Connected Vehicle Pilot Deployment Program Independent Evaluation:

Data Plan—New York City

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16. Abstract

This report describes the data management plan that the TTI Connected Vehicle Pilot Deployment (CVPD) Evaluation Team, as the Independent Evaluator, plans to follow in conducting its evaluation of the New York City CVPD. This plan describes the data that the TTI CVPD Evaluation Team plans to use to identify operational scenarios to be examined in the analysis, conduct the mobility, environmental, and public agency efficiency evaluation, and calibrate the simulation models used in the analysis. The plan also provides the approach that the TTI CVPD Evaluation Team plans to use to maintain privacy in the data it collects. The plan also highlights the step that the TTI CVPD Evaluation Team is using to maintain the quality of the data it collects. This plan also describes how the TTI CVPD Evaluation Team use and upload data to the Security Data Commons.

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Chapter 1. Introduction

The New York City Department of Transportation (NYCDOT) is one of the first waves of connected vehicle (CV) pilot sites selected to showcase the value of and spur the adoption of CV technology in the United States. As one of the three selected pilots, NYCDOT is focusing on improving the safety of travelers and pedestrians in the city through the deployment of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) CV technologies. This objective directly aligns with the NYCs Vision Zero initiative (*1, 2, 3*). Specifically, the aim of the pilot project is to reduce crash frequency and severity, manage vehicle speeds (to the regulatory limit), and evaluate the benefits of deploying CV technology in a dense urban environment with frequent interactions among the participating vehicles. The NYCDOT expects the New York City (NYC) Connected Vehicle Pilot Deployment (CVPD) to become operational in February 2019.

The Federal Highway Administration (FHWA) has selected the Texas A&M Transportation Institute (TTI), along with its team member Gannett Fleming, Kittelson and Associates, Cadmus, and JMC Rota, as the independent evaluator (IE) for the NYC CVPD. The role of the IE is to provide an independent assessment and confirmation of the mobility, environmental, and public agency efficiency benefits associated with the NYC CVPD. The Volpe Institute (Volpe) is responsible for conducting an analysis of the safety benefits associated with the NYC CVPD. The analyses that the TTI CVPD Evaluation Team plans to conduct for NYC CVPD are described in the following documents:

- *Connected Vehicle Pilot Deployment Program Independ Evaluation: Mobility, Environmental, and Public Agency Efficiency (MEP) Refined Evaluation Plan – New York City* (*4*).
- *Connected Vehicle Pilot Deployment Program Evaluation: Analysis, Modeling, and Simulation Plan – New York City* (*5*).
- *Connected Vehicle Pilot Deployment Program Independent Evaluation: Stakeholder Acceptance Plan* (*6*).
- *Connected Vehicle Pilot Deployment Program Independent Evaluation: NYC Stakeholder Survey/Interview Guide (7*).

This document describes the data that the TTI CVPD Evaluation Team plans to use to conduct the independent evaluation of the NYC CVPD. The report documents the approaches that the TTI CVPD Evaluation Team plans to use to collect, process, integrate, manage, and disseminate the data associated with the independent evaluation. This plan also describes any data that the TTI CVPD Evaluation Team will collect or generate beyond that provided by the NYC CVPD Team. The TTI CVPD Evaluation Team plans to analyze all data in the Secure Data Commons (SDC) environment (*8*). The TTI CVPD Evaluation Team agrees to place and store any data collected as part of its evaluation effort in the SDC environment as well. This document also describes the processes and procedures that the TTI CVPD Evaluation Team plans to use to ensure and maintain data quality before uploading it to the SDC.

New York City Connected Vehicle Pilot Deployment

The focus of the NYC CVPD is to improve the safety of travelers and pedestrians in support of the NYC's Vision Zero Initiative (*1*). Led by NYCDOT, the goal of the pilot is to reduce crash frequency and severity, manage vehicle speeds, and assess the potential for deploying CV technologies in a dense urban environment. As shown in Figure 1, the deployment area encompasses three distinct areas in the boroughs of Manhattan and Brooklyn:

- Four one-way corridors (1st, 2nd, 5th, and 6th Avenues from 14th to 57th Streets) and major east-west cross streets (14th, 23rd, 34th, 42nd, and 57th Streets).
- A 1.6-mile segment of Flatbush Avenue in Brooklyn.
- A 4-mile segment of Franklin D. Roosevelt (FDR) Drive in the Upper East Side and East Harlem neighborhoods of Manhattan.

Source: NYC CV Project (1)

Figure 1. NYC CVPD Deployment Corridors.

The NYC CVPD will support the following specific V2V and V2I applications *(2,3)*:

- **Forward Collision Warning**—this application alerts drivers in the event of an imminent rear-end crash with a CV ahead.
- **Emergency Electronic Brake Lights**—this application alerts drivers of stopped or hard-breaking vehicles ahead in time to safely avoid a crash.
- **Blind Spot Warning**—this application alerts drivers when a remote vehicle is traveling in the adjacent lane near the CV and issues an alert to avoid side-swipe crashes.

- **Lane Changing Warning**—similar to the blind spot warning application, this application alerts drivers who are making a lane change when another vehicle is in the adjacent lane in the same direction of travel.
- **Intersection Movement Assist**—this application alerts the driver attempting to cross or turn when it is not safe to enter the intersection.
- **Vehicle Turning Right in Front of Bus Warning**—this application alerts a bus operator if a vehicle attempts to pull in front of the bus to make a right turn.
- **Speed Compliance**—this application alerts drivers when they exceed the posted regulatory speed limit.
- **Curve Speed Compliance**—this application alerts drivers approaching a curve that they are exceeding the recommended advisory speed.
- **Speed Compliance in Work Zones**—this application alerts drivers that they are exceeding the regulatory speed limit of a designated work zone.
- **Red Light Violation Warning**—this application provides an alert to the driver of impending red light running violations.
- **Oversize Vehicle Compliance**—this application alerts commercial vehicle operators when their vehicle exceeds the height restriction of roadway infrastructures, such as bridge or tunnel clearances.
- **Emergency Communications and Evacuation Information**—this application provides alerts to drivers on travel and evacuation information during emergency events.
- **Pedestrian in Signalized Crosswalk**—this application alerts drivers to the presence of pedestrians crossing at a signalized intersection.
- **Mobile Accessible Pedestrian Signal System**—this application informs a visually impaired pedestrian of the signal status and provides orientation to the crosswalk to assist in crossing the street.

In addition to providing these applications, equipped vehicles will integrate with existing infrastructure detection to provide information to New York City's Midtown-in-Motion adaptive traffic signal system.

The NYC CVPD will be deploying CV technologies in up to 8,000 vehicles, including 3,000 taxis; 700 Metropolitan Transit Authority (MTA)/New York City Transit Authority buses; 400 commercial fleet vehicles; and 2,500 NYCDOT fleet vehicles, and 170 Department of Sanitation fleet vehicles. One hundred pedestrians will also be equipped with devices. NYCDOT also plans to install roadside units (RSUs) at approximately 310 signalized intersections, eight on FDR Drive and then at 36 support locations (such as river crossings, airports, vehicle garages, etc.) throughout the city (*1,2*).

Objectives of Independent Evaluation of NYC CVPD

The goals of the TTI CVPD Evaluation Team are to answer the following evaluations questions:

- To what extent did the CVPD improve **mobility** in the study area?
- To what extent did the CVPD improve **air quality** along the deployment corridors?
- What are the **projected** mobility and air quality **benefits** expected over the next seven years in the study area for future traffic and different market penetration rates of CVs and RSUs?

While the TTI CVPD Evaluation Team is not responsible for assessing the extent to which the deployment reduced vehicle crashes, it plans to estimate the mobility and environmental impacts associated with reducing collisions through modeling and simulation. The Volpe Institute is responsible for assessing the safety benefits associated with the NYC CVPD. The TTI CVPD Evaluation Team is using the results of the safety benefits analysis in the benefit-cost assessment.

