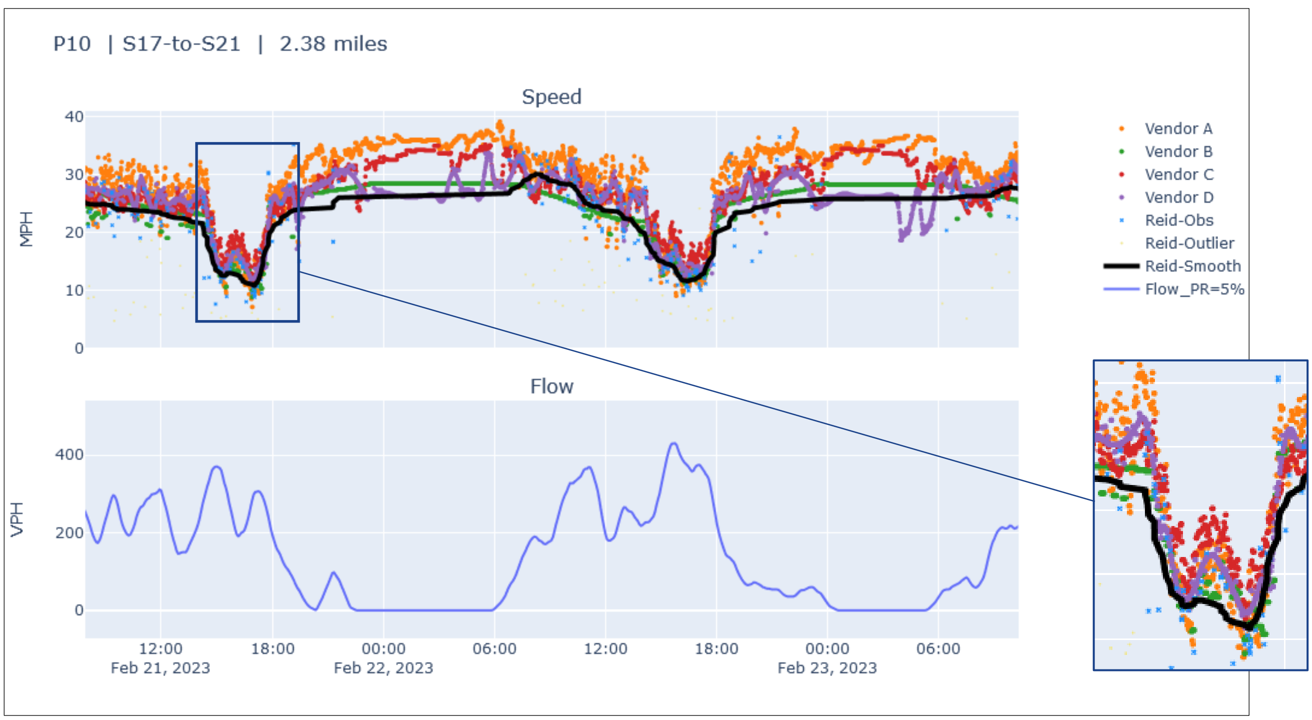

Figure 7: All vendors' travel times /speeds observed along segment P10 during study period

Figures 8-11 show vendor-specific results for the same time period, and additionally include a subplot showing each vendor's "status flag" values. Vendors have latitude to define this flag however they like, but the intent is to communicate whether data is reported using real-time data.

During the daytime all vendors report constant high status flag values, indicating that estimates are based on real-time data. However, during overnight periods the status flag values drops for all vendors – corresponding to the drop in the estimated flows based on Bluetooth detections (Flow subplot). Together this shows that there are minimal vehicles on the road; neither Bluetooth nor probe vendors have much data to work with, and the somewhat large discrepancies in probe speeds are related to how each vendor infers speeds in these conditions.

Figure 8: Vendor A's travel time/speed values and corresponding status flag on P10

