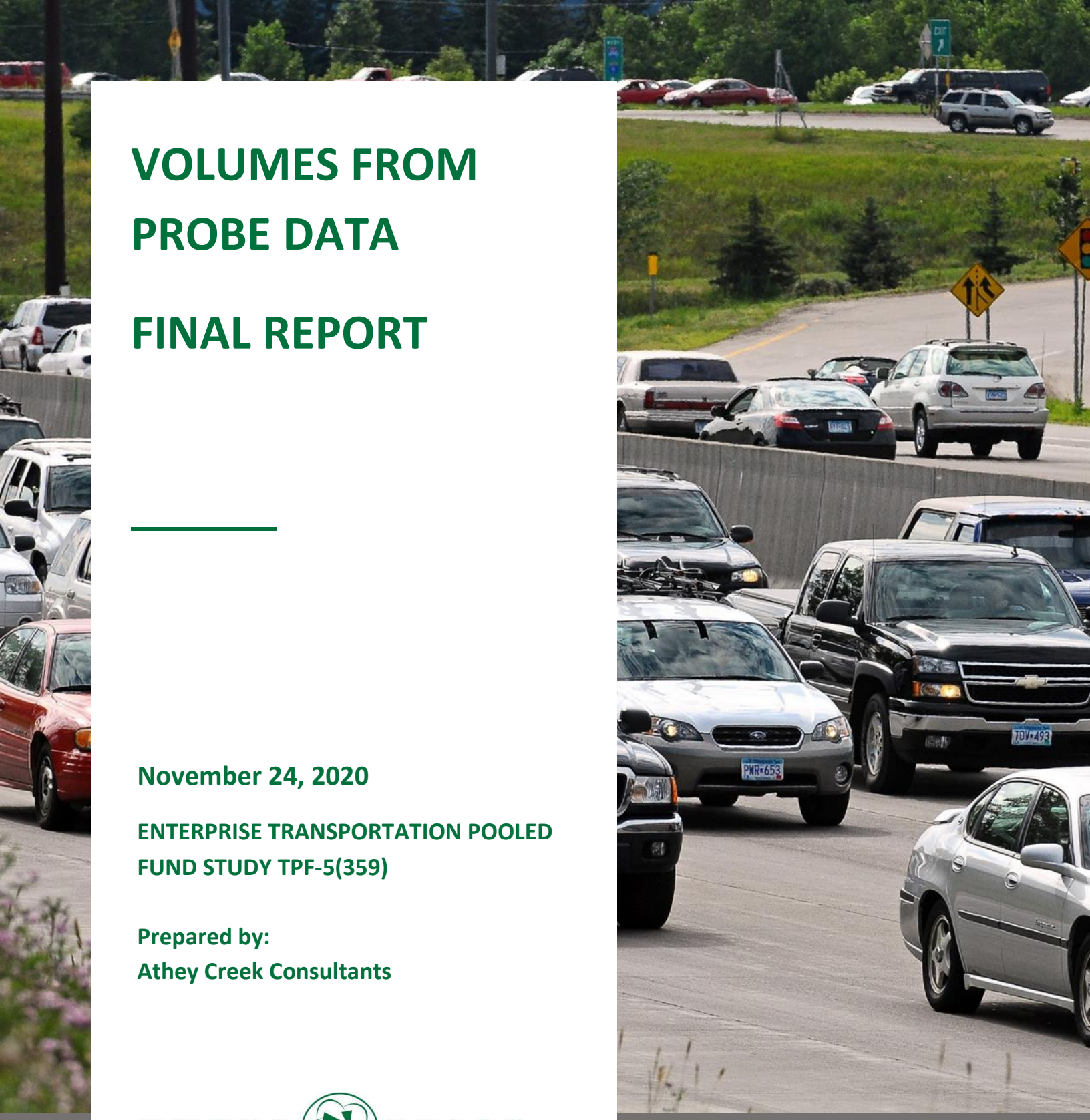

VOLUMES FROM PROBE DATA

FINAL REPORT

November 24, 2020

ENTERPRISE TRANSPORTATION POOLED FUND STUDY TPF-5(359)

Prepared by:
Athey Creek Consultants

ENTERPRISE

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16. Abstract ENTERPRISE members' use of third-party probe-based traffic data is becoming increasingly widespread. Meanwhile, third-party probe data is emerging as a source for traffic volumes. To help ENTERPRISE agencies prepare for probe volume data being more widely available, this project documented 22 potential agency use cases for probe volume data and four business cases outlining benefits and implementation considerations. Traffic operations uses include real-time traffic management (e.g., events, evacuation routes, road closures), operational systems and automated functions (e.g., dynamic shoulder operations, incident detection), and performance management. Work zone use cases range from real-time monitoring to post-analysis and planning future work zones. Transportation planning uses include calibrating and validating travel demand models, estimating traffic impacts to plan for similar future events, and congestion performance reporting. Benefits cited for use of probe volume data include: significantly increased coverage of traffic volumes, less field detection devices, reduced or eliminated need for temporary short-duration volume counts, improved data insights, better situational awareness, more proactive congestion management, increased deployment of traffic management systems, improved accuracy of travel demand models, and more immediate access to traffic volumes for post-event analysis. The results of this project can be used by agencies to plan for and implement probe volume data across several agency functions and user groups.			
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The cover page image is courtesy of the Minnesota Department of Transportation.

Project Champion

Doug Tomlinson, Pennsylvania Department of Transportation, was the ENTERPRISE Project Champion for this effort. The Project Champion serves as the overall lead for the project.

ENTERPRISE Members

The ENTERPRISE Board consists of a representative from each of the following member entities.

- Illinois Department of Transportation
- Iowa Department of Transportation
- Kansas Department of Transportation
- Michigan Department of Transportation
- Minnesota Department of Transportation
- Ontario Ministry of Transportation
- Pennsylvania Department of Transportation
- Texas Department of Transportation
- Wisconsin Department of Transportation

Project Input

ENTERPRISE would like to thank the following entities that provided input for this project:

Transportation Agencies:

- Colorado Department of Transportation
- Iowa Department of Transportation
- Kansas Department of Transportation
- Maryland Department of Transportation State Highway Administration
- Michigan Department of Transportation
- Minnesota Department of Transportation
- North Carolina Department of Transportation
- Ontario Ministry of Transportation
- Pennsylvania Department of Transportation
- Texas Department of Transportation
- Wisconsin Department of Transportation

Other:

- INRIX
- TomTom
- Eastern Transportation Coalition
- University of Maryland Center for Advanced Transportation Technology Laboratory (CATT Lab)
- National Renewable Energy Laboratory (NREL)

Table of Contents

1.0 Introduction

ENTERPRISE members' use of third-party probe traffic data (typically GPS-based) is becoming increasingly widespread and has proven effective for reporting estimated speeds. Meanwhile, third-party probe data is emerging as a source for traffic volume data as well. Benefits that could be realized by agencies with use of probe volume data are many, including: significantly increased coverage of traffic volumes, less field detection devices, reduced or eliminated need for temporary short-duration volume counts, improved data insights, better situational awareness (especially for real-time operational decisions), more proactive congestion management, increased deployment of traffic management systems, improved accuracy of travel demand models, and more immediate access to traffic volumes for post-event analysis.

While probe volume data may not fully replace infrastructure-based traffic volume collection methods, there are several use cases that could be met with probe volume data. To help ENTERPRISE agencies prepare for probe-based volume data being more widely available, this project documented potential use cases for probe volume data and developed business cases for implementation. The use cases describe how various user groups would utilize the data for real-time operations, performance management, post-event analysis, and planning efforts. The business cases present groupings of use cases and summarize high-level data requirements, current data collection methods, the value and benefits of probe volume data, transition considerations, and implementation readiness.

This project documented potential agency use cases for probe-based traffic volume data and developed business cases that outline benefits and implementation considerations.

The primary focus of this project was to create potential use cases and business cases to help ENTERPRISE agencies prepare for implementing probe volume data. As such, the project did not complete a comprehensive state-of-practice review regarding the availability, commercialization status, or performance of currently available probe volume data or estimation models being developed to produce near-real time traffic volumes. Rather, it provides an initial overview of recent advancements related to probe volume data, including examples of historical data available for procurement and advancement toward commercialization of near real-time volume data.

This report includes the following sections:

- 2.0 Project Approach – Describes the research approach and how information was gathered.
- 3.0 Overview of Advancements in Third-Party Probe Volume Data – Presents a high-level overview of third-party probe volume data, in terms of data availability and recent advancements.
- 4.0 Potential Agency Use Cases for Probe Volume Data – Provides an overview of 22 potential use cases for probe volume data, developed by engaging staff from ENTERPRISE agencies in a series of webinars with input from other select agencies.
- 5.0 Business Cases for Probe Volume Data – Summarizes four primary business cases for implementing third-party probe volume data into agency operations.
- 6.0 Summary – Presents a summary of key project findings.
- Appendix – Provides detailed descriptions of 22 potential agency use cases for probe volume data.

2.0 Project Approach

This project was structured to assist ENTERPRISE agencies in preparing for probe-based volume data being more widely available for a number of agency uses, including real-time traffic monitoring, performance management, post-event analysis, work zone planning and monitoring, and transportation planning.

The project completed the following activities:

- **Advancements in Third-Party Probe Volume Data** – This activity provided an overview of recent advancements related to probe volume data, including examples of historical data available for procurement and advancement toward commercialization of near real-time probe volume data. The purpose of this activity was to provide ENTERPRISE members with an overall context, presenting selected examples of historical probe volume data and advancements toward further availability of this type of data.

- **Potential Agency Use Cases for Probe Volume Data** – This activity facilitated input from representatives from ENTERPRISE agencies and other select transportation agencies, to document a total of 22 potential agency use cases for probe volume data. Transportation professionals with expertise in traffic operations, performance management, work zone operations, and transportation planning were engaged to discuss how probe volume data would be used, current methods to obtain traffic volume data, anticipated benefits, and how practices and infrastructure might change as a result of implementing probe volume data.

  Three (3) interactive webinars were conducted in May 2020, to gather input from ENTERRISE agencies for documenting potential use cases.

  - Webinar 1 – Traffic Operations (Real-time Operations and Performance Management)
  - Webinar 2 – Work Zone Planning and Monitoring
  - Webinar 3 – Transportation Planning

  Input gathered during the webinars was used to summarize potential agency use cases. The project also conducted phone calls with representatives from three additional agencies participating in research to advance real-time probe volume data availability: Colorado Department of Transportation, Maryland Department of Transportation State Highway Administration, and North Carolina Department of Transportation. Representatives from these agencies reviewed the draft use cases and contributed to further refine and enhance the content.

- **Business Cases for Probe Volume Data** – This activity developed business cases to make a collective case for agency investment in probe volume data as it becomes commercially available. The business cases describe the value and benefits of probe volume data, grouping similar use cases together. The business cases also present implementation information such as high-level data requirements, considerations for transitioning from traditional field detection infrastructure and methods to the use of probe volume data, and implementation readiness.

Figure 1 presents an overview of the project approach.

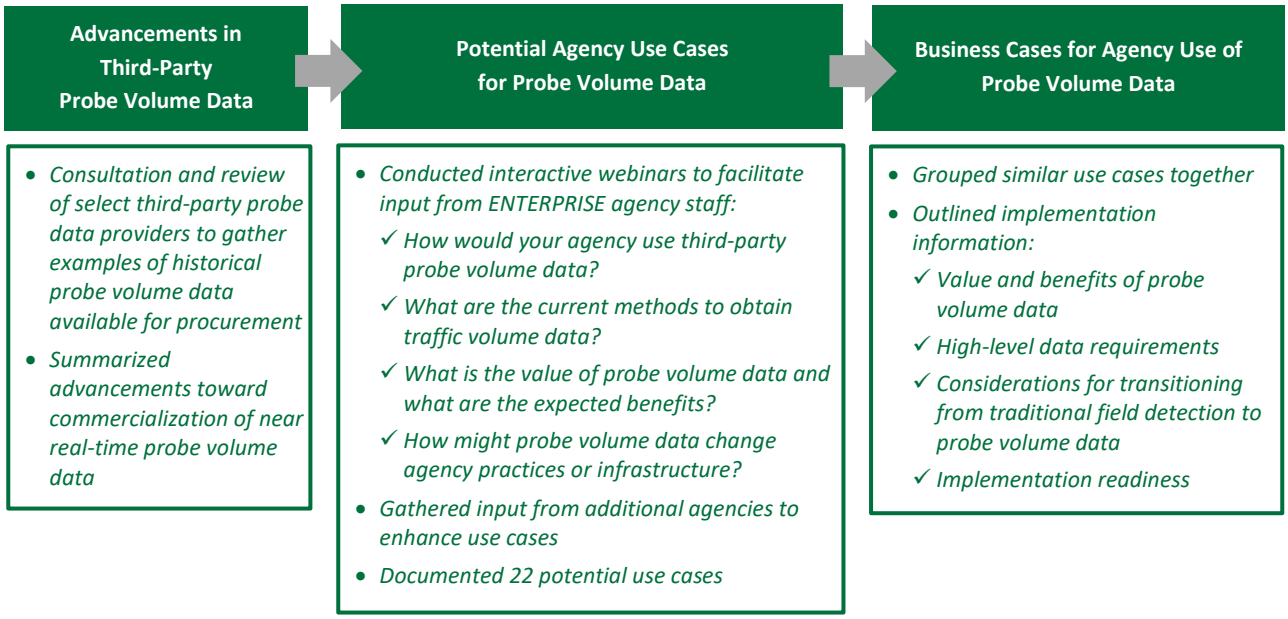

Figure 1: Overview of Project Approach

3.0 Overview of Advancements in Third-Party Probe Volume Data

This section provides a high-level overview and selected examples of third-party (GPS-based) probe volume data. When providing this overview, it is important to note the following:

- The industry offering probe-based traffic data for purchase or licensed use is rapidly evolving and improving. The presence of vehicle-based probes (e.g., probe-equipped vehicles or mobile devices inside vehicles that transmit position information) is growing daily, therefore the penetration rates of probes that provide information for third-party providers to generate traffic data are improving all the time. This is exciting for the industry and offers agencies growing confidence in the accuracy and latency of data delivery. However, this rapid development means that studies that document the availability and performance of probe-based traffic data have a short shelf life, and agencies will benefit from direct interaction with third-party data vendors and by conducting their own testing and validation as they use the data in practice.

