Connected Vehicle Pilot Deployment Program Independent Evaluation:

Comprehensive Evaluation Plan—New York City

www.its.dot.gov/index.htm

Final Report—April 15, 2019 (Revised)
Publication Number: FHWA-JPO-18-670

U.S. Department of Transportation

Produced by Texas A&M Transportation Institute
U.S. Department of Transportation
Intelligent Transportation Systems (ITS) Joint Program Office
Federal Highway Administration

Cover photo courtesy of ITS JPO Module 13 ePrimer Presentation (Connected Vehicles)

Notice

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-JPO-18-670		

4. Title and Subtitle	5. Report Date
Connected Vehicle Pilot Deployment Program Independent Evaluation: Comprehensive Evaluation Plan—New York City	April 8, 2019 (Revised)
	6. Performing Organization Code
7. Author(s) Kevin Balke (TTI), Mike Lukuc (TTI), Beverly Kuhn (TTI), Mark Burris (TTI), Johanna Zmud (TTI), Abigail Morgan (Kittelson), Richard Dowling (Kittelson), Geoff Morrison (Cadmus), Robert Marsters (GeoDecisions), Todd Szymkowski (Gannett Fleming)	8. Performing Organization Report No.
9. Performing Organization Name and Address Texas A&M Transportation Institute Texas A&M University System 3135 TAMU College Station, TX 77843-3135	10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTFH6116D00045/00003
12. Sponsoring Agency Name and Address ITS Joint Program Office 1200 New Jersey Avenue, S.E. Washington, DC 20590	13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code

15. Supplementary Notes

Work Performed for Walter During, Federal Highway Administration

16. Abstract

This report summarizes the analysis plans that the Texas A&M Transportation Institute (TTI), in its role as the independent evaluator, will use to assess the mobility, environmental, and public agency efficiency (MEP) impacts of the New York City (NYC) Connected Vehicle Pilot Deployment (CVPD). This document summarizes the plans for:

- Assessing the MEP benefits associated with the NYC CVPD.
- Estimating the benefit/costs associated with the NYC CVPD.
- Assessing stakeholder acceptance and satisfaction with the deployment.
- Conducting stakeholder surveys and interviews.
- Managing the data that the TTI CVPD Evaluation Team plans to use to conduct the MEP analysis.
- Using modeling and simulation evaluation to assess mobility-related performance.
- Disseminating the evaluation results to various stakeholders and audiences.

This report also provides a detailed cost estimate for completing the planned evaluation. Key risks and uncertainties that may impact the evaluation effort are identified.

17. Keywords	18. Distribution Statement
Connected Vehicle, Connected Vehicle Pilot Deployment, New York City, Independent Evaluation	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	57	

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

Acknowledgments

The authors would like to thank the following individuals for their assistance in developing this plan in support of the independent evaluation of the Connected Vehicle Pilot Deployment Program:

- Walter During, Federal Highway Administration (FHWA).
- Kate Hartman, Intelligent Transportation Systems Joint Program Office (ITS JPO).
- John Halkias, FHWA.
- Gabriel Guevara, FHWA.
- Jonathan Walker, ITS JPO.
- Govindarajan Vadakpat, FHWA.
- Douglas Laird, FHWA.
- Jimmy Chu, FHWA.
- Ariel Gold, ITS JPO.
- Tom Kearney, FHWA.
- James Colyar, FHWA.
- Robert Sheehan, ITS JPO.
- James Sturrock, FHWA.
- Marcia Pincus, ITS JPO.
- Volker Fessmann, FHWA.
- Emily Nodine, Volpe.
- Margaret Petrella, Volpe.
- Najm Wassim, Volpe.
- Karl Wunderlich, Noblis.
- Meenakshy Vasudevan, Noblis.
- Sampson Asare, Noblis.
- Kathy Thompson, Noblis.
- Peiwei Wang, Noblis.

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Chapter 1. Introduction

Surface transportation travel in the United States is on the verge of unprecedented transformation. As a society, we are searching for new and innovative ways to provide transportation services to traditionally underserved groups, such as our aging population, travelers with disabilities, and veterans. Furthermore, millennials are increasingly shying away from ownership of personal vehicles, which is generating increased demand for safe, efficient, reliable, and cost-effective shared mobility services. Meanwhile, roadway networks are experiencing increasing levels of congestion that in 2014 resulted in 6.9 billion hours of extra time spent in traffic and 3.1 billion gallons of wasted fuel, both of which equate to $160 billion in costs to travelers.

Despite these evolving challenges, advances in electronic and wireless technologies along with automated vehicle and connected vehicle (CV) technologies provide a significant opportunity to realize improved travel safety and mobility nationally. The United States Department of Transportation (USDOT) recognizes the magnitude of these rapidly evolving market trends, emerging technological advances, and their potential to transform the way we travel in the years to come. To facilitate the emergence and adoption of transformative approaches to travel, USDOT is funding a range of deployment activities to demonstrate the significant safety and mobility benefits that can be achieved with their implementation. The Connected Vehicle Pilot Deployment (CVPD) Program seeks to spur innovation among early adopters of CV application concepts. Using best available and emerging technologies, the pilot deployments are integrating CV research concepts into practical and effective elements, enhancing existing operational capabilities. The program includes pilot deployments in southern Wyoming—led by the Wyoming Department of Transportation; New York City—led by the New York City Department of Transportation; and Tampa, Florida—led by the Tampa Hillsborough Expressway Authority.