Table 3-2 in the *Connected Vehicle Pilot Deployment Program: Mobility, Environmental, and Public Agency Efficiency (MEP) Refined Evaluation Plan: New York City Pilot Deployment Site* (*4*) lists the hypotheses that the evaluation team will be using to assess the MEP, user satisfaction, and stakeholder acceptance benefits associated with the NYC CVPD evaluation. Table 1 shows them here again for completeness.

Table 1. Key MEP, User Satisfaction, and Stakeholder Acceptance Evaluation Hypotheses for Assessing the New York City CVPD.

ID	Independent Evaluation Hypothesis
1	The pilot deployment will increase compliance with speed limit/speed advisories due to speed compliance warning applications for work zones, curve speed advisories, and speed limits.
2	The pilot deployment will not adversely affect mobility for all vehicles while improving travel reliability, both equipped and unequipped, in the deployment corridors.
3	By reducing crash frequencies and severity, the pilot deployment will improve travel reliability in the deployment corridors.
4	As the market penetration of CVs increases, benefits will increase in terms of reduced queues, delays, emissions, and increased vehicle throughput and travel time reliability.
5	As the market penetration of CVs increases, non-equipped vehicles traversing the pilot deployment area will see reductions in queues, delays, and emissions.
6	The pilot deployment will reduce negative environment impacts through reduction in crashes and increases in speed adherence.
7	The pilot deployment will result in improved public agency efficiency and decision-making by transportation managers.
8	The safety, mobility, environmental, and public agency benefits will exceed the costs associated with deploying and maintaining the CV technologies in the deployment corridors.
9	Incremental increases in CV deployment will result in higher benefit-cost ratio up to a certain deployment cost threshold, after which the benefit-cost ratio will reduce.
10	End users will be satisfied with performance of CV applications and with the impact of the CV deployment on their travel.
11	End users will be satisfied with the performance of the CV devices.
12	Pilot deployment agencies and transportation managers will find that their safety, mobility, environmental, and public efficiency goals were met.

Source: Connected Vehicle Pilot Deployment Evaluation Program: NYC MEP Evaluation Plan

Organization of Report

The remainder of this report contains the following four chapters. The titles of each chapter and the major topics contained therein are:

- **Chapter 2. Data Collection Plan**—this chapter outlines the data collection plan to conduct the mobility and environmental assessments of the CVPD for the NYCDOT site.
- **Chapter 3. Data Privacy Plan**—the chapter outlines the steps and procedures that the TTI CVPD Evaluation Team plans to implement to ensure and protect the privacy of the information used in the independent evaluation of the NYCDOT CVPD.

- **Chapter 4. Data Quality Assurance/Quality Control Plan**—this chapter describes the manual and automated processes (including thresholds and criteria) for verifying data quality, cleaning data, and approach for addressing missing or unavailable data.
- **Chapter 5. Data Management Procedures**—this chapter describes the processes and procedure that the TTI CVPD Evaluation Team plans to use to manage the data for the NYCDOT CVPD evaluation.

Chapter 2. Data Collection Plan

This chapter identifies the primary data sources the TTI CVPD Evaluation Team plans on using for conducting an independent evaluation of the NYC CVPD. Through either their existing systems or system installed as part of this deployment, the site is collecting most of the data that the TTI CVPD Evaluation Team plans to use in the assessment. This includes both CV data logs and traditional traffic management system logs (such as Traffic Management Center [TMC] operator logs, incident logs operations logs). The section also describes the proposed methods of collection for these data and any supplementary data required to perform its analysis.

Table 2 summarizes the data that the TTI CVPD Team plans to use to conduct the independent evaluation of the mobility, environment, and public agency efficiency benefits of the NYC CVPD. The plans for conducting this analysis can be found in the following documents:

- *Connected Vehicle Pilot Deployment Program Independent Evaluation: Mobility, Environment, and Public Agency Efficiency Refined Evaluation Plan—New York City* (*4*).
- *Connected Vehicle Pilot Deployment Program Independent Evaluation: Analysis, Modeling, and Simulation Plan–New York City* (*5*).
- *Connected Vehicle Pilot Deployment Program Independent Evaluation: Stakeholder Acceptance Plan* (*6*).
- *Connected Vehicle Pilot Deployment Program Independent Evaluation: NYC Stakeholder Survey/Interview Guide* (*7*).

The TTI CVPD will collect and use data provided by the sites for the following types of analysis activities:

- The identification operational scenarios.
- The direct assessment of mobility, environmental, and public agency benefits.
- The development and calibration of simulation models.
- The assessment and evaluation of user and stakeholder acceptance.
- The assessment of benefits and cost.

The remainder of this chapter discusses the data need for each of these analysis types.

Table 2. Summary of Data Requirements for Independent Analysis of NYC CVPD

Data Type	Data Elements	Frequency	Aggregation	Source	Used in What Analysis	Gap
Travel Times (System)	• Date • Time • Segment ID • Travel Time	• 5 min	• 15-min average • Deployment Corridors • By event type • Pre- and Post-deployment	• Mid-town-in-Motion Travel time • Taxi cab travel time database • MTA Bus Time System • National Performance Management Research Data Set (NPMRDS)	• Mobility • AMS Model Calibration • Benefit-Cost	No
Travel Times (CVs)	• Date • Time • Segment ID • Travel Time	• Per Event	• Deployment Corridors • By operating mode (active vs. shadow) • Pre- and Post-deployment	• RSU logs	• Mobility • AMS Model Calibration	No
Traffic Demand (Volumes)	• Date • Time • Station ID • Vehicle Count • Vehicle Classification (if available)	• Periodic (2-week period every quarter of deployment)	• 15-min • Deployment Corridors • By event type • Pre- and Post-deployment (Historical data may be required for Pre-deployment)	• NYC DOT Count Stations	• Mobility Analysis • AMS Model Calibration	Maybe

Data Type	Data Elements	Frequency	Aggregation	Source	Used in What Analysis	Gap
Weather	• Date • Time • Sky Condition • Air Temperature • Dew Point • Precipitation • Visibility (miles)	• Hourly	• Hourly • By event type • Pre- and Post-deployment	• National Weather Service	• Mobility Analysis • AMS Model Calibration	No
Incident	• Date • Start and end time • Locations • Type and severity of the incident • Number of lanes impacted	• Per Event (major traffic disruptors only)	• 15-min intervals • Pre- and Post-deployment	• TRANSCOM Incident Logs	• Mobility Analysis • AMS Model Calibration	No
Special Event	• Date • Start and end time • Locations • Duration • Type • Number lanes impacted	• Per Event	• 15-min intervals • Pre- and Post-deployment	• NYCDOT Street closure calendar/ logs	• Mobility Analysis • AMS Model Calibration	No
Work Zone	• Date • Start and end time • Locations • Duration • Type • Number lanes impacted	• Per Event	• 15-min intervals • Pre- and Post-deployment	• NYCDOT Work Zone closure calendar/ logs	• Mobility Analysis • AMS Model Calibration	No

Data Type	Data Elements	Frequency	Aggregation	Source	Used in What Analysis	Gap
Crash Histories	• Date • Time • Locations • Type	• Analysis Period	• Type • Pre- and Post-deployment	• NYC Accident Logs	• Benefit-Cost	No
Incident/Event Response Times	• Date • Time • Duration • Event Type	• Monthly	• By Event Type • Pre- and Post-deployment	• NYCDOT TMC Logs	• Public Agency Efficiency	Maybe
Time Plan Changes	• Date • Time • Duration • Event Type	• Monthly	• By Event Type • Pre- and Post-deployment	• NYCDOT TMC Logs	• Public Agency Efficiency	Maybe

Data for Identifying Operational Scenarios

As specified in the *Traffic Analysis Toolbox, Volume III* (*9*), several key attributes that define the operational and travel conditions experienced impact traffic performance in a corridor. These attributes include the following:

- Traffic Demand.
- Weather.
- Incident.
- Traffic Operations and Management.