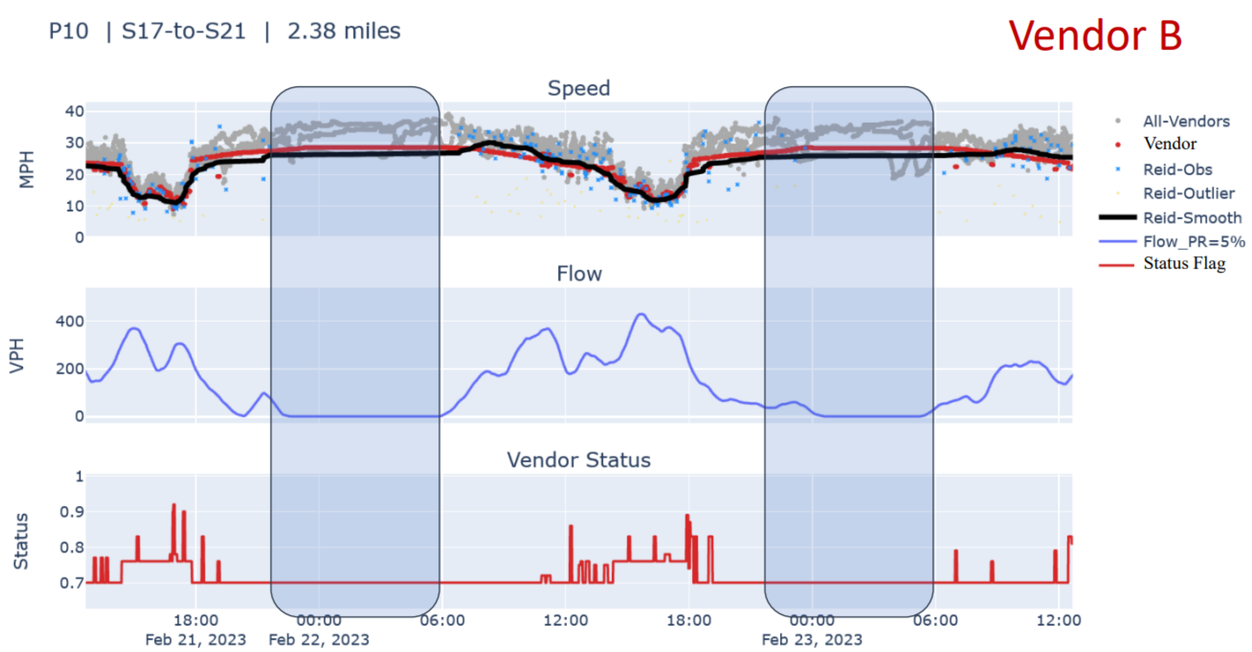

Figure 9: Vendor B's travel time/speed values and corresponding status flag on P10

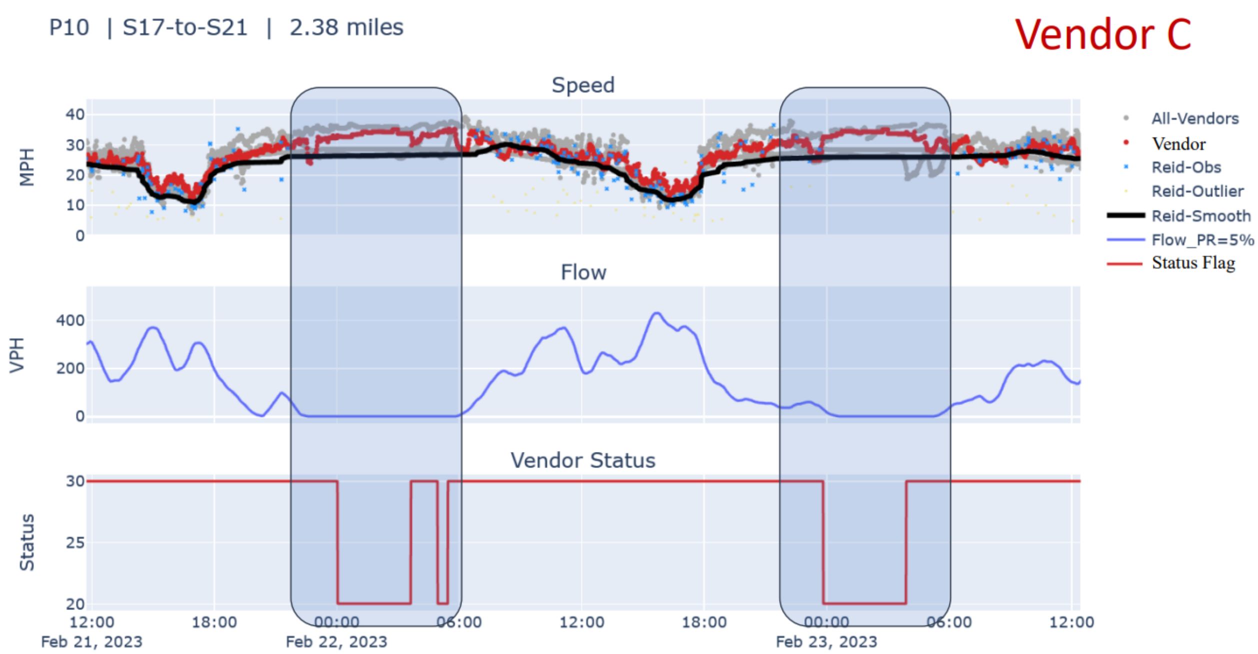

Figure 10: Vendor C's travel time/speed values and corresponding status flag on P10