The industry offering probe-based traffic data is rapidly evolving and improving.

Agencies will benefit from direct interaction with third-party data vendors and by conducting their own testing and validation as they use the data in practice.

- The primary focus of this project was to document potential use cases and business cases to help agencies prepare for implementing probe volume data. Therefore, the project did not complete a comprehensive state-of-practice review regarding the availability, commercialization status, or performance of currently available data or estimation methods to produce near real-time traffic volumes. Rather, this section is intended to provide overall context, presenting selected examples of historical probe volume data and advancements toward further availability of this type of data.

The following sub-sections provide examples of historical probe volume data offered by third-party data providers and advancements toward availability of real-time (or near real-time) probe volume data.

3.1 Examples of Historical Probe Volume Data

Historical probe-based volume data is currently offered by some third-party data providers. Online resources and brief phone consultations with INRIX and TomTom were used to inform this section, which includes selected examples of commercially available historical probe volume data.

Third-party probe data provider StreetLight Data[1] offers AADT volumes, origin-destination data, other types of data, and analytics platforms for procurement by transportation agencies. The Minnesota Department of Transportation (MnDOT) utilizes volumes and other data from StreetLight Data for transportation analyses, with information available at the MnDOT Transportation Analysis with Regional

[1] StreetLight Data. https://www.streetlightdata.com/

Data for Informed Strategies[2] web page. MnDOT's current subscription with StreetLight Data includes access to historical data back to 2014, and the lag time for the provider to receive, process, and publish the data is approximately two months.[3]

INRIX[4] provides a Volume Profile[5], updated on an annual basis, which provides estimated volumes using INRIX Trip Reports, INRIX Speed Profiles, and the Highway Performance Monitoring (HPMS) dataset as calibration factors. The volume data is provided in 15-minute bins, estimated for each segment by time of day and day of week. The volume profile is delivered as a csv file to numerous agencies and companies interested in a systemwide volume profiles at the individual link level. The dataset is also utilized for estimation of User Delay Costs in the RITIS analytics platform[6].[7]

TomTom[8] offers directional road segment-level strictly observed volume data. The road coverage, date, and time ranges are customizable (TrafficStats product). They also offer a map layer with average monthly hourly observed volume data by day of the week for all roads (Traffic Density product). They offer an Origin Destination Analysis product, where, again, the coverage, date and time ranges are customizable. TomTom's partnerships capture probe data at more than twice the industry average enabling volume calculations significantly more granular than AADT. TomTom makes this package available to partners that apply their own established methodologies to combine this with CCS data for volume calculation. Partners in the United States include the National Renewable Energy Laboratory (NREL), University of Maryland, and other commercial partners.[9, 10]

As agencies consider applications for historical data and analytics tools offered by third-party data providers, they will benefit from consultation with the providers to understand and evaluate the source composition of each data type and its suitability to each agency application.

3.2 Advancements Toward Real-time Probe Volume Data

Advancements toward commercialization of real-time probe volume data are well underway. This real-time (or near real-time) traffic volume data could be used by agencies for numerous traffic operations applications. Recent research activities conducted through the Eastern Transportation Corridor Coalition[11] and led by the University of Maryland's Center for Advanced Transportation Technology Laboratory (CATT Lab) and the National Renewable Energy Laboratory (NREL) have made progress towards commercialization of near real-time probe volume data as a part of the Volume & Turning Movement

[2] MnDOT. Transportation Analysis with Regional Data for Informed Strategies. http://www.dot.state.mn.us/tda/tardis.html
[3] MnDOT. (n.d.) *StreetLight Data Frequently Asked Questions.*
[4] INRIX. https://inrix.com/
[5] INRIX Volume Profile. https://inrix.com/products/volume/
[6] Probe Data Analytics Suite. https://pda.ritis.org/suite/tutorials/?video=udc
[7] Trepanier, Ted. (2020, Sep 3). INRIX Interview.
[8] TomTom. https://www.tomtom.com/en_us/
[9] Auble, John and Douglas Gilmour. (2020, Sep 11). *TomTom response to Probe Speed Data on Arterials.* Consultation.
[10] Auble, John. (2020, Oct 23). Email to Athey Creek Consultants.
[11] The Eastern Transportation Coalition. https://tetcoalition.org/

Project.[12] Through this effort, state and local transportation agencies may soon have options to procure volume data for real-time (or near real-time) operations applications.

Traffic volumes are estimated using a modeled approach with inputs such as probe traffic data, road characteristics, weather information, and temporal information. Volume data from trusted agency field detection devices has been used as an input to train the estimation models. Machine learning techniques are used to estimate traffic volumes nearly everywhere on the network, estimating both real-time and historic data.[13] Figure 2 shows an overview of the model estimation methodology.

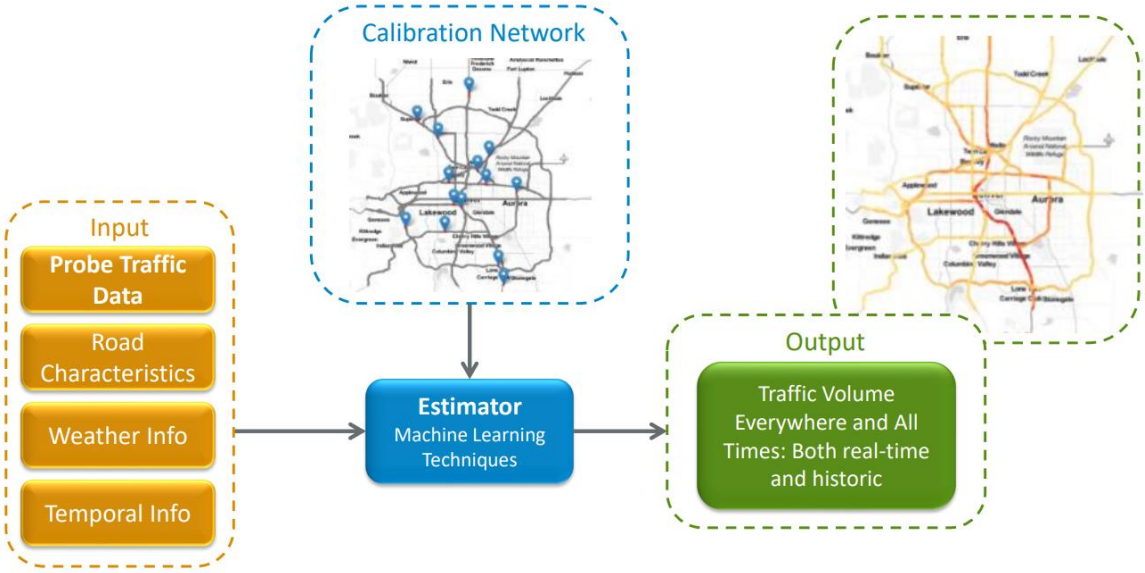

Figure 2: Methodology – Scaling/Conflating Probe Data Information

(Source: April 21, 2020 Webinar on Volume Estimation using Machine Learning Approaches & Probe Vehicle Data – presentation slides)[13]

Research outcomes are consistently producing traffic volume estimations at hourly increments, and the research is targeting 15-minute flow rates.[14] According to *Statewide Traffic Volume Estimation Using GPS Traces and Machine Learning: Florida Cases Study* (Vander Laan, et al., 2019), observations from separate analyses in three states (Maryland, New Hampshire, and Florida) indicate that estimation model performance appears to be consistent and capable of providing accurate hourly estimates. Furthermore, in high volume or high functional road class cases, or when many GPS probe vehicles are observed, the

[12] The Eastern Transportation Coalition. *Volume & Turning Movement (VTM) Project.* https://tetcoalition.org/projects/volume-turning-movement-project/

[13] The Eastern Transportation Coalition. (2020, Apr 21). *Volume Estimation using Machine Learning Approaches & Probe Vehicle Data*. Webinar presentation slides.

[14] The Eastern Transportation Coalition (2019, Nov 13). *Webinar on Phase II: Ubiquitous Traffic Volume from Probe Data*. Webinar presentation slides.

model tends to work particularly well.[15] *Network Scale Ubiquitous Volume Estimation Using Tree-Based Ensemble Learning Methods* (Hou, et al., 2018) reports on traffic volume estimation methods that were tested on major corridors and freeways in Denver, Colorado. The paper indicates that that the machine learning methods were able to provide hourly volume estimates 24 hours a day, 7 days a week, and 365 days a year with around 18% mean absolute error to true volume and about 5% of error with respect to roadway capacity. The low error measures indicate potential application by transportation agencies.[16]

The performance of traffic volume estimation techniques is likely to continue improving as probe penetration rates increase, as probes become more consistently present, and as the research continues to address conditions such as traffic anomalies.

The Eastern Transportation Coalition's Volumes & Turning Movement Project web page provides outreach materials including overview documents, webinar recordings, and presentation slides that provide additional information on research activities and results.

[15] Vander Laan, Zachary, Przemyslaw Sekula, Kaveh Farokhi Sadabadi. (2019, Jan). *Statewide Traffic Volume Estimation Using GPS Traces and Machine Learning: Florida Case Study.* Paper for Transportation Research Board 98th Annual Meeting.
[16] Hou, Yi, Stanley E. Young, Anuj Dimri, Nicholas Cohn, and Venu Garikapati. (2018, Jan). *Network Scale Ubiquitous Volume Estimation Using Tree-Based Ensemble Learning Methods*. Paper for Transportation Research Board 97th Annual Meeting.

4.0 Potential Agency Use Cases for Probe Volume Data

This section presents potential agency use cases for probe volume data. The use cases provide detailed information about how agencies could potentially use third-party probe volume data (sometimes in conjunction with other data such as speeds or origin-destination data, or a combination of historical and real-time data) as it becomes more widely available. The potential use cases also provide anticipated benefits of probe volume data and potential changes in practice that could result from implementation of probe volume data.

As agencies consider applications for probe volume data offered by third-party data providers, they will benefit from consultation with the providers to understand and evaluate the source composition of each data type and its suitability to each potential use case.

In May 2020, a series of webinars engaged representatives from ENTERPRISE agencies to discuss potential use cases for probe volume data. The webinars were organized by the following user groups:

- Webinar 1 – Traffic Operations
- Webinar 2 – Work Zone Planning and Monitoring
- Webinar 3 – Transportation Planning

In addition to the interactive webinars, three additional non-ENTERPRISE agencies (Colorado Department of Transportation, North Carolina Department of Transportation, and Maryland Department of Transportation State Highway Administration) participated in phone interviews, to provide input on how their agencies could potentially use probe volume data. Their input was used to refine and enhance the potential use cases.

As a result of the webinars and phone interviews, 22 potential use cases were summarized. Each use case summarizes the following information with questions asked to prompt documentation for each:

- **Description of the Use Case** – Presents an overview of how probe volume data would be used.
- **Example in Practice** – Describes a real-world example of the use case in practice.
- **Current Mechanism(s) to Obtain Traffic Volumes** – Is volume data currently available to support this use case (e.g., volumes at all locations)? What is the current need or gap?
- **Value of Probe Volume Data** – Why does your agency want this data? What is the value from an operations/work zones/transportation planning standpoint? How would having this data change or improve your practices (e.g., increased coverage of reported volumes, less physical detectors)?
- **Temporal Granularity** – What is the temporal granularity of data needed for this use case (e.g., 5-minute increments, hourly increments, AADTs)?
- **Relationship to other Department of Transportation (DOT) Applications** – Does this use case tie into other DOT applications or a pre-established framework (e.g., decision support systems, automated processes, traveler information systems)? If so, how?

- **Sensitivity to Data Quality During Traffic Anomalies** – Is this use case highly related to time periods or applications when traffic anomalies are likely to occur? Will accuracy of the data during traffic anomalies significantly impact the usefulness of probe volume data?

The potential use cases were documented using input from transportation agency practitioners with expertise in their respective technical areas. These practitioners brainstormed use cases that could potentially be met with probe volume data, sometimes in conjunction with other types of data such as vehicle speeds or origin-destination information. As probe volume data becomes more widely available and agencies procure it, they will likely need to test the applicability and feasibility of probe volume data for the potential use cases documented.

