USDOT Guidance Summary for Connected Vehicle Deployments

Performance Measurement

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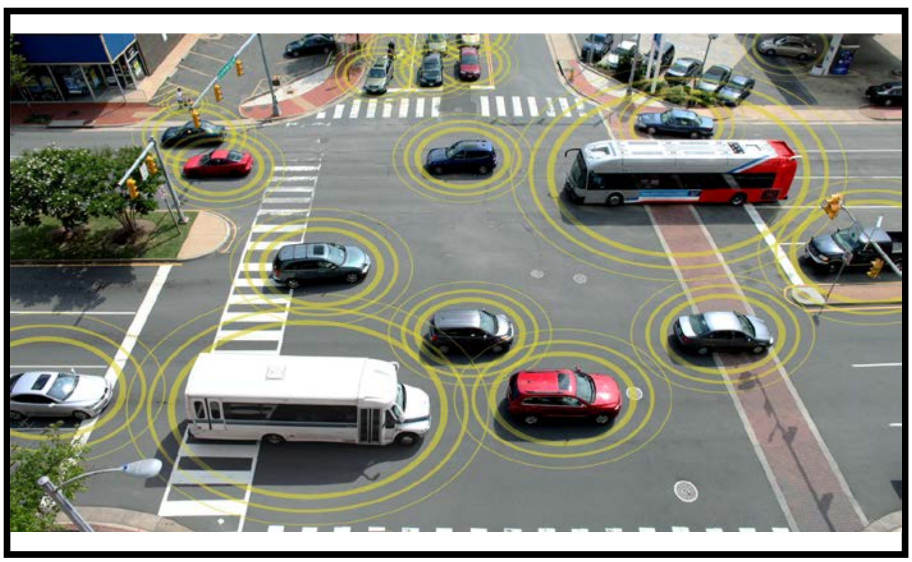

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Work performed for:
Kate Hartman (ITS JPO, CV Pilots Program Manager)

16. Abstract
The document provides guidance to Pilot Deployers in the timely and successful completion of the Connected Vehicle Pilot Concept Development Phase deliverables, specifically in the area of performance measurement. Guidance is provided in developing the Performance Measurement and Evaluation Support Plan in Task 5, identifying performance measurement needs in the Concept of Operations (ConOps) in Task 2 and corresponding requirements in the System Requirements Specification (SyRS) document in Task 6, and other activities related to conducting performance measurement at Connected Vehicle (CV) Pilot Sites.
The document provides definitions of key concepts and terms used in the BAA and summary of key challenges that may affect performance measurement of the CV pilots, including methods that can be used to overcome them. The document also identifies the key deliverables that will benefit from the performance measurement guidance in this document, and a summary of the technical support, including USDOT scheduled webinars and workshops, that is available to the Sites.
This document does not replace or alter the work statement defined in the Broad Agency Announcement (BAA); rather it provides technical guidance to the pilot deployers in completing the tasks and deliverables described in the statement of work.

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1 Introduction

1.1 Purpose of the Report

The purpose of the report is to assist Pilot Deployers in the timely and successful completion of the Connected Vehicle Pilot Concept Development Phase deliverables, specifically in developing the Performance Measurement and Evaluation Support Plan in Task 5, identifying performance measurement needs in the Concept of Operations (ConOps) in Task 2 and corresponding requirements in the System Requirements Specification (SyRS) document in Task 6, and other activities related to conducting performance measurement at Connected Vehicle (CV) Pilot Sites.

This document does not replace or alter the work statement defined in the Broad Agency Announcement (BAA, [1]); rather it provides technical guidance to the pilot deployers in completing the tasks and deliverables described in the statement of work.

1.2 Organization of the Report

This report contains four additional sections and a reference section. Section 2 provides definitions of key performance measurement concepts and terms used in the BAA. Section 3 covers relevant deliverables that will benefit from the performance measurement guidance in this report. Section 4 summarizes the key challenges that may affect performance measurement of the CV pilots, including methods that can be used to overcome them. Section 5 provides a summary of the technical support that is available to the Sites.