The following describes the sources of data that the TTI CVPD Evaluation Team plans to use to identify operational scenarios.

Traffic Demand

The TTI CVPD Evaluation Team needs traffic volume data not only to identify operational scenarios but also to assess throughput and to help calibrate the simulation model to existing conditions. The TTI CVPD Evaluation Team also plans to use traffic volume data to normalize safety and performance measures collected (*4*).

As part of their deployment, the NYCDOT CVPD is anticipating conducting periodic counts in the deployment corridor (*10*,*11*). If NYCDOT is planning on conducting counts for a two-weeks period every quarter during the evaluation period. The TTI CVPD Evaluation Team will use this count as being representative of traffic demands for the quarter in which they are performed.

Ideally, traffic volume should be collected in 15-minute intervals throughout the evaluation period. Traffic volume data will include both equipped and unequipped vehicles. The sensors should be located mid-block and out of the area where queues typically form. The TTI CVPD Evaluation Team expects these data to be collected and reported by direction of flow.

The TTI CVPD Evaluation Team expects that these data will be available and queryable through the SDC.

Weather Conditions

Weather data also play a critical role in determining the operational scenarios. In the New York City deployment, the TTI CVPD Evaluation Team will use data from the National Weather Service as the primary source of weather data. The TTI CVPD Evaluation Team will download daily climatological data for the New York-Central Park area from National Oceanic and Atmospheric Administration Online Weather Data portal (*12*):

- Minimum and maximum air temperature (°F).
- Total precipitation and snowfall amounts.
- Wind speed and direction.

The TTI CVPD Evaluation Team may use other sources, such as Weather Underground or Meteoblue, to obtain hour-by-hour weather observations for specific events. These data sources generally require a fee to use.

The NYC CVPD Team is planning on fusing weather data with its event record data before obfuscation. This will allow the TTI CVPD Team to correlate weather data with traffic and CV data. The TTI CVPD Evaluation will examine these data and potentially use it to identify operational scenarios.

Traffic Operations and Management Data

According to the *Traffic Analysis Toolbox Volume III* (*9*), the types of traffic management strategies deployed during different operating conditions have the potential to change the operating characteristics of the roadway. The TTI CVPD Evaluation Team plans to use several data sets available through NYC's Open Data portal (*13*) to assist in identifying operational scenarios that might impact the performance of the deployment.

Real Time Traffic Speed Data

The NYCDOT TMC maintains a map of the current speed detectors throughout the City. The NYCDOT TMC collects these data from detectors operated and maintained by several different city and state agencies. The NYCDOT uses these data to populate their real-time traffic speed map, which is available on the DOT's website (http://nyctmc.org). These data are available through NYC Open Data portal (*14*). Table 3 lists the data elements contained in this data set.

These data are publicly available through the NYC Open Data portal. The data contained in the data set are updated several times per minute. The TTI CVPD Evaluation Team will need to develop an application program interface to extract and retain this information on a continuous basis.

Weekday and Weekend Traffic Updates

These two data sets provide traffic alert information issued by the NYCDOT. These alerts provide the locations of road construction and events where lane and street closings that will potentially impact traffic flow are likely to occur in the upcoming week. The purpose of this data set is to notify the public that may impede the normal flow of traffic. NYCDOT TMC operations staff compile the data from multiple DOT units plus external agencies. The data set is formatted as a text report. NYCDOT updates the data set weekly. Information in the report is subject to change due to inclement weather or emergencies.

Table 3. Content of the NYC TMC Speed Detector Data Set.

Field Name	Definition
ID	TRANSCOM Link ID
Speed	Average speed a vehicle traveled between end pints on the link in the most recent interval
Travel Time	Time the average vehicle took to traverse the link
Status	Artifact – not useful
DataAsOf	Last time data was received from link
LinkID	TRAMSCOM Link ID (same as ID field)
linkPoint	Sequence of Lat/Long points, describes location of the sensor links Google compatible polyline from
EncodedPolyLine	Google compatible polyline from http://code.google.com/apis/maps/documentation/polylineutility.html
EncodedPolyLineLvls	Google compatible poly levels from http://code.google.com/apis/maps/documentation/polylineutility.html
Owner	Owner of the detector
Trascom_id	Artifact – not useful
Borough	NYC Borough (Brooklyn, Bronx, Manhattan, Queens, Staten Island)
LinkName	Description of the link locations and the end points

Street Closures due to Construction Activities

This data set, maintained by the NYCDOT, provides information on the locations of approved street closures. It identifies the locations in the NYC where full street closures are planned, restricting through traffic, for the purposed of conducting construction related activities on a City Street. This data set is generated based on NYCDOT's construction permitting process. A full closure permit is required for the times when the street may be closed to traffic. The actual closure may last for only a portion of the time permitted and may be open at other times.

Table 4 provides a description of the data field contained in this data set. The TTI CVPD Evaluation Team plans to use the data set to assist in identifying a period when traffic flow may have been impacted by road construction activities.

Table 4. Structure of NYCDOT's Street Closure/Construction Activity Data Set.

Name	Description
SegmentID	The Segment ID is a Department of City Planning LION reference number.
OnStreetName	The On Street Name as is defined in the GOAT, the Department of City Planning Geographic Online Access Translator (GOAT).
FromSteetName	From Street Name refers to the cross street where the lowest house numbers of the on-street begins, or as defined in GOAT.
ToStreetName	To Street Name refers to the cross street where the highest house numbers of the on-street ends, or as defined in GOAT.
Borough_Code	New York City is composed of five boroughs, each borough has a code as an identifier.
Work_Start_Date	The Work Start Date is the date the permit holder can begin the work.
Work_End_Date	The Work End Date is the permit expiration date.
Purpose	Type of work being done at location.

This data set contains only planned work zone activities and does not necessary reflect actual closures that occur.

Data for MEP Performance Measurement and Evaluation

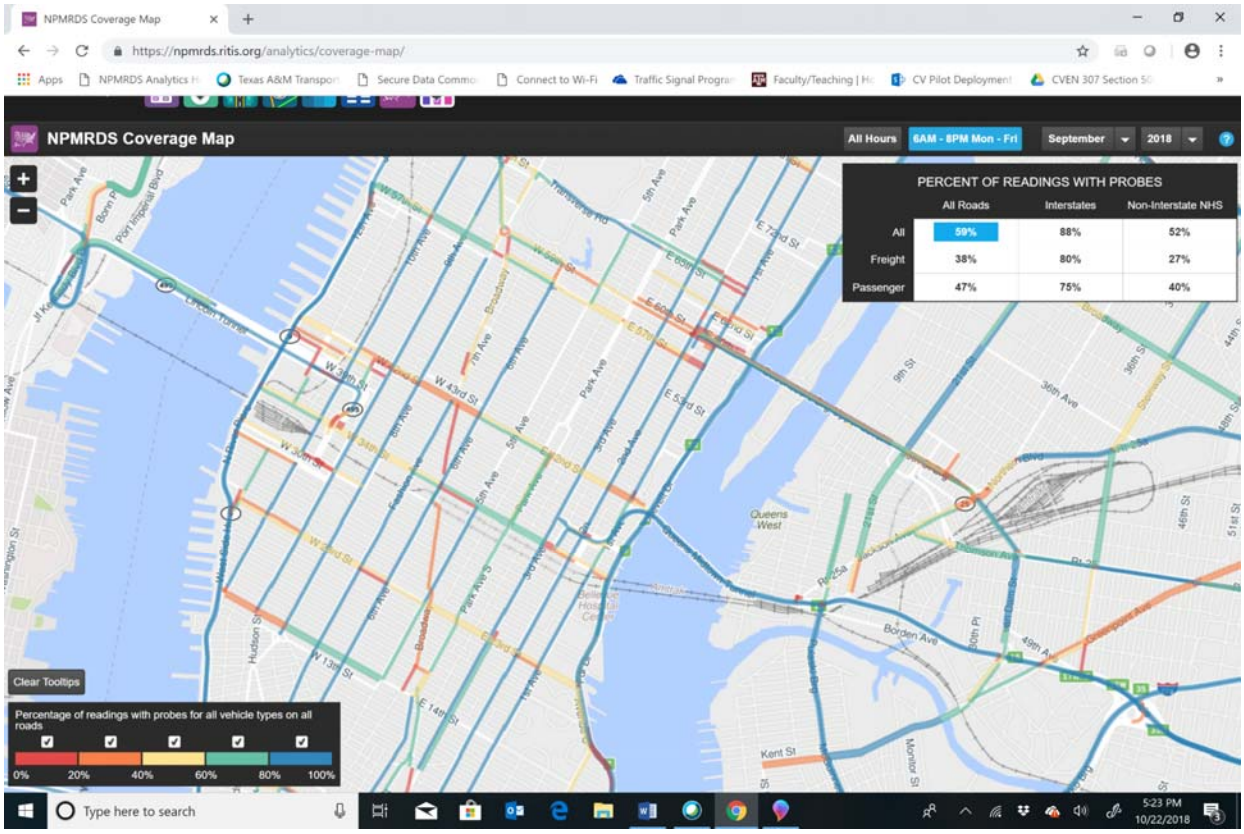
This section identifies the type, quantity, and quality of data that needs to be collected to estimate the MEP-related performance measures.