The following sub-sections present an overview of the 22 potential use cases, sorted by user group.

4.1 Traffic Operations Potential Use Cases

The traffic operations potential use cases for probe volume data include multiple aspects of ongoing traffic operations functions, including the following categories: real-time traffic management, real-time operational systems and automated functions, and performance management.

Table 1 provides brief descriptions of the probe volume data potential use cases identified by the Traffic Operations user group. The Appendix contains the complete use case descriptions which provide additional details for each use case.

Table 1: Traffic Operations Potential Use Cases – Brief Descriptions

Category	Title	Brief Description – How could probe volume data be used?
Real-time Traffic Management	Use Case 1: Event Management	– Predict and monitor congestion as it unfolds during events (e.g., holidays, special events) and trigger traffic management actions; volumes react faster than speed data for more proactive management.
	Use Case 2: Evacuation Route Management	– Understand real-time traffic volumes during evacuations for significant events such as severe weather events and other emergency events. – Monitor traffic volumes in real-time and initiate actions such as adjusting signal timings or revising evacuation routes as conditions change.
	Use Case 3: Monitoring Major Road Closures	– Monitor traffic conditions on alternate/diversion routes during major road closures such as long-term construction or flooding. – Evaluate whether the diversion route is keeping up with traffic capacity and initiate appropriate actions. For example, detour signing, secondary routes, signal changes on alternate routes, staging of motor assist units.

Category	Title	Brief Description – How could probe volume data be used?
Operational Systems and Automated Functions	Use Case 4: Rural Incident Detection	– Detect congestion due to incidents (e.g., crashes, debris in road) in rural areas, to trigger alerts to traffic management center operators and automatically post messages to dynamic message signs (DMS) to warn approaching traffic.
	Use Case 5: Lane-level Incident Detection in Urban Areas	– Detect congestion to identify lane-level traffic incidents (e.g., crashes, debris in road) in urban areas where speed data alone may not be sufficient for lane-level detections. – Identify times when a portion of the total volume (e.g., 1/3 total volume on a 3-lane highway) is experiencing a slowdown.
	Use Case 6: Variable Speed Limit (VSL) Systems	– Operate VSL systems at locations where physical detectors are not present.
	Use Case 7: Dynamic Shoulder Lane Operations	– Use probe volume data in conjunction with other data, such as speeds, for dynamic shoulder lane operations. – Monitor the rate of increase/decrease of volumes on roadway segments approaching temporary shoulder lanes to determine when to open or close the shoulder lane(s).
	Use Case 8: Queue Warnings	– Operate queue warnings at locations where physical detectors are not present, such as high-speed roadways approaching work zones or at known problematic locations.
	Use Case 9: Ramp Metering Operations	– Operate ramp meters or backup to field detection devices that can fail. – Provide volumes from approaching roadways to supplement data from point detection field devices.
Performance Management	Use Case 10: ITS Device Performance Management	– Analyze the performance and general effectiveness of DMS and other ITS devices in managing and responding to traffic events.
	Use Case 11: Signalized Corridor Throughput/ Effectiveness	– Identify poor signal timing for major corridors based on volume throughput drops due to signal choke points. – Assess threshold(s) for maximum capacity along the corridors to identify signals that are out of timing.
	Use Case 12: Understanding Traffic Patterns due to Unpredicted Events	– Review traffic patterns following significant unpredicted events, for example COVID-19 pandemic, evacuations, emergencies, weather events. – Assess traffic patterns during targeted situations, such as truck traffic restrictions during winter weather events. – Plan for future events (response plans, road restrictions) and estimate impacts due to unpredicted events.

4.2 Work Zone Planning and Monitoring Potential Use Cases

The potential work zone planning and monitoring use cases for probe volume data include several aspects related to work zone operations. Each use case discusses multiple components of work zone management, including real-time traffic monitoring during work zone operations, post-analysis, and planning for future work zones.

Table 2 provides brief descriptions of the probe volume data potential use cases identified by the Work Zone Planning and Monitoring user group. The Appendix contains the complete use case descriptions which provide additional details for each use case.

Table 2: Work Zone Planning and Monitoring Potential Use Cases – Brief Descriptions

Title	Brief Description – How could probe volume data be used?
Use Case 13: Work Zone Planning and Design	– Assess trends in traffic volumes to plan and design work zones. For example, determine timing of lane closures, signal timing adjustments, and seasonal fluctuations.
Use Case 14: Determine Detour Routes	– Use probe volume data, with origin-destination data, to investigate detour route scenarios and determine the best route to post. – Use probe volume data to schedule work zone activities, e.g., determine the best days of the week to close a road and implement an alternate route.
Use Case 15: Assess Traffic Throughput through Work Zones	– For real-time operations, identify lane blockages or other issues to prompt real-time traffic management actions or identify adjustments to the work zone. – When planning work zones, perform a traffic forecast for work zone operations to determine strategies (e.g., merge mechanisms, lane shifts).
Use Case 16: Assess Impacts of Ramp Traffic at Freeway Work Zones	– Assess how volumes from ramps are impacting mainline traffic during freeway work zones; provide insights to make changes to optimize flows. – Inform decisions such as deploying temporary ramp meters, closing a ramp, building a longer merge lane, or providing messaging for trucks to use left lanes through the work zone.
Use Case 17: Understand Actual Diversions around Work Zones	– Understand where traffic diverted during work zone operations and overall traffic trends during construction. – Plan for future work zones and determine whether construction projects have resulted in impacts to local roads due to traffic diversions. – Estimate impacts from traffic volume changes to local businesses before, during, and after construction.
Use Case 18: Assess Work Zone Impact on Modes and other Travel Demand Management Strategies	– Determine whether there is a decline in vehicle volumes indicating modal shifts due to long-term road construction projects. – Assess impacts of travel demand management strategies (e.g., carpooling, ridesharing, congestion pricing/tolling, teleworking) during long-term construction projects.

4.3 Transportation Planning Potential Use Cases

The potential use cases for transportation planning applications include model calibration and impact analysis used to inform future events, scenarios, and designs.

Table 3 provides brief descriptions of potential use cases for probe volume data identified by the Transportation Planning user group. The Appendix contains the complete use case descriptions which provide additional details for each use case.

Table 3: Transportation Planning Potential Use Cases – Brief Descriptions

Title	Brief Description – How could probe volume data be used?
Use Case 19: Calibrate and Validate Travel Demand Models	– Validate and calibrate travel demand models. – Estimate external traffic volumes to determine where traffic enters and exits various model areas or zones.
Use Case 20: Understand Impacts from Unexpected Events	– Model actual traffic patterns to understand impacts due to unexpected events such as the COVID-19 pandemic or flooding. – Estimate impacts (e.g., user delays, user delay costs, pavement damage, impacts on commercial vehicle operations, economic impacts). – Perform cost/benefit analyses for various road improvement strategies or infrastructure improvements.
Use Case 21: Modeling Scenarios for Operational Analysis	– Simulate traffic management conditions to determine operational strategies for implementation.
Use Case 22: Calculate Peak Hour Excessive Delay	– Use probe volume data as the input for the peak hour excessive delay measure required for state DOTs to report to the Federal Highway Administration (FHWA). – Improve estimates of segment-level directional volumes that serve as an important input to estimates of delay on urban portions of the National Highway System (NHS).

5.0 Business Cases for Probe Volume Data

As transportation agencies consider whether to implement probe volume data as it becomes more widely available, it is important to understand how the data could be used by multiple user groups within the agency, as documented in Section 4.0 and as outlined in the detailed potential use cases in the Appendix. It is also important to understand the benefits of this data, compared to traditional data collection methods and practices, as well as implementation considerations. This section highlights the benefits of probe volume data and presents four major business cases for implementation of probe volume data.

As agencies consider whether to implement probe volume data, it is important to understand:

- How the data could be used by multiple user groups
- Benefits of probe volume data
- Implementation considerations

The benefits that could be realized by agencies with use of probe volume data include:

- Significantly increased coverage of traffic volume data on roadway networks.
- Less infrastructure-based detection devices, resulting in reduced costs for field equipment and maintenance.
- Reduced or eliminated need for temporary short-duration volume counts.
- Improved data-driven insights.
- Better situational awareness, especially for real-time traffic operations decisions.
- More proactive congestion management, to improve overall mobility as well as safety by anticipating conditions before a crash occurs.
- Increased deployment of traffic management systems.
- Improved accuracy of travel demand models.
- More immediate access to traffic volumes for post-event analysis.

The business cases were developed by reviewing the 22 potential use cases, grouping similar use cases together and developing an overall business case for implementation. The four business cases are:

- Business Case #1: Real-time Traffic Management
- Business Case #2: Real-time Operational Systems and Automated Functions
- Business Case #3: Performance Management and Impact Analysis
- Business Case #4: Planning and Design

Each business case describes how probe volume data would be used, lists example potential agency use cases and current detection methods, describes the value and benefits of probe volume data, and provides other implementation information such as high-level data requirements, transition considerations, and implementation readiness. Each business case contains representative examples of potential use cases that support the business case. Some use cases appear in more than one business case category, depending on the type of volume data to be used. For example, assessing traffic throughput through work zones could use real-time volume data to monitor traffic during work zone operations and could also utilize historical (archived) volume data for post-assessment review and analysis.

5.1 Business Case #1: Real-time Traffic Management

Probe volume data could be used for real-time traffic management to assist traffic management personnel with monitoring conditions in real-time and informing response decisions. Table 4 provides a business case for use of probe volume data for real-time traffic management.

Table 4: Business Case #1: Real-Time Traffic Management

Overview	Real-time probe volume data could assist agencies in understanding traffic volumes during situations that result in congestion, such as planned events, holiday traffic, evacuations, road closures, and work zone operations. Probe volumes would be used by traffic management center operators to predict changing conditions, monitor conditions as they unfold, determine appropriate traffic management approaches in real-time, assess the impacts of traffic management strategies as they are implemented, and monitor conditions following the event. Examples of potential agency use cases include: • Use Case 1: Event Management • Use Case 2: Evacuation Route Management • Use Case 3: Monitoring Major Road Closures • Use Case 15: Assess Traffic Throughput through Work Zones • Use Case 16: Assess Impacts of Ramp Traffic at Freeway Work Zones See the Appendix for detailed descriptions of each use case.
Requirements	These use cases would require real-time probe volume data, for monitoring traffic conditions. Requirements for temporal granularity of probe volume data range from 5-minute to 15-minute increments for real-time monitoring of planned events, holiday traffic, monitoring major road closures, and work zone monitoring during peak traffic periods. Work zone monitoring and multi-day evacuation route monitoring during off-peak periods may require 30-mimute to hourly increments of volume data. These use cases are directly related to traffic anomalies (i.e., when conditions are not the norm) and probe volume data needs to be capable of adjusting to provide accurate real-time volume reports as these anomalies occur. When monitoring long-term major road closures and multi-day evacuations, agencies may be assessing relative change in volumes over a longer period of time, may not be as sensitive to traffic anomalies, and would provide information from probe data where no volume data is currently available.
Current Detection Methods	To meet these use cases currently, traffic detection sensors would need to be installed at many key locations in the field to understand real-time traffic volumes. For example, upstream and downstream of work zone merge points or at detour routes for road closures.
Value/Benefits of Probe Volume Data	• Compared to speed data, rising volumes allow for prediction of imminent congestion before the route becomes over-saturated. • More proactive and timely traffic management responses (e.g., signal timing changes, posting messages to dynamic message signs (DMS), alternate

	routing, changes to diversion routes, revisions to work zone configurations and strategies). • Better overall situational awareness by operators, compared to speeds alone. • Allows operators to understand potential issues before crashes may occur, enhancing safety. • Improved coverage of volume data. Volume data is available at more locations, which can be accessed by operators during unanticipated events (e.g., evacuations). • Less or no field detection devices needed, reducing costs for equipment and maintenance.
Transition Considerations	• Though third-party data providers often offer platforms for viewing probe-based data and conditions in real-time, updates to agency systems (e.g., ATMS software) may be needed to integrate volume data into existing operator user systems, as desired by the agency. • Agency testing will likely be needed, to ensure confidence in the accuracy, granularity appropriateness, and latency of delivery of real-time probe volume data.
Implementation Readiness	• Use of probe volume data for real-time traffic monitoring is a candidate for early implementation, given the significant overall value it will provide to traffic management center operators. • Use cases that require 30-minute to hourly volumes (e.g., multi-day evacuation route monitoring, work zone monitoring at off-peak periods) could be candidates for early implementation, especially as volumes are monitored over longer periods of time. • Real-time event management, which requires volumes at 5-minute increments and needs highly accurate data during traffic anomalies, may take longer to implement.

5.2 Business Case #2: Real-time Operational Systems and Automated Functions

Probe volume data could be used, in conjunction with other data sources such as speed data, to operate real-time traffic management systems or other automated functions. Table 5 provides a business case for use of probe volume data for real-time operational systems and automated functions.