2 Background

Measuring the performance of a transportation system provides the means to quantify the progress made toward attaining established goals [2]. This information can be used to improve an agency's internal operations or communicated to decision-makers to provide accountability for public expenditure as well as to the travelling public [3, 4].

The CV Pilot Deployments will include site-tailored collections of applications that address specific local needs while laying a foundation for additional local/regional deployment. As a result, the sites are expected to demonstrate improved performance in one or more of the following areas: improved safety, mobility, or public agency efficiency; or reduced negative environmental impact [1]. It is the improved performance that would cause widespread adoption of CV applications by transportation agencies. Hence, the need to accurately measure performance of the CV Pilots cannot be over-emphasized.

To effectively conduct performance measurement, some fundamental terms and concepts must be well understood. These terms and concepts, which were identified in the BAA, are briefly discussed below.

2.1 Types of Performance Measures

Performance measures can be categorized as either quantitative or qualitative depending on the nature of the performance variable been measured [5]. These are briefly described below.

2.1.1 Quantitative Performance Measures

Quantitative performance measures provide numerical estimates as an evidence of how a transportation system is performing [6]. These numerical estimates can then be compared with established performance targets to determine the amount of progress/regress made in achieving those targets. These numerical estimates are usually verifiable and yield similar results with repeated trials, when everything else is kept a constant. Quantitative performance measures can either be continuous (e.g., average travel times, average speeds, etc.) or discrete (e.g., average vehicle throughput, average person throughput, etc.). Please refer Guide to Effective Performance Measurement for additional examples [7].

2.1.2 Qualitative Performance Measures

Qualitative performance measures represent the subjective perceptions and satisfaction levels of users or customers [6]. They focus on people's own experiences and help transportation system managers understand how users/customers feel about the service. Although qualitative performance measures are subjective in nature, they provide valuable complementary information to quantitative performance measures to help transportation system managers improve service delivery. Examples of qualitative performance measures include public perception of agency operations, user satisfaction, driver frustration, etc. Please refer Guide to Effective Performance Measurement for additional examples [7].

Sites should identify key performance measures as part of Task 2. Additional quantitative and qualitative measures may be required to support an independent evaluation. The USDOT will provide evaluation-related needs as part of Task 2 (see guidance summary on Evaluation Support).

2.2 Control Group

A control group in an experiment is the group that does not receive any treatment [8]. This group serves as a comparison point to evaluate the magnitude and significance of each treatment [9]. The control group must resemble the treatment group as much as possible for the comparison to be valid.

2.3 Treatment Group

The treatment group is the group that receives the treatment or the intervention, i.e., this group is exposed to the application or strategy being tested [8].

2.4 Counterfactual Modeling

Counterfactual analysis describes the potential outcome in the absence of an intervention, such as the implementation of new operational strategies or adoption of new technologies (e.g., connected vehicle technology). It is essential to establish the counterfactual to measure the impact of these interventions. For example, when measuring the impact of deploying curve speed warning on a section of a freeway corridor with high truck traffic, it is essential to examine what would happen if the curve speed warning application had not been deployed. A commonly used approach is to compare the performance measures estimated before the deployment of the application with those estimated after the deployment. Such a comparison is not the same as establishing a counterfactual since in the before-after analysis, the differences in the performance measures estimated during the before and after periods cannot be attributed solely to the intervention (i.e., the application). There may be other causes for the observed differences (see 2.3).

There are range of options for estimating the counterfactual, including the “use of control groups, comparison groups and expert predictions” [10]. Counterfactuals can be estimated by using a control group where participants are randomly assigned to either the intervention (i.e., the treatment) group or the control group. A second option is “using a comparison group which has not been created by randomization” [10]. There are a number of quasi-experimental research designs that can be used to create comparison groups [10]. The third option, which is a non-experimental design, uses expert predictions of what would have happened in the absence of the intervention. Counterfactuals can also be established through the use of transportation modeling and simulation tools, wherein the “modeled” connected vehicle applications are disabled or deactivated and performance measures are estimated, keeping everything else (i.e., network demand, vehicle split, etc.) the same.