These deployment activities mark a significant point of transformation in that they encompass a philosophical shift in the way we view transportation improvements. These deployments are intended to enhance the mobility, environmental, and public agency (MEP) impacts of transportation. The improvements expected to emerge from these programs will strive to provide all Americans with safe, reliable, and affordable connections to employment, education, healthcare, and other essential services. As a result, these deployments will undoubtedly impact how public and private entities alike develop, implement, and maintain transportation services.

The objectives of the CVPD independent evaluation are to (a) perform a comprehensive, independent assessment of the MEP impacts; and (b) document the stakeholder acceptance and technical, institutional, and financial lessons learned at the three CV pilot deployment sites. This evaluation is being performed independently of the sites, each of which is performing its own assessment of its deployment. The Texas A&M Transportation Institute (TTI) CVPD Evaluation Team will use performance data collected by the sites and analysis, modeling, and simulation (AMS) to provide a quantitative assessment of the mobility and environmental impacts associated with each deployment. The TTI team will also be conducting interviews, surveys, and a workshop to capture the stakeholder acceptance and the financial and institutional implications of the deployments. The stakeholder acceptance and financial and institutional evaluations fall under Task Area C of the CVPD evaluation contract. The Volpe National Transportation Systems Center (Volpe Center) is responsible for conducting the assessment of the safety impacts associated with the deployments. The purpose of this comprehensive evaluation plan is to summarize the overarching plans that the TTI CVPD Evaluation Team plans to use to complete the comprehensive assessment of the MEP impacts of the New York City (NYC) CVPD and to disseminate the findings and lessons learned from the independent evaluation.

Overview of New York City CVPD

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 vehicle-to-vehicle and vehicle-to-infrastructure 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**—like 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, 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*).

Organization of Report

This report is divided into the following nine chapters. The titles of each chapter and the major topics covered are highlighted below:

- **Chapter 1. Introduction**. The first chapter provides an overview of the CV pilot deployment initiative and a quick guide to the topics covered in the individual chapters.
- **Chapter 2. Refined Mobility, Environmental, and Public Agency Efficiency Evaluation Plan**. This chapter summarizes the approaches and data that the TTI CVPD Evaluation Team plans to use to assess the MEP benefits associated with the NYC CVPD. This chapter also describes the process the TTI team plans to use to conduct the benefit-cost analysis.
- **Chapter 3. Stakeholder Acceptance/Satisfaction Evaluation**. The chapter describes the stakeholder evaluation planned to assess whether the CV pilot deployments achieved the vision, goals, and desired MEP impacts.
- **Chapter 4. Survey/Interview Guides**. This chapter highlights the techniques and processes that the TTI CVPD Evaluation Team plans to use to conduct stakeholder surveys and interviews.
- **Chapter 5. Evaluation Data and Data Management.** This chapter summarizes the sources of data that the TTI CVPD Evaluation Team plans to use to conduct the MEP analysis. This chapter also highlights key data management processes that the TTI team plans to implement.
- **Chapter 6. Analysis, Modeling, and Simulation Evaluation**. This chapter describes the analysis, modeling, and simulation evaluation to assess mobility-related performance because of the deployment.
- **Chapter 7. Outreach**. This chapter overviews the evaluation outreach plan designed to disseminate the evaluation results to various stakeholders and audiences.
- **Chapter 8. Detailed Evaluation Cost Estimate**. This chapter presents the estimated cost to complete the independent evaluation of the NYC CVPD.
- **Chapter 9**. **Risks and Uncertainties**. This chapter discusses key risks and uncertainties that may impact the evaluation effort.

Chapter 2. Refined Mobility, Environmental, and Public Agency Efficiency Evaluation Plan

This chapter summarizes the approach the TTI CVPD Evaluation Team plans to use to quantify and assess the MEP impacts of the NYC CVPD. A comprehensive description of the approaches and methods to be used by the TTI team in conducting the MEP impact assessment can be found in the *Connected Vehicle Pilot Deployment Program Independent Evaluation: Mobility, Environment, and Public Agency Efficiency (MEP) Refined* Evaluation *Plan—New York City* (*4*).

The specific objectives for the NYC CVPD are as follows:

- Reduce vehicle-to-vehicle crashes and incidents (or other safety surrogate measures if crashes are rare) in the CVPD corridors.
- Reduce crashes and incidents (or other safety surrogate measures if crashes are rare) and number of signal violations at high-accident intersections through red-light violation warning.
- Reduce truck-bridge strike crashes (or other safety surrogate measures if crashes are rare) in the pilot deployment area roadways that have low clearance bridges through oversized vehicle compliance warning.
- Improve truck safety on curves through curve speed compliance warning.
- Improve work zone safety through work zone speed compliance warning.
- Reduce pedestrian fatalities and injuries by reducing vehicle-to-pedestrian crashes and incidents in the pilot deployment area.
- Improve safety of visually impaired pedestrians through Mobile Accessible Pedestrian Signal System.
- Encourage safe driving by reducing speeding and increasing adherence to posted speed limits.
- Improve mobility for all vehicles, both equipped and unequipped, through reductions in crashes or improved clearance times from less severe crashes.
- Reduce negative environment impacts through reductions in crashes and increase in speed adherence.
- Improve decision-making by transportation managers through CV-based data sets.
- Improve customer satisfaction of end users.