Table 5: Business Case #2: Real-Time Operational Systems and Automated Functions

Overview	Probe volume data could be used, in conjunction with other data sources such as speed data, to operate real-time operational systems or to operate automated functions. Probe volume data would be used by these systems to detect growing congestion conditions and trigger automated warnings or operational actions. Examples of potential agency use cases include: • Use Case 4: Rural Incident Detection • Use Case 5: Lane-level Incident Detection in Urban Areas • Use Case 6: Variable Speed Limit (VSL) Systems • Use Case 7: Dynamic Shoulder Lane Operations • Use Case 8: Queue Warnings

	• Use Case 9: Ramp Metering Operations See the Appendix for detailed descriptions of each use case.
Requirements	These operational systems and automated functions require real-time volume data, with temporal granularity ranging from 1-minute to 15-minute increments. Real-time operational systems that utilize probe volume data would need this data to be capable of adjusting to rapidly changing conditions and traffic anomalies such as incidents and other non-recurring congestion.
Current Detection Methods	Field detection devices currently need to be installed at each location where an operational system is deployed, potentially limiting how widely these systems can be utilized. Installation of extensive field detection equipment would be required for automated incident detection functionality, and it is not feasible to deploy detection devices everywhere an incident could occur.
Value/Benefits of Probe Volume Data	• Significantly improved coverage of volume data compared to current state (i.e., field detectors are not in place everywhere needed to implement operational systems and automated functions). • Less or no field detection devices are needed, reducing costs for equipment and maintenance. • Increased deployment of proven operational systems at problem locations. • More proactive and timely traffic management responses. • Improved ability to detect conditions and provide warnings to traffic management center operators and drivers, reducing secondary crashes (increased safety) and minimizing congestion impacts (improved mobility).
Transition Considerations	• Updates to current software/algorithms/systems may be needed, to use probe volume data (or a combination of volumes and speeds) to operate the system(s) and automated functions. For example, an ATMS may not be capable of detecting congestion to trigger an incident warning, so a new algorithm may need to be developed to use probe volume data for this purpose. Existing software and algorithms for operational systems that utilize speed data only may need to be updated to operate using both speeds and volumes. • Agency testing will likely be needed, to ensure confidence in the accuracy, granularity appropriateness, and latency of delivery of real-time probe volume data.
Implementation Readiness	• Dynamic shoulder lane operations may be viable for early use of probe volume data. Because temporary shoulder lanes are adjusted (opened or closed) at greater intervals, such as an hour at a time based on trends in traffic volumes, the latency and temporal granularity capabilities of probe volume data could be suited for this use case in the short-term. However, implementation readiness will depend on specific configurations, conditions, and operational requirements. • The incident detection applications (rural incident detection and lane-level incident detection in urban areas) may be feasible for early implementation. Probe volume data would significantly advance incident detection from current typical practices, as incidents can go undetected for long periods of time, especially in rural areas.

	• Operational systems and automated functions that require finer granularity (1-minute to 5-minute increments) such as ramp metering, queue warning, and VSL systems may experience a longer transition to use of probe volume data.

5.3 Business Case #3: Performance Management and Impact Analysis

Table 6 outlines a business case for use of probe volume data for improving traffic operations performance management approaches and estimating impacts from traffic-related conditions and strategies.

Table 6: Business Case #3: Performance Management and Impact Analysis

Overview	Probe volume data could be utilized to improve traffic operations performance management approaches and to estimate impacts from traffic-related conditions and strategies. The insights gained from this data will be valuable as agencies review their existing traffic management strategies and plan for more useful, impactful, and efficient strategies in the future. Examples of potential agency use cases include: • Use Case 10: ITS Device Performance Management • Use Case 11: Signalized Corridor Throughput/Effectiveness • Use Case 12: Understanding Traffic Patterns due to Unpredicted Events • Use Case 15: Assess Traffic Throughput through Work Zones • Use Case 16: Assess Impacts of Ramp Traffic at Freeway Work Zones • Use Case 17: Understand Actual Diversions around Work Zones • Use Case 18: Assess Work Zone Impact on Modes and other Travel Demand Management Strategies • Use Case 20: Understand Impacts from Unexpected Events • Use Case 22: Calculate Peak Hour Excessive Delay See the Appendix for detailed descriptions of each use case.
Requirements	These use cases require historical volume data to conduct post-analysis, with temporal granularity requirements at 15-minute increments, hourly volumes, or daily volumes, depending on the use case. These use cases have varying levels of sensitivity to data quality during traffic anomalies. Analysis of traffic management strategies (ITS devices, signalized corridor operations, work zones) are based on responding to traffic anomalies, so data quality during such events would be critical. Variations in data quality during traffic anomalies will not significantly impact the usefulness of Use Case 22 (Calculate Peak Hour Excessive Delay), since it measures congestion over an annual period reflecting typical traffic conditions in an urban area.
Current Detection Methods	Field detection devices currently need to be installed at each location where detailed volume data is needed for post-analysis.

Value/Benefits of Probe Volume Data	• Significantly improved coverage of volume data compared to current state. • Less or no field detection devices needed, reducing costs for equipment and maintenance. • Potential reduction in an agency's need to perform short-duration counts for field data collection. • Historical probe volume data would be available much sooner than relying on traditional methods that estimate volumes based on annual processes and seasonal, short-duration counts. • Increased efficiency due to better data to inform signal timing improvements. • Improved effectiveness of information and traffic management strategies (e.g., assessing performance of ITS devices) provided to the traveling public. • Improved accuracy of Peak Hour Excessive Delay estimate, for reporting to FHWA.
Transition Considerations	• For post-analysis use cases, the temporal granularity of data desired could depend upon the agency's ability to store large datasets. • For some analyses, the level of spatial detail requires volume data to be compatible with whichever type of network segmentation a DOT is using. Many DOTs use calculation tools designed to be compatible with the traffic message channel (TMC) networks used by major probe data vendors. • Agency testing will likely need to ensure confidence in the accuracy, granularity appropriateness, and latency of delivery of real-time probe volume data.
Implementation Readiness	• Overall, the use cases in this category have high potential for implementation as probe volume data becomes available and is tested for appropriateness for each use case. • Strong candidates for early implementation are use cases that rely on average volumes over time and that will benefit significantly from improved accuracy and coverage, such as Use Case 22: Calculate Peak Hour Excessive Delay, Use Case 18: Assess Work Zone Impact on Modes and other Travel Demand Management Strategies, and Understanding Traffic Patterns and Impacts due to Unpredicted Events (Use Cases 12 and 20).

5.4 Business Case #4: Planning and Design

Table 7 provides a business case for use of probe volume data to improve long-range planning and design activities within transportation agencies.

Table 7: Business Case #4: Planning and Design

Overview	Probe volume data could be utilized by agencies to improve long-range planning and design functions. When combined with origin/destination data that becomes available with probe-generated data, probe volume data can be used to calibrate planning models and inform work zone designs, potentially replacing traditional data collection methods that include short-term, seasonal counts. Examples of potential agency use cases include: • Use Case 13: Work Zone Planning and Design

	• Use Case 14: Determine Detour Routes • Use Case 19: Calibrate and Validate Travel Demand Models • Use Case 21: Modeling Scenarios for Operational Analysis See the Appendix for detailed descriptions of each use case.
Requirements	These use cases require historical probe volume data, typically daily volumes (AADTs). Variations in data quality during traffic anomalies will not significantly impact the usefulness of probe volume data for these cases, as average volumes over an extended period of time are typically used.
Current Detection Methods	Permanent field traffic counters and temporary, short-duration counts are currently used to generate annual volume estimates on a rotating cycle.
Value/Benefits of Probe Volume Data	• Improved accuracy of travel demand models. • Less or no field detection devices needed, reducing costs for equipment and maintenance. • Reduced need for temporary short-duration counts. • Significantly improved coverage of volume data. • Larger and more robust datasets including seasonal, weekday, or weekend counts. • Compared to traditional field detection methods, agencies could access volume data much sooner than waiting for end of year annual average volumes (AADTs) to be estimated.
Transition Considerations	• Agencies may need to consider how to store large datasets for post-analysis, if that is not offered by the third-party data provider. • The level of spatial detail requires volume data to be compatible with whichever type of network segmentation a DOT is using. Many DOTs use calculation tools designed to be compatible with the traffic message channel (TMC) networks used by major probe data vendors. • When adding another source of data to existing sources, agencies may consider how to mesh these data sources together, potentially modifying systems to automate an official “one-answer” data value for various use cases.
Implementation Readiness	Historical daily volume data are being offered by at least one third-party data provider and is being used by DOTs in practice for transportation planning applications and impact analysis. This indicates near to full implementation readiness for the use cases in this category.

6.0 Summary

ENTERPRISE members' use of third-party probe-based traffic data is becoming increasingly widespread and has proven effective for reporting estimated speeds. Meanwhile, third-party probe data is emerging as a source for traffic volume data. To help ENTERPRISE agencies prepare for probe-based volume data being more widely available, this project documented potential use cases for probe volume data and developed business cases for implementation.

Selected key findings from the project are as follows:

- ***Advancements in Third-Party Probe Volume Data*** – The industry offering probe-based traffic data for purchase or licensed use is rapidly evolving and improving. Commercially available historical probe volume data is increasingly being used for transportation planning and post-event analysis. Advancements toward commercialization of real-time probe volume data are underway, with progress being made through current research to develop and validate estimation models.

- ***Potential Agency Use Cases*** – Twenty-two (22) potential use cases describing how transportation agencies could use probe volume data were documented. Use cases were generated using input from three ENTERPRISE member agency user groups: Traffic Operations, Work Zone Planning and Monitoring, and Transportation Planning. Figure 3 shows the potential agency use cases for probe volume data, sorted by user groups. Detailed summaries of each potential use case can be found in the Appendix.

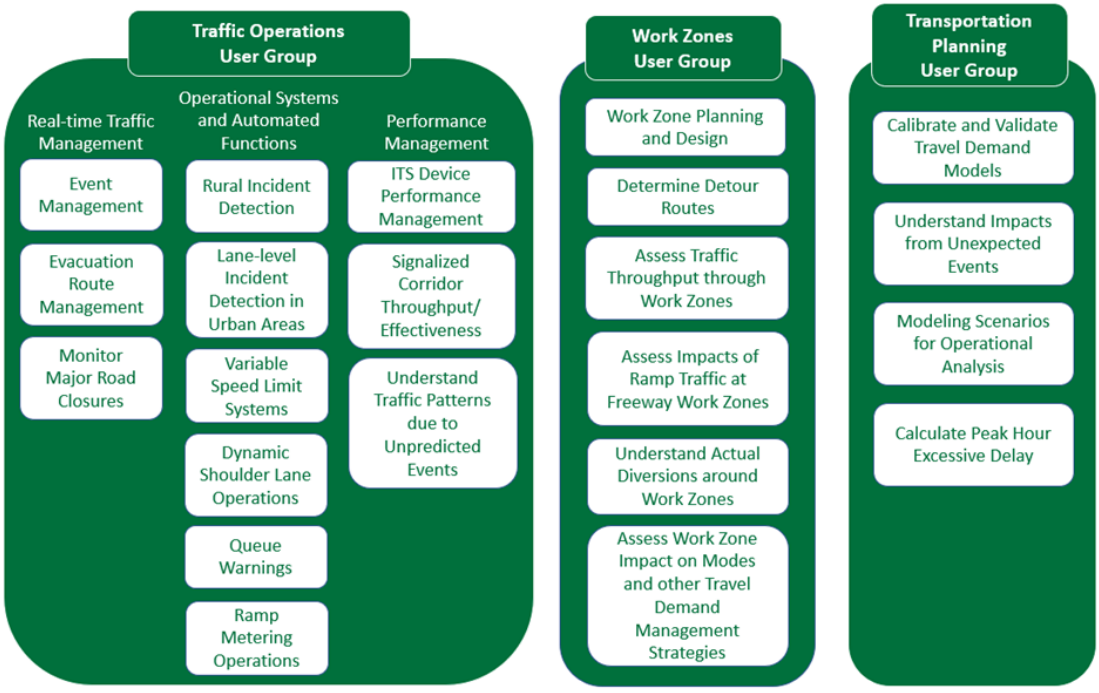

Figure 3: Potential Agency Use Cases for Probe Volume Data

- ***Benefits of Probe-based Volume Data*** – Benefits for future use of probe volume data as cited by project participants include: significantly increased coverage of traffic volumes, less field detection devices, reduced or eliminated need for temporary short-duration volume counts, improved data insights, better situational awareness (especially for real-time operational decisions), more proactive congestion management, increased deployment of traffic management systems, improved accuracy of travel demand models, and more immediate access to traffic volumes for post-event analysis.

- ***Business Cases*** – Four business cases were developed for probe volume data. The business cases present example potential use cases, value and benefits of probe volume data, transition considerations, and implementation readiness. Strong candidates for early implementation are use cases that rely on average volumes over time and that will benefit from significantly improved volume data coverage on the road network. Similar to any new data source, agency testing in practice will likely be needed to ensure confidence in the accuracy, granularity appropriateness, and latency of delivery of real-time probe volume data prior to full implementation.

The results of this project can be used by agencies to plan for and implement probe volume data across various agency functions and user groups. Additional uses could materialize as the data becomes integrated into agency operations.