2.5 Confounding Factors

A confounding factor is a variable that completely or partially accounts for the apparent association between an outcome and a treatment. This is a variable other than the independent variable (that the evaluator might be interested in) that may affect the dependent variable [11]. This can lead to erroneous conclusions about the relationship between the independent and dependent variables [11].

Confounding factors are usually external to the experiment; hence, they are not monitored during the experimental period. In terms of transportation performance measurement, examples of confounding factors may include travel demand, weather, traffic incidents, construction, gas prices, loss or growth in jobs, etc. The effects of confounding factors can be subdued or eliminated completely by using an appropriate experimental design or statistical approach that accounts for these exogenous factors.

2.6 Time Series Analysis (Before and After)

Time series analysis can be employed to measure the impacts of interventions such as the implementation of new operational strategies or adoption of new technologies such as connected vehicle technology. Time series design involves the “repeated measurement of one or more indicators (e.g., average vehicle throughput) over time, encompassing periods both prior to and after implementation” of a treatment (i.e., CV pilot deployment) [12, 13]. The goal of such an analysis is to assess whether the treatment (or program) has "interrupted" or changed a pattern established prior to the program's implementation. The impact of the intervention is then assessed by examining any change in the post-intervention period given the trend in the pre-intervention period.

3 Deliverables

As stated in the statement of work for the BAA (see Page 4 in [1]):

"***The overall objective of concept development Phase 1 is to set the stage for a connected vehicle pilot deployment that has an observable measureable near-term impact, deployed on-time and within budget.***"

The BAA also states that (see Page 4 in [1]):

"***Finally, the ability to capture and analyze observed data to monitor performance over time must be considered as a key requirement of the pilot deployment***."

To fulfill the above key requirement, each CV Pilot Site will need to:

- Identify needs to monitor and quantify a set of quantitative performance measures associated with the motivating needs underlying the Pilot Deployment (Task 2 ConOps)
- Specify requirements corresponding to needs related to performance monitoring and measurement related needs (Task 6 SyRS)
- Develop a plan to ensure quantitative performance measurement against identified targets is a core pilot deployment capability(Task 5 Performance Measurement and Evaluation Support plan)
- Ensure agreement on performance measures and targets among partners for chosen institutional and financial arrangement (Task 10 Partnership Coordination and Finalization)
- Develop a Comprehensive Pilot Deployment (CPD) Plan that describes the objectives, performance measures, applications, geographic scope, and general nature of the pilot deployment (Task 12 CPD Plan)

This section describes the deliverables for which the guidance is intended. The deliverables are identified by task as documented in the CV Pilots BAA [1].

3.1 Task 2: Pilot Deployment Concept of Operations (ConOps)

The BAA states that (see Page 7 in [1]):

"***The purpose of this task is to refine and improve the proposed pilot deployment concept and document this in a complete Pilot Deployment Concept of Operations. Among other elements, the ConOps shall refine the set of proposed high-priority needs through structured stakeholder interaction, rigorously define a set of key performance measures and identify associated quantitative performance targets for each performance measure that are achievable within the time frame of the Pilot Deployment.***"

Moreover, according to the BAA, the Sites should (see Page 8 in [1]):

"***…focus on combinations of applications that result in improved and measureable system performance in one, or preferably more, of the following high level categorical areas: Safety, Mobility, Environment, Public Agency Efficiency.***"

Hence in this task, the Sites may wish to identify needs that correspond to monitoring and measuring performance measures that specifically capture improved system performance as a result of the deployed applications in one or more of the four areas (i.e., safety, mobility, environment, and public agency efficiency). For example, if the Eco-Approach and Departure application, which encourages "green" approach to intersections, is deployed the Site should identify a need that corresponds to monitoring and measuring fuel consumption and emissions.

The BAA also states that (see Page 14 in [1]):

"***The impact of the deployment on a set of key performance measures (identified in Task 2) will be monitored and reported on (at a minimum) a daily, weekly, and monthly basis.***"

Hence, when phrasing the need for monitoring and measuring performance measures, for completeness the Sites may wish to identify how frequently each performance measure will be monitored and reported.