Table 1 shows the performance measures, data sources, and analysis type that the TTI CVPD Evaluation Team plans to use to assess the evaluation hypotheses.

Table 1. Performance Measures and Data Sources for Independent Evaluation of NYC CVPD.

ID	Evaluation Hypothesis	Performance Measure	Data Sources	Analysis Type
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.	• Change in the proportion of vehicle traveling 5 mph at or above speed limit • Change in the proportion of trucks entering curves 5 mph above recommended speed • Change in the proportion of vehicles traveling 5 mph at or above the work zone speed limit	• ASD Action Logs	• With/Without using Observed data
2	The pilot deployment will not adversely affect mobility for all vehicles while improving travel reliability, both equipped and unequipped, in the deployment corridors.	• Change in Average Travel Time • Change in Average Intersection Delay • Change in Average Speed • Change in Vehicle Throughput	• Midtown in Motion Travel Time Monitoring System • MIM Traffic Signal Performance Monitoring System	• Before/After using Observed data
3	By reducing crash frequencies and severity, the pilot deployment will improve travel reliability in the deployment corridors.	• Change in 95th percentile Travel Time • Change in Buffer Time	• Change in 95th percentile Travel Time • Change in Buffer Time	• Before/After using Observed data
4	As the market penetration of CVs increases, benefits will increase in terms of reduced queues, delays, emissions, and increased vehicle throughput and travel.	• Average Trip Time per vehicle (VHT/V) • Average User Delay/Wait Time • Average Speeds • Average vehicle-miles traveled (VMT) per vehicle	• Total Vehicle-hours Traveled (VHT)/Total Vehicle Count • Difference in VHT/Mile at speed limit and VHT/Mile • VMT/Vehicle-hours Traveled • VMT/ Total Vehicle Count	• Modeling analysis to assess the impacts of the With vs Without cases

ID	Evaluation Hypothesis	Performance Measure	Data Sources	Analysis Type
5	As the market penetration of CVs increases, non-equipped vehicles traversing the pilot deployment area will see reductions in queues, delays, and emissions.	• Average Trip Time per vehicle (VHT/V) • Average User Delay/Wait Time • Average Speeds • Average vehicle-miles traveled per vehicle	• Total Vehicle-hours Traveled/Total Vehicle Count • Difference in VHT/M at speed limit and VHT/M • VMT/Vehicle-hours Traveled • VMT/ Total Vehicle Count	• Modeling analysis to assess the impacts of the With vs Without cases
6	The pilot deployment will reduce negative impacts on the environment through reduction in crashes and increases in speed adherence.	• Change in the vehicle emissions • Change in fuel consumption	• Simulation of incident/crash situations	• Modeling analysis to assess the impacts of the With vs Without cases
7	The pilot deployment will result in improved public agency efficiency and decision-making by transportation managers.	• Change in perception of agency awareness of conditions in the deployment corridors • Changes in the perceived accuracy of alerts/warnings/advisories/ traveler information • Changes in the perceived effectiveness of alerts/ warnings/advisories/ traveler information • Changes in timeliness of agency responses to changing travel conditions • Number and type of operational changes (such as signal timing adjustments) and business	• Surveys/Interviews • Agency MIM Operations logs • NYCDOT Incident Management Logs	• Qualitative perception data from surveys • Quantitative data from system logs

ID	Evaluation Hypothesis	Performance Measure	Data Sources	Analysis Type
		practice changes made by transportation managers • Perceived impact/effectiveness of operational and business practice changes • Changes in notification and/or response times to major incidents and crashes • Changes in perceived effectiveness of traffic management system responses to changing traffic conditions		
8	The safety, mobility, environmental, and public agency efficiency benefits exceed the costs associated with deploying the CV technologies in the deployment corridors.	• Total Deployment Costs ○ Development ○ Procurement ○ Installation ○ Operations ○ Maintenance ○ Salvage • Dollar Value of Benefits ○ Safety ○ Mobility ○ Environmental ○ Public Agency Efficiency	• Safety Analysis • Mobility Analysis • Environmental Analysis • Public Agency Efficiency Analysis • Agency Cost Records	• Benefit/Cost
9	Incremental increases in CV deployment will result in higher benefit-cost ratio up to a certain deployment cost threshold.	• Benefit-cost ratio at various market penetrations	• Cost data • Dollar value of benefits	• Simulation

ID	Evaluation Hypothesis	Performance Measure	Data Sources	Analysis Type
10	End users will be satisfied with the performance of the CV applications and with the impact of the CV deployment on their travel.	• Perception of whether advisories/ alerts/warnings/traveler information were: ○ Timely ○ Sufficiently detailed ○ Easy to understand ○ Accurate ○ Useful ○ Appropriateness • Perceived impact (if any) that alerts/warnings/advisories/ traveler information had on safety and/or mobility. • Attitudes toward the consistency of the alerts (Did they fell they consistently received an alert under similar situations?) • Attitudes toward CV systems (related to trust in information, privacy and security, etc.)	• Surveys/Interviews	• Qualitative perception data from surveys
11	End users will be satisfied with the performance of the CV devices.	• Overall satisfaction with performance of CV devices • Number and nature of problems with CV devices	• Survey/Interviews	• Qualitative perception data from surveys