Appendix: Detailed Potential Use Cases for Probe Volume Data

Traffic Operations: Real-time Traffic Management

- Use Case 1: Event Management
- Use Case 2: Evacuation Route Management
- Use Case 3: Monitoring Major Road Closures

Traffic Operations: Operational Systems and Automated Functions

- Use Case 4: Rural Incident Detection
- Use Case 5: Lane-level Incident Detection in Urban Areas
- Use Case 6: Variable Speed Limit (VSL) Systems
- Use Case 7: Dynamic Shoulder Lane Operations
- Use Case 8: Queue Warnings
- Use Case 9: Ramp Metering Operations

Traffic Operations: Performance Management

- Use Case 10: ITS Device Performance Management
- Use Case 11: Signalized Corridor Throughput/Effectiveness
- Use Case 12: Understanding Traffic Patterns due to Unpredicted Events

Work Zone Planning and Monitoring

- Use Case 13: Work Zone Planning and Design
- Use Case 14: Determine Detour Routes
- Use Case 15: Assess Traffic Throughput through Work Zones
- Use Case 16: Assess Impacts of Ramp Traffic at Freeway Work Zones
- Use Case 17: Understand Actual Diversions around Work Zones
- Use Case 18: Assess Work Zone Impact on Modes and other Travel Demand Management Strategies

Transportation Planning

- Use Case 19: Calibrate and Validate Travel Demand Models
- Use Case 20: Understand Impacts from Unexpected Events
- Use Case 21: Modeling Scenarios for Operational Analysis
- Use Case 22: Calculate Peak Hour Excessive Delay

Traffic Operations: Real-time Traffic Management Potential Use Cases

Use Case 1: Event Management	
User Category	Traffic Operations =>> Real-time Traffic Management
Description	***Description of use case:*** Real-time probe volume data would help agencies understand traffic volumes during events that cause congestion, such as sporting events or holiday traffic. Probe volume data would help predict congestion as it unfolds and determine appropriate traffic management strategies (e.g. adjust signal timing, redirect traffic to an alternate route). In addition, traffic volumes are needed to assess the overall success of the traffic management strategies as they are implemented.
Example in Practice	***Describe a real-world example of this use case in practice:*** Two interstates merging outside of an urban area experience significant congestion on the Sunday after Thanksgiving. A highly viable alternative route exists to redirect traffic as queues form. Traffic management center operators use insights from probe volume data to monitor traffic volumes as congestion grows. They post a message on Dynamic Message Signs (DMS) to communicate the alternate route and alert traffic signal personnel who adjust traffic signal timings on the alternate route.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Traffic detection sensors would need to be installed at key locations in the field to understand real-time traffic volumes.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)?*** Probe volume data would eliminate the need for field traffic detection and provide volume data at a wider range of locations. As opposed to speed data, rising volumes allow for prediction of imminent congestion before the route becomes over-saturated and could provide automatic posting to DMS of alternative routing. In addition, use of this data would allow operators to be more proactive in implementing traffic management strategies as volumes report growing congestion.
Temporal Granularity	The closer to real-time the volume data would be, the quicker traffic management centers could react. 15-min increments of volumes is the minimum required, which would be sufficient for gradually changing conditions, such as

	holiday traffic. Finer granularity -- less than 15-min increments -- is needed for special events (e.g. sporting events, concerts) that generate large volumes of traffic in a short time period.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or a pre-established framework (e.g. decision support systems, automated processes, traveler information systems, etc.)? If so, how?*** Probe volume data could be tied into advanced traffic management software (ATMS) and used to automatically activate message boards, alert key staff, and recommend actions.
Sensitivity to Data Quality During Traffic Anomalies	This use case is directly related to traffic anomalies (i.e. when conditions are not the norm), therefore, the data needs to be capable of adjusting to provide accurate volume reports as these anomalies occur.

Use Case 2: Evacuation Route Management	
User Category	Traffic Operations =>> Real-time Traffic Management
Description	***Description of use case:*** Real-time probe volume data would help agencies understand traffic volumes during evacuations conducted for significant events (e.g. severe weather events and other natural disasters, emergencies). Probe volume data would allow agencies to monitor traffic volumes in real-time and initiate actions (e.g. adjust signal timing, revise evacuation routes) as conditions change.
Example in Practice	***Describe a real-world example of this use case in practice:*** A hurricane is predicted to impact the southeast portion of a state in four days. The state DOT initiates evacuation routes based on the current path of the storm. The DOT continuously monitors probe volume data and makes adjustments to evacuation routes as needed. Two days later, the anticipated path of the storm changes to a slightly more western path. The DOT uses probe volume data to estimate how many residents have already evacuated the impacted areas and modifies the evacuation routes as needed.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Traffic detection sensors would need to be installed at key locations in the field to understand real-time traffic volumes.

Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)?*** Currently, traffic volume data is often not readily accessible at locations where it is needed during evacuation operations, as detectors are not installed everywhere an evacuation may be occurring. Agencies can estimate volumes using automatic traffic detector data (ATR) data, but it takes time to process the data for example to estimate volumes between ATR stations. Probe volume data would provide real-time volumes to estimate how many people have evacuated an area, providing the agency with insights necessary to continually assess and revise evacuation routes as needed.
Temporal Granularity	The granularity of volume data needed ranges from 15-min increments for real-time monitoring, to hourly or daily volumes for periodic estimation of the number of residents that have evacuated.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or a pre-established framework (e.g. decision support systems, automated processes, traveler information systems, etc.)? If so, how?*** In addition to monitoring and adjusting evacuation routes as an event unfolds, probe volume data would also be associated with post-assessment and evacuation route planning.
Sensitivity to Data Quality During Traffic Anomalies	When monitoring volumes in real-time (e.g. 15-minute increments), the data needs to be capable of adjusting to provide accurate volume reports as traffic anomalies occur. When assessing conditions on an hourly or daily basis to inform decisions about route adjustments, the average traffic volumes would be adequate and less sensitive to minute-by-minute fluctuations.

Use Case 3: Monitoring Major Road Closures	
User Category	Traffic Operations =>> Real-time Traffic Management
Description	***Description of use case:*** Probe volume data could be used to monitor traffic conditions on alternate routes during major road closures, such as long-term construction, flooding, hazardous material spills, or other planned or unexpected events. Agencies would use probe volume data to evaluate whether the diversion route is keeping up with traffic capacity on the alternate route and to initiate appropriate actions. Insights from this real-time probe volume data could be used, for example, to: – Monitor traffic impacts in real-time

	– Determine where detour signing is needed. – Determine whether a new (or secondary) alternate route is needed, and post related messages. – Evaluate whether the additional traffic on the diversion route is overloading signals on that route and communicate with cities to initiate signal time changes. – Stage motor assist units or involve law enforcement to manage higher than normal traffic diverts onto the alternate route.
Example in Practice	***Describe a real-world example of this use case in practice:*** A major construction project will close a section of a state highway for 3 months. The agency posts a detour route that diverts traffic through a nearby city. When the road closure begins, traffic management center operators use probe volume data to monitor traffic conditions as vehicles divert to the alternate route. Operators notice that growing volumes on the alternate route are likely to result in congestion and choke points at signals within the city. They notify the city's traffic signal staff, who implement signal timing adjustments. A few weeks later, just prior to a seasonal event nearby, volumes appear to be overloading the alternate route despite signal timing adjustments. The agency has identified a secondary alternate route where vehicles would exit several miles in advance of the original detour exit, so they implement the appropriate signage and DMS activations to communicate this alternate route.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Field detection equipment is typically not installed at rural roads where vehicles would divert during road closures or other major road disruptions.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. Increased coverage of reported volumes, Less physical detectors)?*** With insights from probe volume data, agencies could be more proactive in responding to changing conditions on alternative routes and take appropriate actions. It could also allow operators to understand potential issues before crashes occur, enhancing safety.
Temporal Granularity	Real-time monitoring of road closures requires temporal granularity of 5-minute to 15-minute increments of probe volume data. 30-minute to hourly volumes could be adequate for periodic evaluation of road closure impacts and decision-making, such as determining secondary alternate routes or assessing need for signal timing changes on diversion routes.

Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or a pre-established framework (e.g. decision support systems, automated processes, traveler information systems, etc.)? If so, how?*** Insights gained from the probe volume data could be used to inform on-road signing (e.g. static signs or DMS messages) and messages for traveler information mechanisms such as 511 websites or mobile apps. This could also be connected to an ATMS or signal management systems for real-time operational adjustments. Law enforcement and motor assist units may also be involved.
Sensitivity to Data Quality During Traffic Anomalies	For real-time operations, probe volume data needs to be capable of adjusting to traffic anomalies, especially since this use case would introduce increases in traffic on alternate routes that are significantly different from typical conditions. However, the relative change in volumes as monitored by traffic operators would provide new insights that are not currently available if no detection devices are deployed on the alternate routes.

Traffic Operations: Operational Systems and Automated Functions Potential Use Cases

Use Case 4: Rural Incident Detection	
User Category	Traffic Operations =>> Real-time Operational Systems and Automated Functions
Description	***Description of use case:*** Probe volume data could be used, in conjunction with speed data, to detect traffic incidents in rural areas where field detectors are not widely deployed. This data could be used to detect congestion due to an incident (crash, debris in road, etc.), trigger alerts to traffic management center operators, and automatically post messages to DMS to warn approaching traffic, until operators have better information about the incident from the field (e.g. from DOT field staff or law enforcement).
Example in Practice	***Describe a real-world example of this use case in practice:*** A crash occurs on a rural interstate where field detection equipment is not deployed. Algorithms in the agency's ATMS process probe volume data and speed data together on an ongoing basis, to detect incidents based on parameters that signify unusual congestion. These algorithms detect the incident's location, at which time the ATMS provides an alert to operators and automatically posts a message to DMS located upstream of the crash, to warn oncoming traffic.

Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Field detection equipment is typically not deployed widely enough in rural areas to support this use case.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. Increased coverage of reported volumes, Less physical detectors)?*** Probe volume data could significantly improve the timeliness in which incidents can be detected in rural areas. This is especially important where significant slowdowns or stopped traffic occurs at an incident location (crash, debris in the road) on a high-speed roadway, to warn approaching traffic via DMS messages upstream and help avoid secondary crashes. Probe volume data would allow for increased coverage of traffic volumes in rural areas where traffic detection devices are not widely deployed. Having volumes in conjunction with speed data will improve incident detection capability, as traffic densities in rural areas may not be evident with only one data type.
Temporal Granularity	5-minute increments of probe volume data is the minimum required.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or a pre-established framework (e.g. decision support systems, automated processes, traveler information systems, etc.)? If so, how?*** Probe volume data could be tied into an ATMS with algorithms to identify congestion due to an incident, automatically activate DMS, alert key staff, or recommend actions. It could also be tied to law enforcement and/or agency motor assist units, to initiate response efforts. In addition, related messages could be communicated via an agency's traveler information dissemination mechanisms.
Sensitivity to Data Quality During Traffic Anomalies	Volume data for this use case needs to be capable of adjusting to traffic anomalies, especially because this use case is detecting traffic incidents that are not typical of normal conditions. The accuracy of algorithms to detect incidents would be enhanced through the availability of volume data in addition to speed data.

Use Case 5: Lane-level Incident Detection in Urban Areas	
User Category	Traffic Operations =>> Real-time Operational Systems and Automated Functions
Description	***Description of use case:***

	Probe volume data could be used, in conjunction with speed data, to detect lane-level traffic incidents in urban areas where speed data alone may not be sufficient for lane-level detections. For instance, if an incident impacts only one lane of a multi-lane highway, this may cause only a minimal decrease in overall speeds at that location, not triggering an incident detection alert. Probe volume data could be used with speed data to identify times when a portion of the total volume (e.g. 1/3 of the total volume on a 3-lane highway) is experiencing a slowdown, indicating a lane-level incident. This approach could be used to detect congestion from incidents (crashes, debris in road, etc.) in urban settings, and prompt alerts and actions such as posting messages to DMS warning approaching drivers of the lane blockage.
Example in Practice	***Describe a real-world example of this use case in practice:*** Debris is blocking one lane of traffic on a multi-lane highway in a metro area. Algorithms in an agency's ATMS process probe volume data and speed data together on an ongoing basis to detect congestion that indicates a potential incident blocking one or more lanes of traffic. The ATMS detects congestion upstream of the debris and provides an alert to traffic management center operators. Operators use a nearby traffic camera to see that debris is blocking one lane of traffic, as which time they initiate a highway assist unit to clear the debris.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Field detection equipment may be deployed at select locations but may not be in place everywhere on an urban roadway network.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. Increased coverage of reported volumes, Less physical detectors)?*** This data could improve the timeliness in which incidents are detected, to warn approaching traffic and help avoid secondary crashes. Probe volume data could increase an agency's coverage of reported volumes in an urban area.
Temporal Granularity	5-minute increments is the minimum granularity required.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or a pre-established framework (e.g. decision support systems, automated processes, traveler information systems, etc.)? If so, how?*** Probe volume data could be tied into an ATMS with algorithms to identify congestion due to incidents and automatically activate DMS, alert key staff, or recommend actions. This use case could also involve law enforcement and/or agency motor assist units, to initiate response efforts. In addition, related messages could be communicated via an agency's traveler information dissemination mechanisms.

Sensitivity to Data Quality During Traffic Anomalies	Volume data for this use case needs to be capable of adjusting to traffic anomalies, especially because this use case is detecting traffic incidents that are not typical of normal conditions. The accuracy of algorithms to detect incidents would be enhanced through the availability of volume data in addition to speed data.