- Travel times and travel time reliability measures.
- Travel speeds.

Travel Time

The TTI CVPD Evaluation Team plans to use travel time data from four potential sources of data. These include the Midtown-in-Motion travel time monitoring system, the NPMRDS, the Taxi GPS data management system, and the MTA Bus Time system. These systems provide estimates of travel times in the corridor and depend upon equipped vehicle (toll tags, GPS transceivers, and bus tracking technology) to produce estimates of travel in the deployment corridor. The Midtown-in-Motion using Radio Frequency Identification technology to measure travel times using a vehicle re-identification concept. The TTI CVPD Evaluation Team will access this information through the NYC Open Data and the NYC TLC site. NYCDOT will provide Bus Time data directly to the IE. The IE will not have direct access to our Taxi and Bus Time database. However, aggregations of these data sets and the resulting travel time and travel speed data that NYCDOT prepares in-house can be uploaded and shared. TTI will be responsible for uploading this information into the SDC, if it is used in the analysis.

The TTI CVPD Evaluation Team will also plans to use data from the NPMRDS (*16*) as the primary source of mobility data. Figure 2 shows the roadways contained in the NPMRDS where travel time data may be available from the Midtown area.



Source: NPMRDS.

Figure 2. Manhattan Roadways Contained in NPMRDS.

The NPMRDS is a data portal procured by FHWA to assist state and local governments with performance measures. The NPMRDS has 5-minute speed and travel time data sets for over 400,000 road segments, including several roadways in mid-town Manhattan. Travel time in the data set come from two potential sources, Inrix and HERE. Travel time data are stored in three separate databases: one for passenger cars only, one for trucks only, and one for a combination of trucks and passenger cars. These data sets contain the following data elements:

- Speed — Speed is recorded in mph as an integer. The harmonic average speed for all reporting vehicles on the segment.
- Average speed — the historical average speed. Historical average speeds are calculated by the Center for Advanced Transportation Technology Laboratory (CATT LAB) by taking the harmonic average of speeds on each segment for each hour of the day and each day of the week. For data beyond February 1, 2017, the average speed is calculated from February 1, 2017, to June 30,

2017. For data before February 1, 2017, the average is calculated using the 12-month period preceding November 2014.

- Reference speed — an approximation of free-flow speed for the segment. This value is calculated by the CATT Lab using the 95th percentile of the speeds between 10 PM and 5 AM. The reference speed is calculated over a 6-month period starting April 1, 2017–September 30, 2017.
- Travel Time — Travel time recorded in minutes or seconds. It is the ratio between the segment length and the harmonic average speed for all reporting vehicles on the segment.
- Data Density — refers to one of three values.
    - A: Fewer than five values.
    - B: Five to nine values.
    - C: More than nine values.

Using the raw speed measurement data, the NPMRDS calculates the following metrics as defined from the *Travel Time Reliability* publication provided by FHWA and produced by TTI with Cambridge Systematics, Inc. (17)

- Comparative Speed — measured speed as a percentage of the historical average speed for this time of day and day of the week.
- Congestion — measured speed as a percentage of the free flow speed.
- Historic Average Congestion — historic average speed as a percentage of the free flow speed for this time of day and day of the week.
- Buffer Time — the extra time (or time cushion) that travelers must add to their average travel time when planning trips to ensure on-time arrival (95th percentile Travel Time − Average Travel Time).
- Buffer Index — the Buffer Time's percentage value of the Average Travel Time ((95th percentile Travel Time − Average Travel Time) / Average Travel Time). Its value increase as reliability worsens. For example, a buffer index of .4 (40 percent) means that a traveler should budget an additional 8 minutes in a 20-minute trip (20 minutes × 40 percent = 8 minutes) to ensure on-time arrival 95 percent of the time.
- Planning Time — the total time a traveler should plan to ensure on-time arrival (95th percentile Travel Time).
- Planning Time Index — the total travel time that should be planned when an adequate buffer time is included (95 percent Travel Time / Free-flow Travel Time). The planning time index differs from the buffer index because it includes typical delay and unexpected delay. Thus, the planning time index compares near-worst case travel time to the travel time in light or free-flow traffic. For example, a planning time index of 1.60 means that, for a 15-minute trip in light traffic, the total time that should be planned for the trip is 24 minutes (15 minutes × 1.60 = 24 minutes).
- Travel Time Index — Travel time represented as a percentage of the ideal travel time (Travel Time / Free-flow Travel Time).

The NPMRDS uses the traffic message channels standard to identify each road segment uniquely. Under this standard, a unique 9-digit code identifies each road segment. As shown in Figure 3, traffic message channels span a stretch of road from one exit or entrance ramp to the next. The fourth character in the

code signifies whether the segment is an internal or external segment. Internal segments represent stretches of roadways within an interchange, while external segments represent stretches of roadways between interchanges. The typical convention for identifying the direction of travel for the traffic message channel and whether the segment is an internal or external segment is as follows:

- "P" is used to indicate a northbound or eastbound internal link.
- "N" is used to indicate a southbound or westbound internal link.
- "+" is used to indicate a northbound or eastbound external link.
- "-" is used to indicate a southbound or westbound external link.

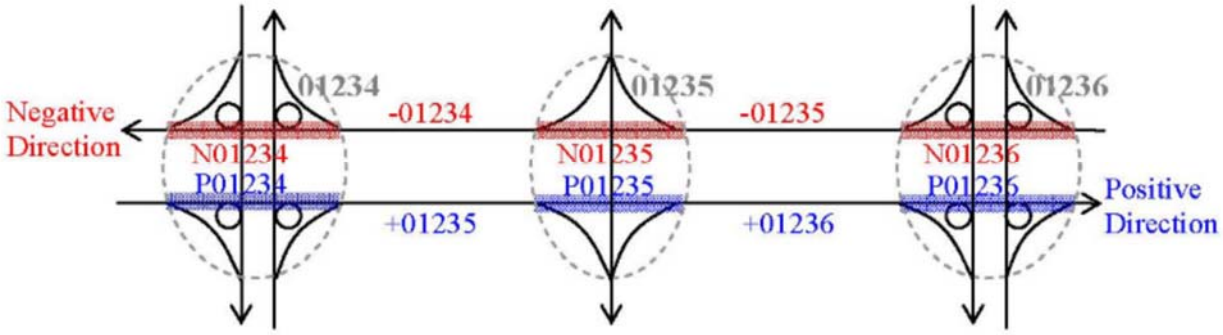


Figure 3. Nomenclature for Identifying Roadways Segments in NPMRDS.