ID	Evaluation Hypothesis	Performance Measure	Data Sources	Analysis Type
12	Pilot deployment agencies and transportation managers will find that their SMEP goals were met.	• Changes needed in business processes • Changes needed in agency systems and technologies capabilities • Changes needed in agency culture • Changes needed in the organizational structure and workforce requirements • Changes needed in institutional arrangements and collaborations • Changes needed in performance measurement practices • Perceived impact/effectiveness/ acceptance of those changes • Perceived extent to which safety, mobility, environmental, and public agency efficiency goals were met • Lessons learned by agencies	• Stakeholder Surveys/ Interviews	• Qualitative perceptions from interview data

Source: Texas A&M Transportation Institute

Analysis Approach

The TTI CVPD Evaluation Team plans to use an interrupted time series with no control group to analyze the impacts of the deployment (*1*). In the TSP application, all transit vehicles using the corridor will be equipped with the CV technologies, so the potential to have a control group does not exist.

As part of the NYC deployment, CV technologies will be installed in over 8,000 vehicles. Currently, the NYC CVPD Team plans to divide the study participants into two user groups: one group that will receive alerts produced by the application and another group that will not receive alerts or silent mode. This second group could potentially serve as a control group for the active group (i.e., the group that will actively receive the alerts from the devices). Vehicles operating in the silent mode will function the same as those vehicles receiving alerts, only no alerts will be issues to the drivers. This may allow a direct comparison of the performance of vehicles with and without the CV applications active. Depending upon the number of individuals assigned to the control group, it may be possible to use that group to control for effects of confounding factors in the corridor as both the treatment and control group would be experiencing the same conditions in each of the study corridors throughout the study period. The TTI CVPD Evaluation Team will have to wait until NYC CVPD Team has finalized their deployment plans to determine if the sample size of observations in this group is adequate to perform this type of analysis.

Identification of Operational Conditions

The TTI CVPD Evaluation Team will identify the key attributes for defining the operational conditions for the NYC CVPD using a cluster analysis. These are the underlying conditions at the site, not the measures of system performance. The TTI CVPD Evaluation Team anticipates the following to be critical attributes impacting operations in the corridors:

- Daily travel demand.
- Weather conditions (type, duration, severity, precipitation amount, pavement conditions, time-lag of weather effects).
- Incident conditions (type, duration [e.g., total lane-minute closure], severity).
- Work zone conditions (type, duration, impact severity).
- Special event conditions (type, duration, impact severity).
- Road closure conditions.
- Holidays.
- Day of week.
- Market penetration observed.

The TTI CVPD Evaluation Team will conduct a cluster analysis around key corridor attributes. The purpose of the cluster analysis is to ensure that comparison of observed data is done for similar conditions in the before and after periods. The TTI team will use the data normalization tool from open-source statistical analysis software (such as R or WEKA) in the Secure Data Commons (SDC) to normalize the data or to transform all data to a common scale so that no single attribute dominates. After normalizing the data, the TTI team will use the software tools to down-select attributes. The TTI team will then perform the cluster analysis on the data using an open-source statistical and data mining tool in the SDC (such as R or WEKA). The TTI team will develop the clusters based on the post-deployment conditions to define the operational conditions for conducting the analyses. The TTI team will then classify pre-deployment data based on the post-deployment clusters to ensure that data from similar operational conditions are comparable.

Mobility Analysis

The mobility analysis will be divided into three parts: system level mobility benefits, CV vehicle mobility benefits, and mobility benefits due to safety improvements. Each of these levels of assessments is discussed below.

- System Level Mobility Impacts—The purpose of this level of the evaluation is to determine the extent to which deploying the CV technologies in the deployment corridor impacted overall travel (or mobility) in those corridors. For this analysis, the TTI CVPD Evaluation Team will use performance measures that reflect how overall mobility in the deployment corridor changed after the introduction of the vehicle equipped with CV technologies compared to mobility before the technologies were introduced. For this analysis, the TTI CVPD Evaluation team will use performance measures that reflect all vehicles traveling in the corridors, both those equipped with CV technologies and those without.
- Vehicle-Level Mobility Impacts—For this comparison, the TTI CVPD Evaluation Team will focus on comparing the mobility performance of those vehicle equipped with CV technologies <u>and</u> actively receiving alerts compared to those vehicles equipped with CV technologies but not actively receiving alerts (i.e., the CV technologies are operating in the silent mode). For this analysis, vehicles that are operating in the silent mode are assumed to operate similarly to those vehicles that are not equipped with CV technologies at all.
- Mobility Benefits due to Safety Improvements—TTI CVPD Evaluation Team plans to use simulation to assess the extent to which mobility benefits can be derived from improvements in safety. For this analysis, the TTI CVPD Evaluation Team will rely heavily on field data to determine how CV and non-CV vehicles behave during different safety-related situations. The TTI CVPD Evaluation Team will use a cluster analysis to identify different safety scenarios that exist in the corridors. Using field data to calibrate traffic demands and travel patterns during these events, the TTI CVPD Evaluation Team will develop modeling scenarios that can be used to quantify the mobility benefits resulting from the safety improvement generated by the CV equipped vehicle traversing the corridors. The simulation model will be used to collect mobility-based performance measures such as delays, stops, travel time, travel speeds, etc.