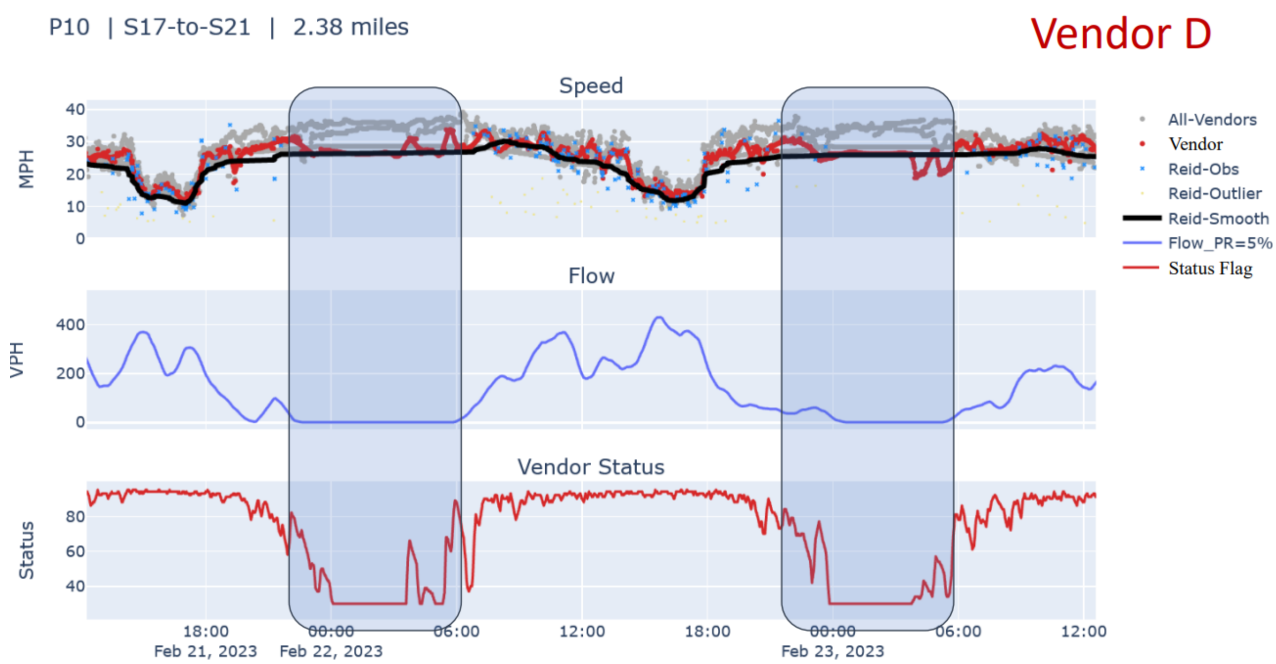

Figure 11: Vendor D's travel time/speed values and corresponding status flag on P10

Conclusions

Although Travel Time/Speed probe data has been well-studied in previous Coalition validation activities, prior attempts to evaluate data quality in rural or low-volume roadways have been limited by an inability to capture traffic congestion events, making it challenging to fully evaluate vendor performance. This activity marks the first time that congestion was successfully captured in such conditions and provides an initial review of vendor data quality for this scenario. The following points summarize the key takeaways:

- **Congestion to/from the ski resort was less severe than it has been historically, but significant enough to meaningfully assess vendor data.** After several prior attempts to capture congestion on rural/low-volume roads, this marks the first real opportunity to evaluate vendors' ability to capture slowdown events in such conditions. However, compared to historical conditions in Stowe – especially over President's Day weekend – congestion was milder through measurable and observable, and did not result in traffic diverting to secondary routes or spilling back to I-89. Nonetheless, the observed congestion signatures provided ample opportunity to evaluate vendor performance.

- **All vendors reflected the slowdown patterns observed in the reference data.** There were some differences between vendors in terms of the magnitude and duration of slowdown events reported, but in general, *this validation activity demonstrated that industry (all vendors) was able to identify congestion on rural and low-volume roads* – including road segments along VT-108 that are not coded to Traffic Message Channel (TMC) locations, the location referencing system for which probe data has traditionally been reported. The archive of all validation data across all ten paths supports this conclusion.

- **Vendor data converged during peak travel times and diverged during off-peak periods**. Due to the rural, low volume nature of this study area, overnight and off-peak hours had minimal traffic, requiring vendors to infer travel times in the absence of real-time data from probes. The observed divergence between vendors during these periods is likely due to how each vendor handles this scenario – each reporting a free-flow travel time based on differing methods. During daytime and peak periods, higher traffic flows enabled vendors to report speeds based on real-time information, which corresponded to much closer agreement between vendors.

This validation provides initial evidence that industry can accurately reflect traffic conditions in a rural / low volume context. The TETC validation team recommends continuing to pursue validation of rural/low-volume roads, and, where possible, identify further opportunities (special events, inclement weather, or planned maintenance activities) to evaluate vendor data accuracy on low-volume roads that experience congestion.