Another key item to note is that for each performance measure quantitative targets needs to be identified that are achievable within the time frame of the Pilot Deployment. Hence, the Sites may wish to specify targets that are achievable for the deployed type, number, and location of connected vehicle technology and existing infrastructure, and for the institutional and financial arrangements that are in place for the pilot deployment.

These measures and targets should be vetted through stakeholder interaction. Additionally, the partners engaged in the CV Pilot should agree on these measures and targets since the BAA also states that (see Page 20 in [1]):

"***This includes an agreement on the main elements of the ConOps, performance measures and targets…***"

Finally, the Sites may wish to format the needs so that these are in compliance with the IEEE Standard 1362-1998 since the BAA states that (see Page 9 in [1]):

"***The Contractor shall follow the guidelines for format and content in IEEE Standard 1362-1998 to develop a ConOps that describes the proposed Pilot Deployment.***"

3.2 Task 5: Performance Measurement and Evaluation Support Plan

The BAA states that (see Page 14 in [1]):

"***In Task 5, the Contractor shall develop a plan to ensure quantitative performance measurement against identified targets is embedded as a core pilot deployment capability.***"

The Sites may wish to include the following sections in their Performance Measurement Plan to address each of the areas mentioned in the BAA:

Performance Measurement Procedures: The BAA states that (see Page 15 in [1]):

"***Procedures built into the pilot deployment system shall generate a set of quantitative estimates associated with each critical performance measure and independent evaluation needs…***"

The Sites may wish to include the procedures for generating quantitative measures (identified in Task 2) from the data collected, processed and presented by the proposed deployed system since the BAA states that (see Page 15 in [1]):

"***The intended actions of the system managers and users in the deployment that ensures accurate performance measurement must be enabled by data collected, processed and presented by the proposed deployed system (SyRS).***"

The section may require the consideration of the following for each measure:

- *Data needed for estimating the performance measure*. For example, time-stamped position data from connected vehicles might be sufficient to estimate trip times.
- *Area (or location) where data should be collected for estimating the performance measure*. For example, for a speed harmonization application deployed on a freeway corridor, data might need to be collected from all lanes on that freeway corridor.
- *Temporal resolution of the data needed for estimating the performance measure*. For example, time-stamped position data might be needed every second from all lanes to estimate lane-specific queue lengths.
- *Approach to estimating the performance measure.* This may be a high-level algorithmic approach or a pseudocode. In some instances, analytical tools may be used to estimate a measure. If that is the case, then this section should clearly identify the tool and how it will be used to estimate the measure. For example, EPA's MOVES may be used to estimate emissions from vehicle speeds collected from the field [14].

The procedures for generating these quantitative measures will be built into the pilot deployment system in the Design/Deploy/Test Phase, and hence the Sites may wish to include sufficient information so that performance measurement can be "***embedded as a core pilot deployment capability***" (see Page 14 in [1]).

Confounding Factors: The BAA states that (see Page 16 in [1]):

"***The Performance Measurement Plan shall identify expected confounding factors that might influence performance measurement. Potential mitigation approaches shall be identified for each confounding factor.***"

In this section the Sites may wish to identify confounding factors that can potentially influence the outcome. It is critical to identify confounding factors and isolate their impacts so that performance improvements are neither overstated nor understated. The Sites may wish to identify, for each confounding factor, potential mitigation approaches, such as use of rigorous experimental designs (e.g., selecting control and treatment groups so that they are comparable); counterfactual modeling and simulation; or statistical techniques. Note that there are other threats that affect the validity of performance measurement, including bias in selection of control and treatment groups, maturation of data (i.e., change in performance may be due to passage of time rather than due to the deployed application/technology), etc. In addition to confounding factors, the Sites may wish to address other threats that impact the validity of their results, and therefore of performance measurement.

Field Performance Data Collection: The BAA states that (see Page 15 in [1]):

"***The Performance Measurement Plan shall define how the proposed operational case ("with Pilot Deployment") and the current case ("no Pilot Deployment") for benchmarking system performance will be represented in the Pilot Deployment Operate and Maintain Phase (Phase 3).***"

When developing this section, the Sites may wish to ensure that the selected timeframes for the operational and current cases are consistent with the discussion in the Confounding Factors section.