Environmental Evaluation

The TTI CVPD Evaluation Team will construct the environmental model using the U.S. Environmental Protection Agency’s Motor Vehicle Emissions Simulator (MOVES) model (*5*). The team will use output data from simulation modeling as input to the MOVES model. MOVES is a project-level simulator that uses a vehicle’s operating mode—including idling, acceleration, deceleration, cruise, and hoteling—to measure emissions and petroleum consumption at the national, county, or project scale. MOVES assigns an emission rate for each unique combination of source and operating mode bins and calculates the total emissions and energy use over a specified period.

Public Agency Efficiency Evaluation

CV technologies can potentially provide public agencies with a new and rich source of data that can be used to improve decision-making by public agencies. Public agencies can potentially use this new source of data to improve operational decision-making, adjust traffic control strategies, respond faster and better to incident conditions, provide travelers with better information about road surface conditions, etc. One part of the TTI CVPD Evaluation is to assess the degree to which deploying CV technologies in the deployment corridor helped public agencies improve their efficiency and effectiveness of detecting, responding, and managing changing traffic conditions—whether they be incidents, unscheduled road closures, inclement weather conditions, or normal day-to-day travel congestion.

Benefit-Cost Analysis

The TTI CVPD Evaluation Team will also conduct a benefit-cost analysis associated with the NYC CVPD. The purpose of the benefit-cost analysis is to determine whether the safety, mobility, environmental, and public agency benefits exceeded the total costs associated with deploying the CV technologies in the deployment corridors. If the project were to increase the cost of travel, result in other increased user costs, or have any other negative benefits, then those results would also be entered as a benefit, but as a negative benefit.

The benefit-cost analysis will encompass the planning, implementation, and 7years of post-deployment operations. The TTI CVPD Evaluation Team will use a combination of field data and simulation data to estimate the benefits and costs. The analysis will assume that the measured impacts of the projects (such as travel time savings) from the early years will continue at the same level in the later years of the project. The analysis will use a 7 percent discount rate for most items in accordance with Office of Management and Budget guidance. The TTI team will discount all monetary amounts to the start of project operations.

The TTI CVPD Evaluation Team will use changes in before and after travel times for each operational condition likely to produce specific benefits from deploying CV technologies. The TTI team will estimate mobility costs associated with each type of operational scenario identified through the cluster analysis. The TTI team will estimate total mobility costs of the deployment by multiplying the costs of individual events by the frequency of occurrence of the event in the evaluation period.

The TTI CVPD Evaluation Team will also include the benefits associated with any reductions in crashes resulting from the deployment. The TTI team will apply the crash reduction predictions for the corridors developed by Volpe to estimate the changes in different types of collisions. (The TTI team will capture the mobility benefits associated with those reductions in crashes in the mobility costs.) The TTI team will use the methodology contained in the *TIGER Benefit-Cost Analysis (BCA) Resource Guide* (*6*) to estimate safety costs.

The TTI CVPD Evaluation Team will also include the benefits associated with any changes in emissions due to deploying the CV technology in the corridors. The TTI team will use simulation to estimate the effects of the deployment on emissions. The TTI team will project changes in emissions between the actual case (with the CV demonstration projects) and a hypothetical base case (with no CV technologies deployed) for a 7-year time frame. The TTI team will include the following pollutants in the benefit-cost analysis: CO_2, volatile organic compounds, NO_X, PM, sulfur oxide, and carbon monoxide.

The TTI CVPD Evaluation Team will also include the estimated fuel usage costs in the benefit-cost analysis. The TTI team will base current and predicted costs for fuel on information from the U.S. Energy Information Administration website (*7*). This website includes current and historical gasoline and diesel fuel prices. Data from this site will be used to develop average fuel costs during the evaluation period. The portion of the cost of fuel that is taxed will be removed prior to calculations since that portion is a transfer and not a change in societal benefits.

The TTI CVPD Evaluation Team will also include the vehicle operating costs as part of the benefit-cost analysis. The TTI team will base these costs on data published by the American Automobile Association (AAA) annually (*8*). Any reduction/increase in vehicle miles traveled will result in reduced/increased maintenance, tires, and depreciation based on average per mile vehicle operating costs as calculated by AAA. The costs *will not* include ownership costs because the TTI team assumes that those costs would be the same whether the vehicle were equipped with CV technologies. Ownership costs include items such as insurance; license, registration, and taxes; vehicle depreciation; and finance charges.

The implementation costs used for the benefit-cost analysis will include the costs associated with deploying the CVPD. These costs will include the following:

- The costs to plan, implement, operate, and maintain the CV deployment project.
- The marginal costs that the agencies and users incurred due to the project.

If applicable, the TTI CVPD Evaluation Team will subtract salvage value from the cost of the equipment. The TTI team will not include items such as fees for the travelers to use part of the CV deployment project in the benefit-cost analysis.

In addition to benefits/costs associated with the current deployment, the TTI CVPD Evaluation Team will also use modeling to examine the extent to which different market penetration rates are likely to affect changes in mobility, safety, and the environment in the deployment corridors. The team will estimate the benefits and costs for both the actual CV penetration rate and higher CV penetration rates. The growth scenarios will use only the existing suite of applications being deployed, and no new applications will be added to the vehicles. At a minimum, the study will use the following:

- The cost to increase the penetration rate (additional purchases of CV equipment, labor, maintenance, etc.).
- The estimates of safety, mobility, fuel, and emissions impacts of higher penetration rates.