The TTI CVPD Evaluation Team plans to assign a TMC link to a variable speed limit (VSL) segment. The TTI CVPD Evaluation Team is extracting the 15-minute average travel times in both directions for the time periods of specific weather events in the corridor by traffic message channel. The TTI CVPD Evaluation Team plans to produce segment travel times by summing the link travel times from all the TMCs associated with a VSL segment.

Vehicle Emissions

The evaluation of the environmental impacts of the CV applications requires the following data in addition to the data cited above for developing and calibrating the traffic simulation model. These data serve as input to the MOtor Vehicle Emissions Simulator (MOVES) model:

- The number, location, and length of the links (obtained from the simulation model[s]).
- Link road types: urban versus rural; restricted versus unrestricted; running versus hoteling (obtained by the TTI CVPD Evaluation Team from an examination of the site).
- Link volumes: the total number of vehicles per hour on each link (obtained from the output of the simulation model).
- Link average speed: speeds of vehicles on links (obtained from the output of the simulation model).
- Average grade of each link (obtained by the TTI CVPD Evaluation Team from an examination of the site).

- Vehicle mix in the study area by buses, motorcycles, light-duty vehicles, single-axle trucks, combination trucks during specific events. The TTI CVPD Evaluation Team is requesting the site provide these data. Failing that, the TTI CVPD Evaluation Team plans to select appropriate default values that would be representative of the site conditions.
- Age distribution of vehicles in the study area by vehicle type. The TTI CVPD Evaluation Team will request these data from the sites. Failing that, the TTI CVPD Evaluation Team plans to select appropriate default values that would be representative of the site conditions.
- Meteorological data on humidity and temperature (obtained from online historical records).

The TTI CVPD Evaluation Team is planning to report the following model outputs from MOVES in emissions or energy consumption per hour:

- Carbon dioxide (CO_2).
- Particulate matter: PM-2.5.
- Particulate matter: PM-10.
- Nitrogen oxides (NO_x).
- Petroleum energy consumptions.

To create customized scenarios for the NYCDOT CVPD site, the TTI CVPD Evaluation Team plans to enter input parameters in the MOVES graphic user interface. The smallest unit of analysis in the MOVES model is a link. A link is an off-network location where a similar type of vehicle activity occurs. MOVES can model four separate conditions of hoteling loads:

- Extended idle.
- Auxiliary power units (APU).
- Battery power.
- Engine off.

Additionally, MOVES can model the number of engine starts (the more starts, the higher emissions all else equal) and the soak time with the engine off. The TTI CVPD Evaluation Team plans to work with the site to obtain the best values for the following input variables:

- Operating Mode Distribution (%)— the fraction of time long-haul trucks spend in each operating mode (e.g., APU, grid-supported, and others).
- Vehicle population (#)—number of trucks in hoteling (i.e., stationary) mode.
- Start Fraction (%)— the average fraction of the population that started during the hour.
- Road type of link (restricted/unrestricted rural/urban).
- The length of the link (miles).
- The volume of the link (vehicles/hour)—output from the microsimulation model.

- The grade of the link (optional) (%)—grade of the link. Obtained from the site.
- Vehicle mix on the link (%)— the fraction of vehicle hours traveled for each vehicle/fuel combination. Fractions must sum to 1 for each link.

Public Agency Efficiency

The TTI CVPD Evaluation Team recognizes that the primary goal of the NYC CVPD is to improve reduce collisions, and that changes in public agency efficiencies are ancillary. To the extent possible, the TTI CVPD Evaluation will try to quantify the extent to which NYCDOT was better able to manage operations in the corridor. Potential measures of improved public agencies efficiency include the following:

- Improve timeliness of responses to unplanned events or situations (such as weather events).
- Increased in situational awareness of roadway and traffic conditions.
- Implementation of traffic management strategies, including traffic signal timing plan changes, as a response to changing traffic conditions in the corridors.

Stakeholder interviews will be the primary source of data for investigating public agency efficiencies. The TTI CVPD Evaluation Team plans to interview key NYCDOT team members about their perceptions of improved to operational efficiency and situational awareness of operations in the deployment corridors because of the deployment.

The TTI Evaluation Team also plans to evaluate available pre- and post-deployment NYCDOT TMC logs to see if the timeliness and accuracy of event information (e.g., incident, weather, or travel condition alerts) improved by having access to CV data. The NYCDOT Phase II Data Management Plan (*10*) list the following as potential sources of public agency efficiency data sources:

- NYCDOT travel advisory log (including acceptance rate and time to operator acceptance).
- Log of the number of messages sent and received between NYCDOT TMC, RSUs, and on-board units (OBUs).
- Incident detection and response time log.
- Automated Emergency Notification log including number and time received and response time.

The TTI CVPD Evaluation Team is relying heavily on the data collected by the NYCDOT CVPD Team in assessing the change in public agency efficiency due resulting from the deployment. The following lists some of the specific data elements that the TTI CVPD Evaluation Team plan to use:

- The number of messages sent from the NYCDOT TMC that are received by the RSU.
- The number of messages sent and received between the RSU and NYCDOT fleet vehicles' OBU (when vehicles are near an RSU).
- The number of emergency notifications first received in the NYCDOT TMC from CVs (compared to traditional methods, such as 911 caller).

Safety Performance Estimates

The TTI CVPD Evaluation Team is not responsible for assessing, through either direct observations or simulation and modeling, the safety benefits associated with the different CV applications deployed by NYCDOT. The Volpe Institute is responsible for conducting the safety assessment. However, the reduction in potential crashes and improved safety plays a critical part in the Benefit/Cost Analysis. The TTI CVPD Evaluation Team is looking to Volpe to provide information related to the reduction of the probability of crashes or harm reduction factors. The TTI CVPD Evaluation Team plans to work with Volpe to estimate potential estimates of crash reductions that it can use in the Benefit-Cost Analysis. The TTI CVPD Evaluation Team will coordinate this activity with the Volpe Team.

Data for Simulation Model Development and Calibration

The TTI CVPD Evaluation Team expects simulation and modeling to play a significant role in the Independent Evaluation. The following section describes that data that the TTI CVPD Evaluation Team requires to verify the model development and to calibrate the model for the specific operational conditions.

Base Model Development

As discussed in the *Connected Vehicle Pilot Deployment Independent Evaluation: Analysis, Modeling, and Simulation (AMS) Plan for NYCDOT* (*5*), the TTI CVPD Evaluation expects the NYCDOT CVPD Team to deliver a baseline model. The base model development encompasses all the data required to portray the existing roadway conditions accurately. The base model shall include the following:

- Model Network Geometry—the TTI CVPD Evaluation Team is assuming the NYCDOT CVPD Deployment Team is coding the network geometry as part of their model development effort. The TTI CVPD Evaluation Team plans to verify the network geometry by comparing the representation of the network geometry in the model to online data sources, such as Google Earth or Google Maps. The TTI CVPD Evaluation Team will discuss any discrepancies with the NYCDOT CVPD Team.
- Traffic Signal Control Timing Plans — these plans are the traffic signal control timing plans that NYCDOT uses to manage signal operations in the deployment corridors. The TTI CVPD Evaluation Team is assuming the model provided by the deployment already contains these algorithms.
- Traffic Demands—the TTI CVPD Evaluation Team is assuming the NYCDOT is collecting traffic data at 15-minute intervals for use in their base model. To be able to verify the accuracy of the microsimulation model, the TTI CVPD Evaluation Team needs the basic traffic demand data that NYCDOT has used the traffic volume counts obtained from NYCDOT.
- Vehicle stock—the TTI CVPD Evaluation Team is assuming the NYCDOT is including the distribution of age and vehicle types, for both the CVs and non-CVs.