Use Case 6: Variable Speed Limit (VSL) Systems	
User Category	Traffic Operations =>> Real-time Operational Systems and Automated Functions
Description	***Description of use case:*** Variable speed limit (VSL) systems could use probe-generated volume data, in conjunction with other data sources such as speed data, at locations where physical detectors are not present. For example, at areas with severe recurring congestion, locations with a known safety problem (rear-end crashes, sight distance limitations), or approaching work zones.
Example in Practice	***Describe a real-world example of this use case in practice:*** A stretch of highway located outside the metro area beltway has a severe recurring congestion problem that has resulted in several crashes. This location does not have point detectors in place. The deploying agency uses probe-generated volume data to operate a VSL system that adjusts speed limits displayed to drivers based upon the changing congestion levels.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** A significant number of field detectors are needed for current VSL systems. With probe-generated volumes, fewer or no detectors would be needed to operate VSL systems.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. Increased coverage of reported volumes, Less physical detectors)?*** Less or no field detectors would be needed. These VSL systems could be deployed anywhere in conjunction with other data sources, without physical detection devices. More VSL systems could be implemented for improved safety.
Temporal Granularity	1-minute to 5-minute increments of probe volume data is required.

Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, ATMS, traveler information systems, etc.)? If so, how?*** These VSL systems would likely be connected to an ATMS for algorithms to determine variable speed limits and for posting to DMS. They could also be integrated into 511 systems. In addition, there is a relationship to law enforcement, for enforcing the resulting speed limits.
Sensitivity to Data Quality During Traffic Anomalies	Though VSL systems are deployed at locations with known recurring congestion, operational systems that utilize volume data need this data to be capable of adjusting to traffic anomalies such as incidents and other non-recurring events.

Use Case 7: Dynamic Shoulder Lane Operations	
User Category	Traffic Operations =>> Real-time Operational Systems and Automated Functions
Description	***Description of use case:*** Systems/algorithms used to determine operations of temporary dynamic shoulder lanes could use probe-generated volume data in conjunction with other data sources, such as speed data. These systems monitor the rate of increase/decrease of volumes on roadway segments approaching temporary shoulder lanes, to determine when to open or close the temporary shoulder lane(s).
Example in Practice	***Describe a real-world example of this use case in practice:*** A transportation agency has implemented a temporary dynamic shoulder lane on a metro area interstate. The shoulder lane is opened as a general purpose lane, as needed, during periods of high traffic volumes. Algorithms in the agency's ATMS use probe volume data to monitor the rate of volumes increases on the interstate itself, as well as two other highways that feed morning rush hour traffic onto that interstate. As volumes increase at a pre-determined rate on these approaching segments, the ATMS alerts management center operators, who then open the shoulder lane.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Field detection equipment is currently needed to monitor volumes on approaching road segments, to determine when to open or close shoulder lanes.

Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. Increased coverage of reported volumes, Less physical detectors)?*** If probe-generated volume data was available, less or no field detectors would be needed to support operations of temporary dynamic shoulder lanes.
Temporal Granularity	15-min increments of probe volume data may be appropriate, possibly 5-min granularity is needed. Temporary shoulder lanes are typically adjusted (opened or closed) at greater intervals, such as an hour at time, based on trends in traffic volume changes.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, ATMS, traveler information systems, etc.)? If so, how?*** These systems would likely be connected to an ATMS that run algorithms to monitor increasing and decreasing volumes approaching the temporary shoulder lane, and to operate related signage and gates. It could also be integrated into 511 systems.
Sensitivity to Data Quality During Traffic Anomalies	Operational systems that utilize volume data need this data to be capable of adjusting to traffic anomalies such as incidents and other non-recurring congestion. Because dynamic shoulder lanes are operated based on trends in volume changes over a period of time (such as at hourly intervals that the shoulder lane is opened or closed) this use case may be less sensitive to traffic anomalies, compared to other systems that operate at more frequent intervals, such as queue warning or ramp meters.

Use Case 8: Queue Warnings	
User Category	Traffic Operations =>> Real-time Operational Systems and Automated Functions
Description	***Description of use case:*** Probe-generated volume data, in conjunction with other data sources such as speeds, could be used to detect growing congestion indicating traffic queues and trigger warnings at locations where physical detectors are not present. For example, these warnings could be deployed at locations where traffic queues tend to form approaching "choke points" or closed lanes, such as at high-speed roadways approaching work zones or at known problematic locations.
Example in Practice	***Describe a real-world example of this use case in practice:***

	An agency is using probe volume data, in conjunction with speed data, to detect growing congestion indicating a traffic queue and to activate a warning to drivers in advance of a work zone on a rural interstate. In this instance, drivers traveling at high interstate speeds are not expecting to experience slow or stopped traffic ahead, so the queue warning provides an advanced alert about the condition ahead.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Currently, field detectors need to be deployed to operate queue warnings.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. Increased coverage of reported volumes, Less physical detectors)?*** With probe-generated volume data, less or no field detectors would be needed to activate queue warnings. Probe volume data could be used together with speed data to help to make more accurate determinations for detecting growing traffic queues and activating warnings to drivers. These queue warnings could be deployed at more locations, especially in areas no field detectors in place, such as in advance of work zones on rural, high-speed roadways.
Temporal Granularity	1-min increments of probe volume data is required, to support rapidly changing conditions and trigger queue warning messages.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, ATMS, traveler information systems, etc.)? If so, how?*** Queue warnings may be connected to an agency's ATMS, to run algorithms that operate the warnings.
Sensitivity to Data Quality During Traffic Anomalies	Automated functions that utilize probe volume data need this data to be capable of adjusting to rapidly changing conditions and traffic anomalies such as incidents and other non-recurring congestion.

Use Case 9: Ramp Metering Operations	
User Category	Traffic Operations =>> Real-time Operational Systems and Automated Functions
Description	***Description of use case:*** Probe-generated volume data could be used in conjunction with field detection devices to operate ramp meters, or as a backup to field detection devices that can fail. Probe volume data could provide a range of volumes from approaching roadways, to supplement data from point detection field devices. The granularity of probe data may not be fast enough to detect vehicles on a frontage road approaching ramp meters. It will likely be a long transition to operating ramp meters solely with probe volume data.
Example in Practice	***Describe a real-world example of this use case in practice:*** An agency operates several ramp meters with detectors in the field. At some locations, various field detectors begin to fail, which disrupts ramp metering operations until these detectors can be replaced. Probe volume data procured by the agency is used to estimate a range of traffic volumes to supplement field detection data.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Currently, field detectors need to be deployed to operate ramp meters.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. Increased coverage of reported volumes, Less physical detectors)?*** It is a challenge for agencies to maintain the extensive number of field detection devices that are required to operate ramp meters, especially with multiple ramp meters deployed in a metro roadway network. Use of probe volume data would help to sustain accurate ramp metering operations during times when field detectors fail.
Temporal Granularity	1-min increments of probe volume data is required to support ramp metering operations.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, ATMS, traveler information systems, etc.)? If so, how?*** Ramp meters are often connected to an ATMS for ramp metering operations.
Sensitivity to Data Quality During Traffic Anomalies	Operational systems that utilize probe volume data need this data to be capable of adjusting to rapidly changing conditions and traffic anomalies such as incidents and other non-recurring congestion.

Traffic Operations: Performance Management Potential Use Cases

Use Case 10: ITS Device Performance Management	
User Category	Traffic Operations =>> Performance Management
Description	***Description of use case:*** Probe volume data could be utilized to analyze the performance and general effectiveness of DMS and other ITS devices in managing/responding to traffic events.
Example in Practice	***Describe a real-world example of this use case in practice:*** Agencies used probe volume data to determine the effectiveness of DMS messaging in impacting traveler behavior – such as detouring and re-routing -- for major events, construction / work zones, and other non-recurring congestion conditions.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Agencies typically have access to a very limited number of permanent traffic count stations, however these count stations provide the ability to do a comprehensive study across the state.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. Increased coverage of reported volumes, Less physical detectors)?*** Agencies may be able to develop or re-write DMS message guidelines based on data that shows which types of messages are most effective. With real-time data, agencies could automate DMS congestion messaging to provide appropriate guidance as traffic volumes increase. This would also be relevant to work zone messaging on portable DMS/queue protection systems.
Temporal Granularity	15-minute increments of probe volume data is needed at a minimum.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or a pre-established framework (e.g. decision support systems, automated processes, traveler information systems, etc.)? If so, how?*** This could inform DMS guidelines, ATMS message posts, and 511 (traveler information).

Sensitivity to Data Quality During Traffic Anomalies	This analysis is based entirely on responding to traffic incidents, anomalies, and work zones, so data quality during such events would be critical to the usefulness in these efforts.

Use Case 11: Signalized Corridor Throughput/Effectiveness	
User Category	Traffic Operations =>> Performance Management
Description	***Description of use case:*** Probe volume data could be used to identify poor signal timing for major corridors based on volume throughput drops due to signal choke points. This would include assessing threshold(s) for maximum capacity along the corridors, to identify signals that are out of timing to assess signal timing plans.
Example in Practice	***Describe a real-world example of this use case in practice:*** Using probe volume data, agencies could build or use a tool (e.g. in an ATMS) to assess signal performance measures on a signalized corridor to determine before and after throughput analysis of signal timing changes, in areas without adaptive signals.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Volume data from field detectors is available in some places, but not comprehensively. Traffic signals and related data collection systems are becoming more connected with expanded communications infrastructure in place, allowing agencies to become more sophisticated to monitor signal timing and make adjustments in real-time. Use of volumes from probe data could reduce the need for extensive communications infrastructure, especially in areas where communication is not needed for other purposes.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. Increased coverage of reported volumes, Less physical detectors)?*** ATMS has the ability to activate signal action sets of pre-defined timing plans for an entire corridor of signals. ATMS operations staff would be able to monitor, in real-time, the before/after impacts on volumes when they enact a signal action plan. It would broaden the ability to do this type of analysis outside of areas where that type of technology is deployed. It may also limit an agency's need to deploy expensive vehicle count technology on signals in certain areas. It would evolve DOT traffic signal staff to be able to be more proactive with signal re-timing by setting a baseline

	standard of available data across the state. Agencies typically do not have real-time monitoring capabilities (e.g. cameras) to view conditions along signalized corridors; probe volume data would provide a level of monitoring that is not currently available in many locations.
Temporal Granularity	15-minute increments of probe volume data would be needed at a minimum.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or a pre-established framework (e.g. decision support systems, automated processes, traveler information systems, etc.)? If so, how?*** This use case is related to ATMS, central signal command and control software (e.g. MaxView), DOT traffic signal practices, and potential automated business rules for signal re-timing.
Sensitivity to Data Quality During Traffic Anomalies	Data quality during traffic anomalies is critical to this analysis – if changes from typical volumes can't be detected, before and after analysis is not possible.

Use Case 12: Understanding Traffic Patterns due to Unpredicted Events	
User Category	Traffic Operations =>> Performance Management
Description	***Description of use case:*** Probe volume data could be used to review traffic patterns following significant unpredicted events, to understand the event's impact on traffic volumes. For example, events such as the Covid-19 pandemic, evacuations/emergencies, or road weather events. Probe volume data could also be used for targeted situations such as assessing vehicle behavior when temporary winter weather restrictions (e.g. truck traffic restrictions during snow events) are in place. Having this data would help agencies plan for future events (e.g. develop response plans, modify road restrictions) and estimate related impacts such as user delay and economic impacts.
Example in Practice	***Describe a real-world example of this use case in practice:*** The state transportation agency evacuates an impacted area due to a hurricane according to pre-established response plans. During the evacuation, the agency notices significant traffic delays occurring at unanticipated locations. After the hurricane has passed, the agency uses probe volume data to understand how many vehicles were evacuated from the area, and in what locations they traveled. This impacted area has only one permanent traffic counter installed at a

	major highway, so the probe volume data is used to assess traffic on other highways and local roads that didn't have traffic detection installed.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Some field detection devices may be in place, but these devices are not deployed everywhere statewide or may not be deployed at critical locations where traffic is diverting based on the location of the unexpected event.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from an operations standpoint? How would having this data change/improve your practices (e.g. Increased coverage of reported volumes, Less physical detectors)?*** Probe volume data would allow agencies to have significantly increased coverage of traffic volumes, available for post-event analysis.
Temporal Granularity	The granularity required depends on the type of analysis being conducted. For example, daily volumes (AADTs) for pandemic analysis, and 15-min increments to hourly increments for weather events or emergencies.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, ATMS, traveler information systems, etc.)? If so, how?*** This data could be imported into traffic data analytics software, for detailed analysis of historical traffic volume trends.
Sensitivity to Data Quality During Traffic Anomalies	This analysis is based entirely on responding to unexpected events that create traffic anomalies, so data quality during such events would be critical to the usefulness in these efforts.