The study will use simulations based on data collected from the CV deployment project. In addition to examining changes in performance with different penetration rates, the TTI CVPD Evaluation Team will project the effects of changes in background traffic demands on mobility performance in the corridors.

Chapter 3. Stakeholder Acceptance/ Satisfaction Evaluation Plan

As part of the independent evaluation, the TTI CVPD Evaluation Team will also be collecting stakeholder acceptance and satisfaction information to gather stakeholder impressions and experiences related to the NYC CVPD. The results will be of benefit to the long-term sustainability of the CV deployed applications and to other entities seeking to deploy CV applications. The *Connected Vehicle Pilot Deployment Program Independent Evaluation: Stakeholder Acceptance Plan* (*9*) describes the approach that the TTI team will use to gather stakeholder acceptation and satisfaction information.

Table 2 shows the stakeholders for the NYC CVPD.

The TTI CVPD Evaluation Team will use structured pre- and post-deployment interviews to assess stakeholder perceptions of whether the pilots achieved the intended goals and impacts. Pre-deployment interviews will be used to obtain initial expectations prior to deployment. The TTI team plans to conduct two iterations of the post-deployment interviews: (a) the near-term post-deployment interviews will be check-in interviews shortly after deployment to get initial feedback, and (b) the long-term post-deployment interviews will be toward the end of deployment to assess how these perceptions change as the deployment progresses. The TTI team will also document challenges, solutions, and lessons learned at two points in time, shortly after activation and near the end of the pilot deployment.

The TTI CVPD Evaluation Team plans to conduct a post-deployment survey to gather information from important—but less engaged in day-to-day operations—stakeholders on whether and how the three CV pilot deployments achieved the vision, goals, and desired MEP impacts. The timing of this survey is long-term post-deployment. The survey will also quantify technical challenges, adopted solutions, and lessons learned. The TTI team plans to administer the survey online, accessible through a link in a recruitment email. The TTI team will coordinate with the NYC CVPD Team to determine whether TTI can administer the survey directly or if the NYC team prefers to administer the survey.

The TTI CVPD Evaluation Team will conduct one post-deployment workshop at the NYC site. The purpose of the workshop is to foster additional dialog among the deployment managers, deployment teams, and operating agencies concerning the lessons learned and major takeaways from planning and implementing the deployment. The TTI team will also use the workshop to gather information needed to conduct the financial and institutional assessments. The TTI team envisions that the workshop will be one-half to one day in duration. The TTI team will develop open-ended questions designed to facilitate and guide the discussion in the workshop.

Table 2. NYC Stakeholder Group Types.

Stakeholder Category	Agency/Entity
Deployment Manager	• New York City Department of Transportation (NYCDOT)
Deployment Team Members	• TransCore • Cambridge Systematics • KLD Engineering • Onboard Security • New York University, University Transportation Research Center
Operating agency system managers	• MTA NYC Traffic Management Operators • NYC Department of Information Technology
Fleet owners/operators	• NYC Department of Sanitation • NYC Taxi and Limousine Commission • United Parcel Service • Taxi Garage Operators • Metropolitan Transportation Authority (MTA) • New York City Transit
Supporting agency managers	• Pedestrians for Accessible and Safety Streets Coalition
Policymakers	• Mayor's Office • New York City Council

Source: NYC CVPD Team.

Chapter 4. Survey and Interview Guides

The *Connected Vehicle Pilot Deployment Program Independent Evaluation: Stakeholder Survey/Interview Guide—New York City* (*10*) provides details on the questions and approach that will be used to obtain input from the various NYC CVPD Deployment Team stakeholders. The TTI CVPD Evaluation Team will use a multipronged approach for the data collection that includes qualitative interviews, an online survey, and a workshop:

- Interviews will be used to gather in-depth information from those stakeholders most invested and involved in the CV pilot deployment. Interviews will take place at three points in time: pre-deployment, post-deployment near term, and post-deployment long term.
- An online survey will be used to gather information from stakeholders less involved in the day-to-day pilot and execution.
- A workshop will be used to obtain additional cross-stakeholder dialog to confirm interview findings and reveal additional insights.

Table 3 shows the distribution of data collection activities across stakeholder types.

Table 3. Data Collection Method by Stakeholder Type.

Stakeholder Type	Pre-Deployment Interviews	Post-Deployment Interviews Near Term[1]	Post-Deployment Interviews Long Term[2]	Survey	Workshop
Deployment Managers	X	X	X	—	X
Deployment Team	X	X	—	—	X
Operating Agencies	X	—	X	—	X
Fleet Operators	—	—	—	X	—
Supporting Agencies	—	—	—	X	—
Policy Makers[3]	X	—	X	—	—

— No data.
[1] Near-term post-deployment is 2–3 months after activation.
[2] Longer-term post-deployment is 9–12 months after activation.
[3] If the champion is no longer in office post-deployment, the TTI CVPD Evaluation Team will interview the incumbent instead.

Source: Texas A&M Transportation Institute

Interviews

The TTI CVPD Evaluation Team plans to conduct three types of interviews:

- Pre-deployment interviews—These interviews will elicit vision, goals, and expectations and gather information on financial and institutional preparedness. The TTI team plans to execute these interviews just before activation of the test CV applications.
- Near-term post-deployment interviews—These interviews will capture early deployment experiences, challenges, and solutions. The TTI team plans to conduct these 1–3 months after activation of the deployment.
- Long-term post-deployment interviews—These interviews will gather opinions on whether the deployment achieved the desired vision, goals, and MEP impacts. The TTI team also plans to collect observations and experiences about challenges (e.g., technical, institutional, financial), adopted solutions, and lessons learned. The TTI team will use these interviews to measure stakeholder levels of satisfaction with pilot outputs/outcomes and the long-term sustainability of the CVPD. The team will conduct these interviews about 9–12 months after activation of the applications.