The BAA also states that (see Page 15 in [1]):

"***The Performance Measurement Plan shall identify, by data source, the data elements, frequency, precision, and nature of observed data to be collected, processed and utilized to measure pilot deployment impact against targets.***"

The Sites may wish to ensure that the information contained here is consistent with the data identified in the Performance Measurement Procedures section. The section may also require the consideration of identification of methods for processing the data, including cleaning, removing of Personally Identifiable Information (PII) (Please refer guidance on *Privacy Considerations* for more information.), and aggregating and or fusing with contemporaneous data from other sources. Note that raw data may need to be provided to support the evaluation effort. Please refer guidance on *Evaluation Support* for more information.

Participant Action Logs: The BAA states that (see Page 15 in [1]):

"***The Performance Measurement Plan shall contain a proposed protocol for recording actions taken by key deployment participants.***"

The Sites may wish to define a protocol that at a minimum includes information on what types of actions should be recorded, by whom, when, how frequently, and how or where (e.g., online log forms, offline digital forms, etc.). These protocols may need to be tested in the next phase.

Modeling and Simulation: The BAA states that (see Page 15 in [1]):

"***The Performance Measurement Plan shall describe plans to incorporate modeling and simulation (in coordination with field data collection) to assist in key system performance measurement/estimation.***"

The BAA also states that (see Page 16 in [1]):

"***The Performance Measurement Plan shall include a summary of the nature of proposed analytic software (i.e., tools) and software inputs (i.e., models)…Each item in the summary shall be described in terms of current maturity, proposed extension or integration, and the ability of a third-party evaluator to access and utilize developed tools, models, and/or analytic outputs."***

Modeling and simulation tools might be necessary to estimate measures that are difficult to observe directly. Modeling and simulation tools might also be used to control for confounding factors. Hence, the Sites may wish to identify when modeling and simulation tools will be used to estimate a measure or control for confounding factors and other threats that affect the validity of results. The section may require the consideration of the following:

- Purpose (e.g., estimate a key performance measure, control for confounding factor X)
- Analytic software (i.e., tool), including version that will be used
- Software inputs (i.e., models that represent a specific facility, corridor, or region, etc.)
- Current maturity of tool, including proposed extension or integration
- Ability of a third-party, including the independent evaluators to access and utilize the tools, models, and outputs

Use Cases/Scenarios: The BAA states that (see Page 16 in [1]):

"***The Performance Measurement Plan shall describe methods used to create, identify or otherwise generate the specific use cases where the Pilot Deployment is expected to have the most impact in achieving target performance goals.***"

The Sites may wish to identify the use cases that will be examined for estimating the performance measures, and provide information on how suitable participants will be identified, recruited, and compensated. The Sites may wish to ensure that the selection of the use cases and participants are consistent with the approaches discussed in the Confounding Factors section for mitigating impacts of confounding factors. The Sites may wish to take steps to ensure that there is no inherent bias in the participant selection process to ensure validity of the performance measurement results.

Support to Independent Evaluation Effort: The BAA states that (see Page 16 in [1]):

"***The Performance Measurement Plan shall specifically identify data flows (including but not limited to field data, calculated performance measures, and action log entries) that will be provided to support the evaluation effort.***"

The data that are provided to support the evaluation effort may be raw, cleaned, aggregated, removed of PII or may include PII. Please refer specific guidance on *Evaluation Support* for information on how to structure this section.

Data Sharing Framework: The BAA states that (see Page 16 in [1]):

"***The Performance Measurement Plan shall include a Data Sharing Framework, a description of performance measurement data to be generated and transmitted to COR, including the frequency of these updates.***"

Data collected will need to be shared through the RDE and will be subject to the protection of intellectual property rights and personal privacy (see Page 67 in [1]). Please refer specific guidance on *Data Sharing Framework* for information on how data may be shared.

The Sites should, in addition to the development of the Performance Measurement and Evaluation Support Plan, conduct a webinar.