Calibration

Calibration refers to adjusting model parameters to represent the field conditions accurately compared to the operational conditions developed previously. This step encompasses both the local and system-wide performance. Data associated with calibration often includes all operational condition data for a sample of historical events. As specified in the AMS Plan for NYCDOT (*5*), the TTI CVPD Evaluation Team plans to use the following data to calibrate the simulation model to the operational scenarios:

- Traffic demands—15-minute turning movement counts for freeway segments.
- Road weather conditions—hourly rate of rainfall and snowfall, hourly miles of visibility for fog conditions, and hourly pavement temperature to indicate icy road surface conditions.
- Crashes and work zones—milepost location and direction, start time, end time, number of lanes blocked each 15-minute period over the duration of the incident.
- Special events (if applicable)—venue, attendance, start time, end time, hourly arrival and departure volumes over the duration of the event, any special lane and signal controls before, during, or after the event. In this corridor, special events also include construction events and incidents.
- Travel Times—15-minute travel times through for the modeled sections of Mid-town.

The TTI CVPD Evaluation Team would like to use 365 days of data. At a minimum, we can work with 100 days of data to be able to predict to the nearest 1 percent the probability of a combination of demand, weather, and crash events occurring for the site in the future. For NYCDOT, 100 days minimum is essential, because the winter weather may last only about 100 days, not 365 days. The TTI CVPD Evaluation Team plans to aggregate the data to 15-minute intervals. The TTI CVPD Evaluation Team plans to use data from both pre- and post-deployment conditions.

Stakeholder Evaluation and Survey Data

Stakeholder acceptance and survey data are significant data elements the TTI CVPD Evaluation Team is responsible for collecting and digitizing. These data are qualitative and needs to be coded with numerical values to provide a foundation for objective analysis.

As referenced in the CVPD *Stakeholder Evaluation Plan* (*6*), the TTI CVPD Evaluation Team plans to use different data collection methods to collect acceptance/satisfaction information from the stakeholder types due to varying roles in the CV pilots:

- The TTI CVPD Evaluation Team plans to conduct qualitative interviews in the form of one-on-one, dyads, or triads with deployment managers, deployment team members, operating agencies, and policymakers. TTI plans to interview deployment managers, deployment team members, and operating agencies because these stakeholders are the most invested and involved in the pilots and will be able to provide productive feedback. TTI also plans to interview policymakers as well, given their status and potential influence on long-term sustainability. TTI plans to conduct these interviews at three points in time: (a) immediately after the planning/design stage (i.e., pre-deployment), (b) shortly after activation (i.e., near-term post-deployment), and (c) toward the end of the deployments (i.e., long-term post-deployment). TTI plans to use the pre-deployment

interviews view and opinions on the vision, goals, and expectations of the deployment. Post-deployment interviews serve to capture information about deployment experiences, outcomes, and satisfaction.

- The TTI CVPD Evaluation Team plans to administer the post-deployment online survey (rather than in-depth interviews) to fleet operators and supporting agencies because they are less involved in day-to-day pilot planning and execution. The survey is intended to gather information on how well the pilot deployment program fulfilled these stakeholders' goals and objectives.
- TTI plans to hold site-specific post-deployment workshops after the interviews have been completed to foster additional dialog among deployment managers, deployment team members, and operating agencies. Workshops are intended to capture distinct information and foster cross-stakeholder dialog and discussion about challenges, solutions, and lessons learned. TTI also plans to use the workshops to confirm and clarify critical findings.

The specific questions that the TTI CVPD Evaluation Team plans to use in each of these can be found in the *Stakeholder and Interview Guide for NYCDOT* (*7*).

Cost Data

To complete a benefit-cost analysis, the TTI CVPD Evaluation Team is asking the NYCDOT CVPD Team to provide cost data related planning, implementation, and operation of the pilot. To the extent possible, the NYCDOT CVPD Team is asked to provide cost information that is as comprehensive and disaggregate as possible. The types of cost data needed by the TTI CVPD Evaluation Team include the following:

- **Planning and design costs**—these costs include any costs associated with the planning and design of the CVPD deployment. These costs represent primarily Phase I costs. Examples of the types of costs included in the planning cost include the following:
    - The costs associated with performing the system engineering for the deployment. These costs include the cost of developing the concept of operations, detailed system requirements, and test plan development.
    - The costs associated with any proof-of-concept testing performed by the deployment team before procuring the equipment.
    - The costs associated with developing outreach and participant recruitment and training materials.
    - The preparation of the performance and evaluation test plan support.
    - Any other costs that the NYCDOT CVPD Team might have incurred as part their Phase I activities not included above. The TTI CVPD Evaluation Team asks that the NYCDOT CVPD Team list these costs.
- **Deployment and Implementation Costs** — these costs include any costs associated with the physical deployment and integration of system needed to support the pilot deployment. These costs are primarily Phase II costs. Example of the types of costs include the following:
    - The costs associated with the development, testing, and integration of applications. If possible, the TTI CVPD Evaluation Team asks that the site to disaggregate the costs by

each application. If that is not possible, then the TTI CVPD Evaluation Team requests that the NYCDOT CVPD Team note all the applications included in each cost figure provided.

- The costs associated with procuring and installing the connected technology in the vehicles.
- The costs associated with procuring and installing the infrastructure devices and technologies (e.g., RSU, communications).
- The costs of recruiting and training of both private- and public-sector participants (including any incentives for maintaining participation in the pilot deployment).
- The costs associated with collecting and developing the baseline (pre-deployment) evaluation of the corridor.
- Any other one-time costs incurred by the deployment team. These costs may represent any costs incurred by the NYCDOT CVPD Team as this is the first time for deploying the application. An example of these one-time costs might be the costs associated with development, testing, and evaluation of a first-time application where if another entity were to deploy the application, they would not incur these costs.

- **Actual Annual Operations and Maintenance Costs (Year 1 after Activation)** —- these costs include any costs associated with operating and maintaining the deployment once it becomes live. These costs would include anything required to keep the system operational and in a good state of repair, including planned equipment replacement (both vehicle and infrastructure equipment), emergency repairs, recurring communications costs (i.e., cellular modems), and others. The site may combine operations and maintenance into one row. These would represent the costs incurred by the NYCDOT and the other stakeholders during Phase III.
- **Estimated Annual Operations and Maintenance Cost (Years 2 through 7 after Activation)** — these would include the estimated costs associated with operating and maintaining the deployment in a state of good repair for Years 2 through 7. NYCDOT should base these costs estimates on their Year 1 experiences.
- **Salvage Value** — this represents the estimated value of any equipment at the end of the Year 7 after activation of the CVPD. As the deployment is expected to become part of NYCDOT's normal operations, the TTI CVPD Evaluation Teams does not expect salvage value; however, the NYCDOT CVPD Team plans to remove or deactivate any application after the deployment period, it should provide salvage values, if any, for the removed technologies. If NYCDOT envisions keeping the deployment active beyond Year 7, then no salvage value should be reported. Also, as noted by the NYCDOT CVPD Team, as standards and communications technology evolve, the salvage values may reach zero much earlier than the seven years forecast. The TTI CVPD Evaluation Team will work with the NYC CVPD Team to determine the appropriate salvage value to use in the analysis. Figure 4 provides a template that the NYCDOT CVPD Team can use to collect, and report cost information to the TTI CVPD Team. Figure 5 shows a similar template that the NYCDOT CVPD Team can use to report costs after the pilot has become operational. Note that the NYCDOT CVPD Team needs to estimate operating and maintenance costs annually for 6 years before the first year of operations.

Costs Category	Year 1 (Actual)	Year 2 (Actual)	Year 3 (Actual)
PHASE I – Planning and Design			
Planning/Concept Development Costs			
Evaluation Planning Costs			
Other Costs*			
PHASE II – Deployment			
Vehicle Technology • Procurement • Installation			
Infrastructure Technology • Procurement • Installation			
Participant Recruitment and Training			
Evaluation (Baseline)			
Other Costs*			
*Please specify. Please list multiple costs separately.			