The TTI CVPD Evaluation Team has developed interview protocols that probe the various stakeholder groups on the following topics:

- Policy challenges.
- Institutional challenges.
- Collaboration.
- Financial issues.
- Business processes.
- Performance measures.
- Systems and technology.
- Workforce development.
- Outreach.

The specific questions to be asked in these interviews can be found in the *Connected Vehicle Pilot Deployment Program Independent Evaluation: Stakeholder Survey/Interview Guide—New York City* (*10*).

Online Survey Questionnaires

The TTI CVPD Evaluation Team has developed separate questionnaires to gather perceptions of the outcomes of the pilot deployments from the fleet operators and the supporting agency stakeholders. These surveys will be administered to these stakeholders 9–12 months after activation. The TTI team anticipates that respondents will require 10–15 minutes to complete the questionnaire. To not overburden fleet operators, the TTI team will coordinate the administration of the fleet online survey with the NYC CVPD Team. This coordination will consist of when, where, and how the team will administer the online survey and could potentially involve combining this survey with other surveys already planned by the NYC team.

For information on the specific questions to be addressed in the questionnaires, see the *Connected Vehicle Pilot Deployment Program Independent Evaluation: Stakeholder Survey/Interview Guide—New York City* (*10*).

Post-Deployment Workshop

The TTI CVPD Evaluation Team will conduct a workshop at the end of the NYC deployment period. The purpose of the workshop is to foster additional dialog among the deployment managers, deployment teams, and operating agencies concerning the lessons learned and major takeaways from planning and implementing the deployment. The common themes identified in the post-deployment interviews will be used to frame the group discussion, which will explore the following topics in more detail:

- Expectations and satisfaction.
- Technical challenges.
- Institutional arrangements.
- Financial arrangements.
- Lesson learned.
- Sustainability.
- Expectation for future operations.

Workshop participants will represent the deployment managers, deployment team members, and operating agencies from NYC. It is expected that 15–20 persons will participate in the workshop. Some, but not all, will be individuals who have participated in the interviews. The TTI CVPD Evaluation Team will coordinate with the deployment managers to identify persons to invite to the workshop.

Examples of the specific questions to be asked in the workshop can be found in the *Connected Vehicle Pilot Deployment Program Independent Evaluation: Stakeholder Survey/Interview Guide—New York City* (*10*).

Chapter 5. Evaluation Data and Data Management

The *Connected Vehicle Pilot Deployment Program Independent Evaluation: Data Plan—New York City* (*11*) describes the data that the TTI CVPD Evaluation Team plans to use to identify operational scenarios to be examined in the analysis, conduct the MEP evaluation, and calibrate the simulation models for the analysis. The plan also provides the approach that the TTI team plans to use to maintain the privacy and quality of the data it collects. In addition, the plan describes how the TTI team will use and upload data to the SDC.

Sources of Evaluation Data

Table 4 summarizes the data that the TTI CVPD Evaluation Team plans to use to conduct the independent evaluation of the MEP benefits of the NYC CVPD.

Table 4. Summary of Data Requirements for Independent Analysis of NYC CVPD.

Data Type	Data Elements	Source	Used in What Analysis
Travel Times (System)	• Date • Time • Segment ID • Travel Time	• 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
Travel Times (CVs)	• Date • Time • Segment ID • Travel Time	• RSU logs	• Mobility • AMS Model Calibration
Traffic Demand (Volumes)	• Date • Time • Station ID • Vehicle Count • Vehicle Classification (if available)	• NYC DOT Count Stations	• Mobility Analysis • AMS Model Calibration
Weather	• Date • Time • Sky Condition • Air Temperature • Dew Point	• National Weather Service	• Mobility Analysis • AMS Model Calibration

Data Type	Data Elements	Source	Used in What Analysis
	• Precipitation • Visibility (miles)		
Incident	• Date • Start and end time • Locations • Type and severity of the incident • Number of lanes impacted	• TRANSCOM Incident Logs	• Mobility Analysis • AMS Model Calibration
Special Event	• Date • Start and end time • Locations • Duration • Type • Number lanes impacted	• NYCDOT Street closure calendar/ logs	• Mobility Analysis • AMS Model Calibration
Work Zone	• Date • Start and end time • Locations • Duration • Type • Number lanes impacted	• NYCDOT Work Zone closure calendar/ logs	• Mobility Analysis • AMS Model Calibration
Crash Histories	• Date • Time • Locations • Type	• NYC Accident Logs	• Benefit-Cost
Incident/Event Response Times	• Date • Time • Duration • Event Type	• NYCDOT TMC Logs	• Public Agency Efficiency
Time Plan Changes	• Date • Time • Duration • Event Type	• NYCDOT TMC Logs	• Public Agency Efficiency

Source: Texas A&M Transportation Institute (*11*).