Work Zone Planning and Monitoring Potential Use Cases

Use Case 13: Work Zone Planning and Design	
User Category	Work Zone Planning and Monitoring
Description	***Description of use case:*** Probe volume data could be used to plan and design work zones. This data would allow agency staff to see trends in traffic volumes and apply insights to work zone operations. For example, to:

	• Determine timing of lane closures (e.g. day of week, hours of day), signal timing adjustments, and other strategies. • Assess seasonal fluctuations in traffic volumes (e.g. Memorial Day weekend vs. a typical summer weekend) without deploying temporary counters during work zone planning. • Review historical data during planned special events and take advantage of changes in traffic patterns (lower volumes during an event) to implement/deploy selected work zone operations. This use case would primarily utilize historical trends in volume data to plan for future work zones but could also utilize real-time data to verify and monitor current volumes during work zone operations.
Example in Practice	***Describe a real-world example of this use case in practice:*** An agency has planned a work zone that is scheduled to begin the following year, in August. During the winter, work zone designers learn that the construction project for this work zone has moved up to begin in May rather than August. It is too late to deploy a temporary counter to assess typical season volumes for May at this work zone location, so work zone designers review historical probe volume data to determine whether the current design is still appropriate or if changes need to be made. When the work zone is in place, the agency reviews real-time probe volume data to adjust the timing of critical operations (e.g. saw cutting, setting barrier wall, and work zone staging changes) to avoid peak traffic volumes.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Permanent count stations do not provide complete datasets in every location where volume data is needed for planning work zones. Temporary counts often provide this volume data currently.
Value of Probe Volume Data	***Why does your agency want this data? What's the value for planning and monitoring work zones? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)?*** This data could fill gaps between permanent count stations, supplement data from detectors that are not operational (e.g. sensor failures or while counters are down for maintenance), and eliminate the need to conduct temporary, seasonal counts to obtain volume data, which in some cases needs to be completed a year in advance of a work zone deployment.
Temporal Granularity	AADTs or hourly increments of probe volume data would be required, depending on the specific work zone planning application. 15-min volumes may be required for real-time monitoring.

Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, transportation management plans (TMPs), traveler information, etc.)? If so, how?*** Work zone plans and designs resulting from use of probe volume data would be documented in TMPs, as appropriate. This data could also be used to inform Public Information Plans (PIPs) to inform impacted communities of expected traffic patterns such as increased or decreased traffic during construction.
Sensitivity to Data Quality During Traffic Anomalies	AADTs are likely less sensitive to data variations during traffic incidents/anomalies because they reflect averages over an annual period. Any real-time volume data used for work zone monitoring needs to be able to adapt to changing traffic conditions that are common during work zone operations.

Use Case 14: Determine Detour Routes	
User Category	Work Zone Planning and Monitoring
Description	***Description of use case:*** Probe-generated volume data could be used during work zone planning efforts to determine detour routes for major work zones. Detour route studies utilize traffic volumes (AADTs) and origin-destination (O/D) data to investigate various detour route scenarios and determine the best route to post during construction. In some cases, especially in rural areas, an agency may be confined to only one available detour route or a decision is made to maintain lanes throughout construction, in which case this type of analysis is not needed. This use case could be useful in metropolitan areas where multiple detour routes are available, to determine the least disruptive route for overall traffic on the network. This data could also be used to schedule work zone activities, such as determining the best days of the week and/or weekends to close a road and use an alternate route.
Example in Practice	***Describe a real-world example of this use case in practice:*** An agency is planning a full road closure in a metro area, for a bridge reconstruction. Agency planners conduct a detour route study using probe volume data and O/D data to determine the detour route that will be communicated to drivers during construction. AADTs are broken down into time of day volumes in order to simulate various scenarios during peak congestion periods for each candidate detour route. After a detour route is chosen and construction begins, the detour route is communicated to drivers via static signs, DMS messaging, and via the agency's 511 website.

Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** This use case typically utilizes a structured traffic counting process to determine AADTs, which includes data from permanent traffic detection stations supplemented by temporary counts conducted on a regular schedule – for example annually for interstates and 4-year counts for other roadway classifications.
Value of Probe Volume Data	***Why does your agency want this data? What's the value for planning and monitoring work zones? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)??*** If multiple routes are available, this data would be used to anticipate traffic patterns and estimated impacts from candidate detour routes. Probe volume data offers more complete coverage compared to traditional counting methods, and would not require location-specific counts when planning for work zones (e.g. temporary counts that need to be initiated a year prior to construction to understand traffic volumes during the season/months of anticipated work zone activities.)
Temporal Granularity	AADTs would be used for calibration and validation, then broken down into hourly increments for detour studies.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, transportation management plans (TMPs), traveler information, etc.)? If so, how?*** Detour routes may be documented in the TMP for the work zone, documenting why the detour route was chosen, or why a detour route was implemented rather than maintaining lane(s) during construction. The resulting detour routes are posted via traveler information mechanisms (e.g. DMS, 511 systems) and could be monitored or adjusted in real-time during construction.
Sensitivity to Data Quality During Traffic Anomalies	AADTs are likely less sensitive to variations in data due to traffic incidents/anomalies because they reflect averages over an annual period. When high accuracy counts are needed, agencies may put out temporary counters to obtain volume data.

Use Case 15: Assess Traffic Throughput through Work Zones	
User Category	Work Zone Planning and Monitoring

Description	***Description of use case:*** Agencies could use probe volume data to determine traffic throughput through designed work zones. This use case applies to real-time work zone monitoring and planning for future work zones. • For real-time operations, this volume data would allow agency staff to monitor traffic through work zones, to identify lane blockages or other issues. This could prompt real-time traffic management actions (e.g. on-road messaging, traveler information) or help work zone designers identify adjustments as needed after the work zone is in place. • When planning work zones, this data would allow agencies to perform a traffic forecast for various work zone operations and determine related strategies such as merge mechanisms or other lane shifts. • This data could be used to assess traffic volumes on designated detour routes or on roads where traffic is diverting to avoid a work zone, either while the work zone is active or during post-assessment. • The data could also be used to assess on-road messaging, to understand traffic patterns such as where and to what degree traffic diverts based on the messaging implemented (i.e. static signs or dynamic message signs.)
Example in Practice	***Describe a real-world example of this use case in practice:*** An agency has implemented a work zone on a multi-lane interstate in a metropolitan area. The agency uses probe volume data to monitor traffic throughput during work zone operations. Traffic management center operators use this data to determine and implement messaging strategies in advance of the work zone, which leads to traffic diverting away from the work zone. After construction is complete, work zone designers review historical probe volume data and determine that during the peak period (morning, for this direction of travel), traffic volumes through the work zone are not has high as anticipated because many vehicles diverted to alternate routes. Designers use this information as they plan for a similar work zone deployment further upstream that will occur the following year. They add a lane closure to this planned work zone, which reduces the overall duration of the work zone operation.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Agencies need to deploy field detection devices, upstream and downstream of work zone merge points, to obtain traffic volume data.
Value of Probe Volume Data	***Why does your agency want this data? What's the value for planning and monitoring work zones? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)?***

	Agencies could deploy less field detection equipment and have additional insights into actual impacts of work zone operations. The availability of probe volume data would open up opportunities for planning, operations, and post-assessment evaluation.
Temporal Granularity	5-minute to 15-minute increments of probe volume data are needed for real-time monitoring. Hourly increments may be sufficient for post-assessment and planning.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, transportation management plans (TMPs), traveler information, etc.)? If so, how?*** This data and insights could be integrated into planning processes (TMPs) and may influence construction contract documents and change orders. It could also be tied to traveler information mechanisms such as on-road static signs, DMS, and 511 systems, to help determine messages for various operations and assess changes in traffic patterns due to messaging strategies.
Sensitivity to Data Quality During Traffic Anomalies	This analysis is based on assessing traffic conditions that are different from the norm while work zones are in place, so data quality during such events would be critical to the usefulness in these efforts.

Use Case 16: Assess Impacts of Ramp Traffic at Freeway Work Zones	
User Category	Work Zone Planning and Monitoring
Description	***Description of use case:*** Agencies could use probe volume data to assess how volumes from ramps are impacting mainline traffic during freeway work zone operations, providing insights to make modifications as needed to optimize flows. Having this data could inform decisions such as deploying temporary ramp meters, closing a ramp, building a longer merge lane, or providing messaging for trucks to use left lanes through the work zone. Traffic volumes and vehicle classification data are needed to understand overall impacts, including whether density of truck traffic on the mainline is negatively impacting merges by vehicles at ramps. Agencies would need volume data at the mainline and at the ramp(s), to understand the point at which capacity is reached.
Example in Practice	***Describe a real-world example of this use case in practice:*** An agency has deployed a work zone on an urban freeway. All entrance ramps remain open during the first few weeks of construction. Using probe volume data, the agency reviews volumes along the freeway and at the entrance ramps

	and discovers that during the morning peak period, there is a constant queue at one of the ramps. At this ramp, the volumes have dropped 50% from pre-construction volumes, and the influx of traffic onto the mainline is significantly impacting flows through the work zone. The agency decides to close that entrance ramp and deploy temporary ramp meters on two nearby entrance ramps. After these adjustments are made, the agency reviews probe volume data to verify that throughputs in and around the work zone have improved.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Agencies would need to deploy field detection devices at entrance ramps and along the freeway mainline to obtain volumes.
Value of Probe Volume Data	***Why does your agency want this data? What's the value for planning and monitoring work zones? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)?*** Agencies could deploy less field detectors and have additional insights into actual impacts of work zone operations. Wider coverage of probe volume data, compared to traditional detection methods, would open up new opportunities for planning, operations, and post-assessment evaluation of traffic impacts due to work zones.
Temporal Granularity	During the peak traffic periods, 5-minute increments of probe volume data would be needed. Hourly increments would likely be sufficient for off-peak hours.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, transportation management plans (TMPs), traveler information, etc.)? If so, how?*** Insights from probe volume data could be integrated into planning processes (e.g. TMPs) and may influence construction contract documents and change orders. It could also be tied to traveler information mechanisms such as DMS and 511 systems, to help determine messages for various operations. Insights from this data could also influence how agencies design future work zones, in particular ramp configurations, merge lengths, and layouts (e.g. loop ramp versus short merge ramp, one-lane versus two-lane merges) for traffic merging into work zones.
Sensitivity to Data Quality During Traffic Anomalies	This analysis is based on assessing traffic conditions that are different from the norm while work zones are in place, so the data needs to be capable of adjusting to provide accurate volume reports during these situations.

Use Case 17: Understand Actual Diversions around Work Zones	
User Category	Work Zone Planning and Monitoring
Description	***Description of use case:*** Probe volume data could be used (in combination with origin-destination data) to assess and understand where traffic diverted during work zone operations, such as signed detour routes versus other available routes, and overall traffic trends during construction. This information could be used to help plan for future work zones or to determine whether construction projects have resulted in impacts to local roads (e.g. road damage) or local communities (e.g. economic impacts) due do to traffic diversions. This data could also be used to estimate impacts from traffic volume changes to local businesses before, during, and after construction. Agencies should understand how having this type of data could prompt more regular assessment of shared costs due to impacts from road construction.
Example in Practice	***Describe a real-world example of this use case in practice:*** A work zone is deployed for a construction project on a suburban state highway. This project includes adding a lane in each direction through a suburban city with several businesses along the construction route. A detour route is posted, and vehicles use various routes to divert around the work zone. The state agency uses historical probe volume data and origin-destination data, to determine that most of vehicles used the official detour route and only a small portion of vehicles used other routes. After construction is complete, the agency conducts an analysis to determine volumes through the impacted city before, during, and after construction. The analysis shows that though traffic volumes dropped temporarily during construction, the volume reductions were not as severe as the city had anticipated. In addition, traffic volumes following construction increased significantly due the new lanes added. The agency works collaboratively with the city to communicate these traffic changes to local business owners.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Currently, this volume data would be obtained by installing field detection devices to determine where (and how much traffic) diverted to various routes.
Value of Probe Volume Data	***Why does your agency want this data? What's the value for planning and monitoring work zones? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)?*** Use of probe volume data would be more convenient and simpler than installing field detection devices at every location where traffic might divert. Probe volume data would provide more complete datasets, without installing field detection devices.

Temporal Granularity	Post analysis (next day, next week) would require a minimum of 1-hour volume increments. 15-minute granularity may be needed in some situations, depending on the duration of the work zone and time of day included in the analysis. For post-analysis use cases, the granularity desired could depend upon the agency's ability to store large datasets.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, transportation management plans (TMPs), traveler information, etc.)? If so, how?*** This type of information might be used to plan future work zones that are documented in a TMP, depending on the scope and impact of the construction project. This data could also be used to inform future Public Information Plans (PIPs), to inform impacted communities of expected traffic patterns such as increased or decreased traffic during construction.
Sensitivity to Data Quality During Traffic Anomalies	This analysis is based on assessing traffic conditions that are different from the norm while work zones are in place, so data quality during these conditions would be important to support this use case.

Use Case 18: Assess Work Zone Impact on Modes and other Travel Demand Management Strategies	
User Category	Work Zone Planning and Monitoring
Description	***Description of use case:*** Probe volume data could be used to determine whether there is a decline in vehicle volumes indicating modal shits, such as a shift from personal vehicles to other modes (e.g. bus, train, bicycle), due to long-term road construction projects. This post-analysis would assess the degree to which road users move to other modes during construction and whether they return to personal vehicles following construction. This analysis could help determine the effectiveness of communications efforts that encourage travelers to use other modes during construction and inform planning efforts, allowing DOTs to inform entities such as transit agencies of potential induced demand to their operations as lane closures and other work zone operations are planned. To fully understand impacts on mode shift, the volumes of other modes (e.g. buses, trains, etc.) before and after construction would also be needed for this analysis. Similarly, probe volume data could be used to assess the impacts of travel demand management strategies such as carpooling, ridesharing, congestion pricing/tolling, and teleworking during long-term construction projects.