Figure 4. Template for Providing Planning and Deployment Costs Associated with NYCDOT CVPD.

Costs Category	Year 1 (Actual)	Year 2 (Est.)	Year 3 (Est.)	Year 4 (Est.)	Year 5 (Est.)	Year 6 (Est.)	Year 7 (Est.)
PHASE III – Operations							
Operations Costs*							
Maintenance Costs							
Equipment Replacement • Vehicle • Infrastructure							
Evaluation (Post-Deployment)							
Other Costs**							
Decommissioning							
Salvage Value*** • Vehicle • Infrastructure							

*NYCDOT may combine operations and maintenance on one row.

**Please list multiple costs separately.

***Shown as a negative cost

Figure 5. Template for Providing Projecting Costs Associated with NYCDOT CVPD.

Chapter 3. Data Privacy Plan

The chapter outlines the steps and procedures that the TTI CVPD Evaluation Team plans to implement to ensure and protect the privacy of the information used in the independent evaluation of the NYCDOT CVPD.

Data Ownership

All data collected by and held by NYCDOT in any system owned by and/or maintained by NYCDOT is the property of NYCDOT and will be stripped of any data or metadata that can be construed to be Personally Identifiable Information (PII) or which may be linked with other data to become PII. As previously noted, no raw data will be retained by NYCDOT throughout the life of the operation period; raw data are only expected to be temporarily held at the TMC during the testing of and validation of the obfuscation, normalization, aggregation, and analysis algorithms; thereafter, only the resulting obfuscated data will be retained.

The TTI CVPD Evaluation Team has deemed that the United States Department of Transportation (USDOT) and the NYCDOT are the owners of that data uploaded by NYCDOT into the SDC (*8*). The TTI CVPD Evaluation Team agrees to use the data provided by the NYCDOT CVPD Team only for the purposes outlined in the *Connected Vehicle Pilot Deployment Program Independent Evaluation: Mobility, Environment and Public Agency Efficiency Refined Evaluation Plan—New York City* (*4*). The TTI CVPD Evaluation Team also agrees not to use or share the data in any manner that exceeds the parameters of the informed consent document. The TTI CVPD Evaluation Team plans to limit the access to the data only to authorized Team members.

Any data collected by the TTI CVPD Evaluation Team, including the simulation input file and result files, becomes the property of the USDOT once the project is complete. After removing any PII from the data, the TTI CVPD Evaluation Team plans to upload any data files generated in the analysis to the SDC. The TTI CVPD Evaluation Team will reference and credit appropriately any data obtained from the NPMRDS.

The TTI CVPD Evaluation Team adhere to the policies and procedures of the Texas A&M University Institutional Review Board (IRB) for any data containing PII. The TTI CVPD Evaluation Team plans to prepare summaries of the interview and survey information. TTI plans to remove any identifiable information to any individual when preparing these summaries. TTI plans to secure any raw notes from the findings in a locked filing cabinet in the TTI offices. The TTI CVPD Evaluation Team plans to destroy any raw notes from the stakeholder interviews, surveys, and workshops after they have been summarized and uploaded to the SDC.

Personally Identifiable Information

The PII and Sensitive Personally Identifiable Information (SPII) is paramount for the USDOT, the NYCDOT CVPD Deployment Team, and the TTI CVPD Evaluation Team. PII refers to any information that can be used to distinguish or trace an individual's identity, such as their name, Social Security number, biometric records, alone, or when combined with other personal or identifying information can be linked or linkable to a specific individual. SPII is a subset of PII and is sensitive in that, if lost, compromised, or disclosed without authorization, could result in substantial harm, embarrassment, inconvenience, or unfairness to an individual. Both the NYCDOT CVPD Team and the TTI CVPD Evaluation Team have implemented policies and procedures for protecting and controlling PII and SPII information.

Removing PII from Collected by TTI Evaluation Team

The TTI CVPD Evaluation Team does not envision needing access to any PII or SPII obtained from the sites. The NYCDOT CVPD Team plans to remove any PII and SPII before posting the data in the SDC.

The TTI CVPD Evaluation Team is responsible for accessing stakeholder acceptance and satisfaction information. The TTI CVPD Evaluation Team plans to collect this information through a series of interviews and surveys performed at different times during the operational phase (Phase III). The TTI CVPD Evaluation Team is required to post this information into the SDC. Before posting this information, the TTI CVPD Evaluation Team plans to remove any PII from the data. The information that TTI plans to remove includes the following:

- The name of the individual being interviewed or surveyed.
- The name of the agency that employs the interviewee.
- The address of the individual and agency completing the interview or survey.
- The email address and phone number of the individual.
- Any other information linkable to any specific individual.

Chapter 4. Data Quality Assurance/ Quality Control Plan

This chapter describes the manual and automated processes (including thresholds and criteria) for verifying data quality, cleaning data, and approach for addressing missing or unavailable data.

Data Quality Checks

The NYCDOT CVPD Team is responsible for verifying the quality of their data before uploading data to the SDC. Therefore, the TTI CVPD Evaluation Team is assuming all data going into the SDC to be clean. The TTI CVPD Evaluation Team plans to spot-check the data to ensure the quality of the data is satisfactory for the analysis. The TTI CVPD Evaluation Team plans to follow the data quality verification process specified in NCHRP's *Guide to Effective Freeway Performance Measures* (***Error! Reference source not found.***). This section describes the additional steps that the TTI CVPD Evaluation Team will take to verify the quality of the data.

Since the event record obfuscation process is designed to hide precise time and location of recorded information, verifying data post-obfuscation may not be possible. The TTI CVPD Evaluation plans to meet with the NYC team to review the data error checking, data fusion, and obfuscation processes on raw data behind the firewall once the process is up and running.

Verify Data Quality

The TTI CVPD Evaluation Team will not conduct site visits to verify the data through field inspection or survey, as commonly done in traffic analysis studies. Instead, the TTI CVPD Evaluation Team will compare data from multiple sources to verify the accuracy of the data. The TTI CVPD Evaluation Team will screen the NYCDOT CVPD Team-provided data by comparing data from the same sensor over time or by comparing data from neighboring sensors. The TTI CVPD Evaluation Team will abide by the following data screening procedures (***Error! Reference source not found.***):

- Traffic data screening categories.
    - Known errors recorded in the field.
    - Thresholds on a single variable (e.g., speed usually ranges from 5 to 70 mph in urban areas).
    - The relationship between the variables (i.e., that volume, speed, and occupancy conform to the fundamental traffic diagrams).
    - The relationship among records at the same sensor over time (e.g., time series data could be mathematically fitted by a time series model with specific errors under control).
    - The relationship among records reported by neighboring sensors over time.

- Explore and understand the data.
    - Understand the aggregation level and methods used for aggregations.
    - Understand data type included.
    - Understand spatial and temporal resolution of data (e.g., lane-by-lane data or aggregated lane data; 10 records per seconds or an aggregated record every 5 minutes).
- Evaluate the applicability of screening.
    - Speed below 5 mph (human walking speed usually ranges from 3–4 mph).
    - Average effective vehicle length.
    - Volume–speed relationship.
    - Volume–occupancy relationship.
- Select thresholds for the data screening.
    - Law enforcement policy may provide potential thresholds for traffic movement (e.g., speed limit and high-occupancy vehicle lane).
    - The thresholds can be selected based on either statistical estimators using field observation or prior knowledge of traffic studies.
- Identify additional tests from data exploration. Various data sources may have unique features. Additional data screening tests are required if traffic data are not ubiquitous.
- Validate selected screening tests.

The TTI CVPD Evaluation will flag data that appear to be suspect and report the anomalies to NYCDOT. If the NYCDOT cannot resolve the anomaly, TTI may consider removing the faulty data from the analyses.