Performance Reporting: The BAA states that (see Page 15 in [1]):

"***Further, performance against baseline measurements and targets are anticipated to be routinely and publically reported throughout Phase 3 daily (or more frequently). Some results related to prototype application performance are posted at www.its.dot.gov/pilots to assist the Contractors. Weekly and monthly summaries/dashboards of performance to date covering all key measures are anticipated to be required features in all Phase 3 deployment sites.***"

In this section, the Sites may wish to address the mechanisms for reporting performance of their system. The Sites may also wish to address the frequency of reporting. A range of mechanisms that are tailored to varied audience may be proposed. For example, weekly and monthly dashboards may be developed for the community, while detailed tables may be generated for consumption by the independent evaluators. Please refer FHWA Performance Reporting for keys to reaching an audience [15].

3.3 Task 6: Pilot Deployment System Requirements

The BAA states that (see Page 17 in [1]):

"***The Contractor shall develop a System Requirements Specification (SyRS) Document based on the COR-approved ConOps, following the guidance in IEEE Standard 1233-1998.***"

The BAA also states that (see Page 17 in [1]):

"***Procedures built into the pilot deployment system shall generate a set of quantitative estimates associated with each critical performance measure and independent evaluation needs (these requirements shall be described and referenced in the System Requirements Specification (SyRS) Document).***"

The Sites may wish to develop requirements that correspond to the performance monitoring and measurement-related needs identified in the COR-approved ConOps.

The Sites may also wish to develop requirements that correspond to the procedures for estimating the measures (see Task 5). Procedures for generating the quantitative measures will be built into the pilot deployment system in the Design/Deploy/Test Phase.

The Sites may wish to formulate these requirements so that these comply with IEEE Standard 1233-1998.

3.4 Task 9: Participant Training and Stakeholder Education Plan

The BAA states that (see Page 19 in [1]).

"***The Contractor shall prepare a high-level plan for the recruitment and training of all travelers, drivers, and other personnel participating in the Pilot Deployment.***"

With respect to performance measurement, the Sites may wish to include guidance or training on how to record Participant Action Logs (see Page 15 in [1]). The guidance will need to be consistent with the protocols developed in Task 5 for the action logs. For example, training may need to be provided on the type and frequency of information that needs to be recorded, and the approach for recording.

3.5 Task 10: Partnership Coordination and Finalization

The BAA states that (see Page 20 in [1]):

"***The Contractor shall document the status of developing and implementing agreements, contracts and subcontracts among partner organizations in a Partnership Status Summary. This includes an agreement on the main elements of the ConOps, performance measures and targets, operational changes associated with the Pilot Deployment, governance framework and processes, and financial agreements.***"

The Sites may wish to specifically document the status of partner consensus on measures and targets identified in Task 2 through stakeholder interaction.

3.6 Task 11: Deployment Outreach Plan

The BAA states that (see Page 21 in [1]):

"***Anticipated levels of Outreach, at a minimum, are expected to include:***

- …
- ***Participation in two USDOT-organized webinars a year regarding pilot deployment progress/performance.***"

The Sites may wish to report the performance measures, monitored and measured according to the Performance Measurement and Evaluation Support Plan, in an easily-understandable and accessible format.

3.7 Task 12: Comprehensive Pilot Deployment Plan

The BAA states that (see Page 21 in [1]):

"***The Contractor shall prepare a Comprehensive Pilot Deployment (CPD) Plan. Drawing on all materials prepared in Tasks 2-11, this plan shall summarize the overarching pilot deployment concept and expected outcomes.***"

The Sites may wish to specifically identify "***the key measures of performance and the methods of assessing these impacts on a continuous basis***" in the CPD Plan (see Page 21 in [1]).

4 Key Challenges

This section identifies the key challenges that may arise during the CV Pilots, and methods to overcome them to ensure effective and valid performance measurement.

4.1 Erroneous Data

Performance measurement based on erroneous data can be misleading as it will not accurately capture the impacts of the deployed applications/technology. The quality of data used in measuring performance is essential to the usefulness and credibility of estimated performance measures.

Erroneous data are data reported by detectors that are not physically feasible and are typically treated as a source of missing data [16]. Erroneous data may arise from equipment malfunctioning, software errors or communication errors. Hence, the first step in controlling for erroneous data is to calibrate the equipment to ensure consistent performance. Procedures should be developed for noting when an equipment goes down or the power fails, as these hardware failures may lead to erroneous or missing data.