Example in Practice	***Describe a real-world example of this use case in practice:*** A state DOT begins a construction project in a metropolitan area that is expected to last 3 years. The agency works with a regional transit agency to initiate a communications campaign encouraging travelers to consider transit options during construction. Several months into construction, the DOT uses probe volume data to determine that traffic volumes have decreased, indicating potential mode shift. Data from the transit agency indicates that ridership has increased during the same period. The DOT and transit agency work together over several years to assess mode shifts and refine communications strategies for future construction projects. The DOT also reviews probe volume data to understand traffic patterns of vehicles using High Occupancy Vehicle (HOV) and High Occupancy Toll (HOT) lanes before, during, and after construction. This analysis concludes that a sizable number of travelers used HOT lanes for carpooling and HOV lanes for tolled access during construction, but the majority transitioned back to use of the general purpose lanes after construction was complete.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Field detection devices need to be installed to capture volume data at specific work zone deployment locations, if it is not already in place.
Value of Probe Volume Data	***Why does your agency want this data? What's the value for planning and monitoring work zones? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)?*** Probe volume data would provide the necessary coverage across a metro area network, without having to install field detection devices.
Temporal Granularity	Daily traffic volumes are required for this use case.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, transportation management plans (TMPs), traveler information, etc.)? If so, how?*** Results from analysis of probe volume data could be documented in post-construction reports or de-brief documents. Insights gained could inform public information campaigns, determine messages for dynamic message signs or 511 traveler information systems, and inform other entities such as transit agencies of potential impacts due to work zones. This data could also be used to work with large corporations in metropolitan areas, to encourage telework and/or flex time during construction to alleviate peak period traffic during construction.

Sensitivity to Data Quality During Traffic Anomalies	Daily traffic volumes used in this analysis would not be impacted significantly by data quality issues during traffic incidents/anomalies because it assesses volumes over time, looking at relative differences for pre-construction, during construction, and post-construction.

Transportation Planning Potential Use Cases

Use Case 19: Calibrate and Validate Travel Demand Models	
User Category	Transportation Planning
Description	***Description of use case:*** Agencies could use probe volume data for developing travel demand models, to validate and calibrate the models. This data could be used in conjunction with origin-destination (O-D) data to estimate external traffic volumes, to determine where traffic enters and exits various model areas or zones. For instance, for statewide models, this data could be used to estimate traffic volumes entering and exiting the state.
Example in Practice	***Describe a real-world example of this use case in practice:*** A state transportation agency is updating its statewide travel demand model. The model was developed using traffic volumes from permanent traffic counters and temporary short-duration counts. The agency has recently procured probe-based volume data and O-D data. This procured data is used to calibrate the state's travel demand model, increasing the agency's confidence in the accuracy of the data in the model. This state borders five other U.S. states, and this new source of volumes and O-D data helps the agency refine the model to account for traffic that is entering and exiting the state.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Volume data from permanent field traffic counters and "temporary" counts (i.e. short-duration counts) is used to develop travel demand models and for Highway Performance Monitoring System (HPMS) reporting to FHWA, based on a rotating cycle. For example, agencies typically collect traffic volume data via temporary field detection methods (such as pneumatic tubes) in areas not covered by permanent traffic counters, rotating the locations of temporary counts throughout the state so that each area is counted once every few years.

Value of Probe Volume Data	***Why does your agency want this data? What's the value from a transportation planning standpoint? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)?*** Probe volume data would help agencies calibrate and validate the statewide model, to understand and estimate an acceptable amount of error, and to minimize overall error. This data would allow agencies to have volume data where ATRs are not deployed resulting in more robust datasets, including seasonal counts, weekend counts, etc. It would also provide traffic volume data for segments where the agency wouldn't have field detection devices deployed, for example outside of state borders. Improved and larger traffic volume datasets will enhance many aspects of agencies' transportation planning activities, for example such as estimating vehicle miles traveled (VMT) per capita and estimating environmental and economic impacts.
Temporal Granularity	Daily volumes (AADTs) are needed for creating and maintaining statewide travel demand models. (Note: Regional models maintained by Metropolitan Planning Organizations (MPOs) may need finer granularity than AADTs, but probe volume data and O-D data would likely bring value to their models as well.)
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, reporting procedures)? If so, how?*** Probe volume data, in this use case, allows agencies to compare and validate data against traditional traffic counting processes. When significant events (such as construction projects) are taking place, this data could be tied to better understanding of how these types of events impact the overall quality of data estimates used in travel demand models.
Sensitivity to Data Quality During Traffic Anomalies	Variations in data quality during traffic anomalies (e.g. incidents, crashes, and other non-recurring congestion) will not significantly impact the usefulness of the data for this use case, because forecasting uses rely on daily volume estimates.

Use Case 20: Understand Impacts from Unexpected Events	
User Category	Transportation Planning
Description	***Description of use case:***

	Agencies could use probe volume data, in conjunction with other data sources such as O-D data, to understand impacts due to unexpected events such as flooding or other natural disasters. Historical probe volume data would be used to model actual traffic patterns for these types of events. Insights from this data could help agencies: • Plan for future similar situations, such as planning for emergency detour routes or other response strategies; • Estimate impacts due to road closures, for example user delays, user delay costs, pavement damage on diversion routes, impacts to commercial trucking operations, and economic impacts; and • Perform cost/benefit analyses to compare multiple potential road improvement strategies (e.g. raise the road elevation or build a levee nearby to mitigate future flooding impacts).
Example in Practice	***Describe a real-world example of this use case in practice:*** A severe flooding event has occurred in the western part of a state, washing out roads and bridges on state highways. The DOT needs to understand where traffic has diverted as the impacted roads were closed. Historical probe volume data is used to model actual traffic patterns as vehicles divert around road closures, define impacts to the surrounding roadway network, and quantify road user delays and costs.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Some permanent traffic counters may be used to obtain volume data, but these may not be in place at key locations where an unknown event has occurred. Alternate data collection mechanisms (e.g. camera-based systems or temporary traffic counters in the field) may need to be installed to collect data needed for this use case. When volume data on local roads is needed to assess traffic on diversion routes, the state or provincial agency would need to request it from local agencies, and this data may not be available if field detection devices are not in place.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from a transportation planning standpoint? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)?*** Probe volume data would be valuable as it could supplement data from field detection devices, which may not be in place at key locations to assess the traffic impacts due to unexpected events. Agencies could use this data for a wide range of impact analyses, from estimating pavement damage to assessing potential improvements and estimating economic impacts. When compared to traditional field detection (ATRs) that are used to estimate daily volumes, probe volume data would allow agencies to access data much sooner than waiting for end-of-year annual average volumes (AADTs) to be determined.

Temporal Granularity	Daily volumes (historical probe volume data) are needed for this use case.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, reporting procedures)? If so, how?*** This use case could be connected to other aspects of DOT operations, such as emergency planning, emergency response, and traffic management during the duration of an unexpected event. The insights gained from probe volume data could also be used to coordinate with local agencies or other infrastructure authorities (e.g. for nearby levees) as impacts are determined and to plan for future similar events.
Sensitivity to Data Quality During Traffic Anomalies	The quality of probe volume data during traffic anomalies would be important in this use case, since traffic conditions during unexpected events are different from the norm. However, some of the analyses conducted would assess relative changes in daily volumes as trends are assessed over time.

Use Case 21: Modeling Scenarios for Operational Analysis	
User Category	Transportation Planning
Description	***Description of use case:*** Probe-generated volume data, in conjunction with O-D data, could be used to simulate various traffic management strategies during an operational analysis and determine the best strategies for implementation, for example to improve freeway operations during peak periods. Probe-based data could be used to validate an agency's models, comparing against other available data (e.g. from field detection devices) and models (e.g. MPO or other agencies' models), to increase confidence in the data used to build travel demand models.
Example in Practice	***Describe a real-world example of this use case in practice:*** A state DOT is using traffic volume data and O-D data to conduct an operational analysis in which several potential freeway management strategies are simulated and reviewed, to determine their effectiveness in reducing congestion during peak periods. In doing this, the state DOT compares traffic volumes and O-D data from its travel demand model to that of an MPO's travel demand model. Where discrepancies occur, probe-based data is used as a validation source, to refine the state DOT's model. The operational analysis concludes that a dynamic shoulder lane and additional, strategically placed dynamic message signs are the best strategies to reduce congestion on the freeway network.

Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Volume data for this analysis would typically be collected via field detection methods including permanent traffic counters and temporary traffic counting procedures.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from a transportation planning standpoint? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)?*** Probe volume data (and corresponding O-D data) would help agencies calibrate and validate their travel demand models, to increase confidence in the data used to generate and update these models. This additional source of data could also allow agencies to model different sets of zones, leading to more robust regional and statewide models.
Temporal Granularity	15-minute increments of historical probe volume data during peak periods is needed for this modeling and analysis.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, reporting procedures)? If so, how?*** This use case is related to freeway traffic operations within the agency, for modeling, reviewing, and selecting operational technologies and strategies. It could also be connected to agency partners, such as MPOs, to review and compare travel demand models and data, for calibration and validation.
Sensitivity to Data Quality During Traffic Anomalies	This use case is primarily assessing typical congestion during peak periods, so variations in data quality during traffic anomalies (e.g. incidents, crashes, and other non-recurring congestion) would not significantly impact the usefulness of probe volume data to meet this use case. Traffic disruptions could be simulated in the model for various scenarios, as desired, during analysis.

Use Case 22: Calculate Peak Hour Excessive Delay	
User Category	Transportation Planning
Description	***Description of use case:*** Agencies could use probe volume data as an input for the peak hour excessive delay measure required for state DOTs to report to the Federal Highway Administration. Peak hour excessive delay (PHED) is an annual measure of severe congestion during peak periods. This measure is currently required for urban areas with populations of more than 1

	million and beginning January 1, 2022 the population threshold will change more than 200,000[17]. In this case, the use of archived volume data from probes would allow for improvements to estimates of segment-level directional volumes that serve as an important input to estimates of delay on the urban portions of the National Highway System (NHS).
Example in Practice	***Describe a real-world example of this use case in practice:*** A State DOT is calculating the peak hour excessive delay measure for three urban areas with a population of more than 1 million. The agency uses historical probe volume data for the calculation, which improves the accuracy of the results and simplifies the overall calculation process. In 2022, the agency will be required to estimate peak hour excessive delay for 15 additional urban areas, and they plan to continue using probe volume data for these calculations.
Current Mechanism(s) to Obtain Volumes	***Is volume data currently available to support this use case (e.g. volumes at all locations)? What is the current need/gap?*** Currently, state DOTs submit volumes obtained through permanent traffic counters and temporary field data collection techniques (i.e. short-duration counts) to the Highway Performance Monitoring System (HPMS), to estimate daily traffic volumes. These daily volumes are converted to 15-minute volumes for each roadway link, through a process that involves entering daily volumes, assuming directional flows, applying hourly volume profiles generated from secondary sources, then assuming the distribution of volumes within the hour (typically by simply dividing hourly volumes by four), to arrive at the 15-min volumes required for the calculation.
Value of Probe Volume Data	***Why does your agency want this data? What's the value from a transportation planning standpoint? How would having this data change/improve your practices (e.g. increased coverage of reported volumes, less physical detectors)?*** Use of probe volume data would allow state DOTs to refine the 15-minute volume estimates needed for this calculation, ultimately improving accuracy of the PHED measure. Use of probe volume data would also simplify the calculation by eliminating the need to convert daily volumes to 15-minute increments through the process described above; this will be especially useful as the population threshold for this measure changes from 1 million to 200,000, at which time more urban areas will fall under this requirement. If probe volume data is widely used to meet similar

[17] Federal Highway Administration. (n.d.) *Transportation Performance Management.* https://www.fhwa.dot.gov/tpm/rule/pm3/phed.pdf

	traffic volume estimation needs, it could reduce the agency's need to perform short-duration counts for field data collection.
Temporal Granularity	15-minute temporal granularity (historical data) is required for this calculation. The level of spatial detail requires the volumes to be compatible with whichever type of network segmentation a given DOT is using. Many DOTs currently use calculation tools designed to be compatible with the traffic message channel (TMC) networks used by major probe data vendors.
Relationship to Other DOT Applications	***Does this use case tie into other DOT applications or pre-established frameworks (e.g. decision support systems, automated processes, reporting procedures)? If so, how?*** Probe volume data could be used calculate, document, and monitor congestion trends through state-level performance management processes (e.g. MnDOT's metro freeway congestion report). 15-minute granularity, compared to hourly increments, would be an improvement for this type of reporting.
Sensitivity to Data Quality During Traffic Anomalies	Variations in data quality during traffic anomalies (e.g. incidents, crashes, and other non-recurring congestion) will not significantly impact the usefulness of this use case, since PHED measures congestion over an annual period, reflecting typical traffic conditions in an urban area.

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