Traffic Simulation Model Data Quality Check

The TTI CVPD Evaluation Team will follow the error checking process outlined in the FHWA *Traffic Analysis Toolbox Volume III* (*9*) to validate the site-provided simulation model input files:

- Review software errors.
- Review input coding errors, including geometry, control, demand, and driver behavior and vehicle characteristics.
- View animation.

The TTI CVPD Evaluation Team will review the model input files for the following data quality:

- Geometric data—spot-check the geometric and traffic control type data using Google Earth; look for apparent violations of design standards and practices.
- Traffic control data—spot-check the traffic signal phase and timing data using site-provided signal timing plans.

- Traffic counts—spot-check traffic counts for internal consistency (balancing within 10 percent).
- Traffic operations and management data— spot-check travel time and speed data from CV data or control vehicle probe data if available.

The TTI CVPD Evaluation Team plans to follow the *Highway Capacity Manual* (*18*) methodology for measuring travel time distributions and reliability performance measures.

Driver Behavior Model Verification

If the sites do not share this detailed data required for model validation, then it will not be possible for the TTI CVPD Evaluation Team to validate the driver behavior model. If that is the case, then the sites must develop their process to demonstrate that the driver behavior model they developed is calibrated accurately to the existing conditions. The TTI CVPD Evaluation Team will ask the NYCDOT CVPD Team to provide the data that they used to develop the CV driver behavior model developed. The TTI CVPD Evaluation Team will also conduct a visual check of the simulation to see if unusual vehicle behaviors appear in the animation. The TTI CVPD Evaluation Team will work with the NYCDOT CVPD Team to resolve issues associated with unusual vehicle behaviors in the simulation model. If the NYCDOT and TTI cannot resolve the anomaly, TTI may consider removing the faulty data from the analyses.

Data Availability

Based on a review of the draft *Connected Vehicle Pilot Deployment Program Phase 2: Data Management Plan* (*10*), it appears that the NYCDOT CVPD Team is providing the data necessary to conduct the planned independent evaluation. The TTI CVPD Evaluation Team will supplement these data from data from other sources (e.g., NPMRDS).

Table 5. Availability of NYCDOT CVPD Data Sources

Data Type	Data Needed for Independent Evaluation	Pre-Deployment (Baseline)	Post Deployment
CVPD Vehicle Travel Times	Yes	-	✓
Vehicle Interaction Speed Compliance Events Logs	Yes	-	✓
NYCDOT TMC Generated Travel Time and alerts, and warning	Yes	✓	✓
Taxi and MTA Bus Activity Logs	Yes	✓	✓
NYCDOT Short- and Long-Term Construction Logs	Yes	✓	✓
TRANSCOM Traffic Incident Logs	Yes	✓	✓
NYCDOT Special Event Road Closures Logs	Yes	✓	✓
Crash Data Records	Yes	✓	✓
Fleet Manager Survey Responses	Yes	✓	✓
Driver Survey Responses	Yes	-	✓
NYCDOT Staff Surveys and Interviews	Yes	✓	✓

Source: Adapted from *CVPD Program Phase 2, Data Management Plan*

Chapter 5. Data Management Procedures

This chapter describes the processes and procedure that the TTI CVPD Evaluation Team will use to manage the data for the NYCDOT CVPD evaluation. Specifically, this chapter presents the plans for sharing data and disseminating data to others. The data sharing section discusses how the TTI CVPD Evaluation Team plans to share data internally within the Team, while the Data Dissemination section discusses how the TTI CVPD Evaluation Team plans to share data with individuals external to the Evaluation Team.

Data Sharing

The USDOT requires the TTI CVPD Evaluation Team to conduct all data analyses and statistical comparisons within the structure of the SDC. The SDC is a cloud-based, online analytic portal where data from each of the CVPD Teams are placing the data collected by their systems for use in the independent evaluation. The purpose of the SDC is to provide a secure platform that will enable USDOT and others to share large data sets, both structured and unstructured, for evaluation and collaboration (*8*). Except for charts, figures, and tables generated to support the preparation of evaluation reports, the TTI CVPD Evaluation Team will not be able to download any raw or processed data from the SDC. The TTI CVPD Evaluation Team will work with the USDOT and the SDC development team to ensure that proper resources and analytical tools are available to the TTI CVPD Evaluation Team in the SDC.

The only exception to USDOT's requirement may be the simulation and modeling effort. While the TTI CVPD Evaluation Team will attempt to conduct the simulation modeling directly in the SDC platform, licensing and software requirements may require the TTI CVPD Evaluation Team to perform the planned simulation modeling outside of the SDC environment. If the TTI CVPD Evaluation Team cannot make the simulation modeling software run in the SDC environment, the TTI CVPD Evaluation Team will conduct the modeling outside of the SDC environment. NOTE: The TTI CVPD Evaluation Team already has the simulation software installed and functioning on standalone machines outside of the environment. If the TTI CVPD Evaluation Team must perform simulations outside the SDC environment, the TTI CVPD Evaluation Team will device a process for uploading and downloading input and data files to the SDC. TTI will explore the possibly of embedding a version control software tool (such as GitHub or other version control tools) into the SDC to store and manage the data files. Initial data files will be developed and stored on local machines. Prior to running each model, the TTI CVPD Evaluation Team will upload the all the data files to the version control tool. After the simulation is complete, the TTI CVPD Evaluation will upload the output for the simulation models into the same version control tool. That way, input files can be correlated with output files. The SDC will be responsible for providing backups of the data files. Once the modeling is complete, TTI CVPD Evaluation Team will upload final copies of the input and output files into the SDC for storage and future use by other researchers and all copies of the files will be removed from the local machines.

As the NYCDOT CVPD Team are the original owners of the simulation models, the TTI CVPD Evaluation Team will not share original versions of the simulation and emission models outside of the SDC and the ITS Public Data Hub.

Data Dissemination

Other than summary charts, figures, and tables contained in published reports, the TTI CVPD Evaluation Team does not plan to disseminate or distribute the data in any form. The SDC should prohibit the TTI CVPD Evaluation Team from downloading any data, in full or in part. The TTI CVPD Evaluation Team will upload any data that it collects (such as survey data or ancillary data to support the evaluation) to the SDC, once the TTI CVPD Evaluation Team has removed all the PII and SPII data. While the TTI CVPD Evaluation does not expect to collect or need any sensitive data, the TTI CVPD Evaluation Team will place any sensitive data in a secured location.

Managing Survey and Interview Data

As specified in the *CVPD Independent Evaluation Program: Stakeholder Evaluation Plan* (*6*), the TTI CVPD Evaluation Team will keep the data gathered from the qualitative interviews, online survey, and workshops confidential. Survey and interview participants can be identified by only authorized team members of the TTI CVPD Evaluation Team. TTI will not list any individual responses to questions posed in the qualitative interviews, online survey, or workshops. TTI plans to keep all PII separate from data for analysis in a locked file cabinet.

Informed consent procedures approved by the Texas A&M University IRB will be followed in conducting the interviews, online survey, and workshops. TTI plans to send each participant a consent form via email before scheduling an interview appointment, starting the online survey, or participating in the workshops. Each prospective participant will have an opportunity to ask questions about the study and will have ample time to decide whether to participate.

The TTI CVPD Evaluation Team will prepare summaries of all interviews, surveys, and workshops. Even though the PII will be separated from the information gathered, there is the risk that an individual could be identified through his/her responses to questions. To minimize this risk, the TTI CVPD Evaluation Team will scrub any publicly released reports or technical memoranda to ensure that a specific individual cannot be deciphered through his/her responses. After preparing the summaries, raw survey responses and interview notes will be kept in a secure file cabinet under lock and key until the final report is prepared. Once the final report is approved by USDOT, the TTI CVPD Evaluation Team will destroy any raw notes or materials obtained in interviews or workshops.

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