Next, data quality standards should be established. The intended use of the data should dictate the quality standards a dataset is subjected to. For example, an intelligent signal optimization application may be tolerant to less than 10% error in vehicle speeds for estimating queue lengths; whereas a drayage optimization application may be tolerant to higher errors (e.g., up to 20%) in vehicle speeds for estimating trip times. Thus, before checking for erroneous data it is necessary to understand the intended purpose of the data and establish data quality standards.

Sites will benefit from developing and using a combination of automated and manual procedures to detect erroneous data. For example, the Texas Transportation Institute (TTI) applied 16 data validity checks to ensure that the quality of data that was used to monitor urban freeways was acceptable [17]. For example, if speed value for a timestamp is not zero when traffic volume is zero, then such data point might be inaccurate and should not be used for further analysis. Similar such automated routines should be designed to identify erroneous data. However, automated routines for identifying and eliminating errors should be used carefully in case meaningful outlier data are misidentified as errors. It is best to use automated routines for issue identification and supplement with manual verification for issue resolution.

4.2 Data Gaps

Data gaps or missing data is a common occurrence in any data collection process. As noted earlier, failure in hardware can result in missing data. Depending on the size of gaps, continuous performance monitoring can be interrupted significantly leading to a failure in the capture of inherent trends and patterns. Thus, completeness of data is essential for accurate performance measurement. There are several methods to addressing missing data that range from simple heuristics that make use of interpolation to complex statistical imputation techniques (e.g., maximum likelihood imputation, multiple imputation, etc.) [16, 18]. It should be noted that unconstrained imputation of missing data points can lead to unrealistic straight-line patterns that can skew the results. The chosen imputation technique should depend on the size of the data gap relative to the total dataset, the underlying distribution of the missing data variable (i.e., if known), and availability of statistical packages.

4.3 Measurement Uncertainty Due to Equipment

Wear and tear and environmental conditions may impact the performance of data collection equipment during the pilot deployments. Periodic changes in the performance of an equipment may introduce errors of varying magnitude into the data gathered. A possible solution is to calibrate all data collection equipment regularly to ensure consistent performance. Calibration is the verification that a measuring device is within accuracy limits. Accuracy limits may be determined based on past history, manufacturer recommendations, national standards or customer requirements.

4.4 Confounding Factors

As mentioned in Section 2, confounding factors are external factors which can distort the validity of experimental findings if not controlled for. The effects of confounding factors can be minimized by using appropriate experimental designs or statistical techniques that account for these external factors [19]. For example, techniques such as counterfactual modeling, pairwise matching enabled by cluster analysis, or modeling and simulation may be used to control for confounding factors.

5 Technical Support

A series of USDOT-sponsored webinars were developed to assist early deployers of connected vehicle technologies with Concept Development activities. The webinar described below provides support for the development of a Performance Measurement Plan.

1. Preparing an Effective Performance Measurement Plan for Connected Vehicle Deployments

This webinar presents the USDOT perspective on the development of a Performance Measurement Plan, a key step in the concept development phase for deployment planning. Performance measurement is essential for improving an agency's internal operations as well as for providing accountability for public expenditure. Dr. John Halkias of Federal Highway Administration describes the concept and the requirements of an effective Performance Measurement Plan, including identifying confounding factors and methods to mitigate their impacts; crafting meaningful and feasible use cases/scenarios; and preventing issues that may arise if performance measurement is not carefully planned.

To access the presentation slides and audio recording for this webinar, please visit the technical assistance page of the CV Pilots website: http://www.its.dot.gov/pilots/technical_assistance_events.htm

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Appendix: List of Acronyms

Table A-1: List of Acronyms

Acronym	Meaning
BAA	Broad Agency Announcement
CPD	Comprehensive Pilot Deployment
CV	Connected Vehicles
DMA	Dynamic Mobility Applications
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
MED	Mobility, Environmental, and Public Agency Efficiency Evaluation Designer
MOVES	Motor Vehicle Emission Simulator
PII	Personally Identifiable Information
RDE	Research Data Exchange

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