Data Ownership and Privacy

USDOT and NYC Department of Transportation are the owners of the data uploaded by NYC CVPD into the SDC. Any data collected by the TTI CVPD Evaluation Team, including the simulation input file and result files, become the property of USDOT once the project is complete. After removing any personally identifiable information from the data, the TTI team plans to upload any data files generated in the analysis to the SDC. The TTI team will reference and credit appropriately any data obtained from external sources. Both the NYC CVPD Team and the TTI CVPD Evaluation Team have implemented policies and procedures for protecting and controlling personally identifiable information.

Data Analysis and Management Procedures

The TTI CVPD Evaluation Team plans 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 collected by each of the CVPD teams are placed 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. The TTI team will work with USDOT and the SDC development team to ensure that proper resources and analytical tools are available to the TTI team in the SDC. Other than summary charts, figures, and tables contained in published reports, the TTI team does not plan to disseminate or distribute the data in any form outside of the SDC.

The TTI CVPD Evaluation Team will keep the data gathered from the qualitative interviews, online surveys, and workshop confidential. Survey and interview participants can be identified only by authorized team members of the TTI team. The TTI team will prepare summaries of all interviews, surveys, and the workshop. 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 team will destroy any raw notes or materials obtained in the interviews or workshop.

Chapter 6. Analysis, Modeling, and Simulation

Modeling and simulation will play a big part in the TTI CVPD Evaluation Team's approach for assessing the mobility and environmental benefits associated with the NYC CVPD. The *Connected Vehicle Pilot Deployment Program Independent Evaluation: Analysis, Simulation, and Modeling Plan—New York City* (*12*) contains TTI's plan for how modeling and simulation will be used in the independent evaluation. Specifically, the TTI team will use the AMS analysis to perform the following:

- Estimate the impacts of rear-end and intersection-related vehicle crashes on 1st, 2nd, 5th, and 6th Avenues in midtown Manhattan on mobility, travel time reliability, and corridor throughput under the different operating conditions and time of day that prevail in the corridor (IE Hypothesis 2).
- Estimate the impacts of rear-end and intersection-related vehicle crashes on Flatbush Avenue in Brooklyn on mobility, travel time reliability, and corridor throughput under the different operating conditions and times of day that prevail in the corridor (IE Hypothesis 2).
- Estimate the impacts of reducing vehicle infrastructure strikes on FDR Drive on mobility, travel time reliability, and corridor throughput under the different operating conditions and times of day that prevail in the corridor (IE Hypothesis 2).
- Estimate the impacts on the environment due to changes in mobility under different operating conditions that prevail in the corridors (IE Hypothesis 5).
- Estimate the cumulative effects of different market penetration levels of CVs and changes in background traffic levels on system performance on the deployment corridors in Manhattan and Brooklyn (IE Hypotheses 3, 4, and 8).

To estimate these impacts, the TTI CVPD Evaluation Team will use the base model that the NYC CVPD Team will develop.

The TTI CVPD Evaluation Team will first verify that the model is functioning properly and will then calibrate the model to the operational scenarios identified through the cluster analysis. The TTI team will be responsible for any model enhancements, calibration, and measurement estimations that diverge from what the NYC CVPD Team plans to do.

The key mobility-related performance measures the TTI CVPD Evaluation Team will compute for each operational scenario include the following:

- Total vehicle miles traveled.
- Total vehicle hours traveled.
- Average travel time.
- Average operating speed.

- Average system vehicle hours of delay.
- Average system speed variance.
- Average system time (i.e., VHT) spent in queue.

The TTI CVPD Evaluation Team will compute these performance measures using data from multiple simulation runs for each operational condition. The team will use these measures to estimate environmental performance measures too.

Model Development and Calibration

To estimate these impacts, the TTI CVPD Evaluation Team will use a base model that the NYC CVPD Team developed. The TTI team will receive from the NYC team a functioning model that is free from errors and calibrated to some level of performance. The TTI team will then refine the model and calibrate it for both speed and throughput for the operational conditions identified through the cluster analysis. The TTI team will follow the procedures specified in the *Traffic Analysis Toolbox III Guidelines for Applying Traffic Microsimulation Modeling Software* (*13*) to calibrate the model. The TTI team anticipates that the model will cover both the eastbound and westbound directions of travel in the corridors.

Analysis of Simulation Results

Model scenario identification comes after the cluster analysis of historic data has identified the relevant operating conditions to be included in the model scenarios. Each scenario is then the combination of different CV deployment level alternatives and the operational conditions determined from the cluster analysis. Weather conditions can affect vehicle travel speed (e.g., traveling slower than usual). Not controlling for the effects of changes in weather conditions has the potential to invalidate conclusions about the effectiveness of the CV pilot deployment in addressing the needs of the pilot site. Table 5 lists the known confounding factors likely to influence travel behavior in the NYC CVPD corridors.

The TTI CVPD Evaluation Team will not model different demand levels independently of the weather, congestion, and crashes. The TTI team will select a set of historical study periods (called historic days for convenience) based on the cluster analysis. The TTI team will input traffic counts, crash data, and weather collected simultaneously for those selected days into the simulation model. The TTI team will calibrate the model's performance results on a day-by-day basis to the speeds observed simultaneously for those same days.

The TTI CVPD Evaluation Team will follow standard statistical analysis procedures to assess differences in system performance between the pre- and post-deployment periods. The TTI team will use analysis of variance of the alternatives to test each mobility-related hypothesis across the range of market penetration levels. Hypothesis testing will deal with the confounding effects of weather, demand, and crashes on mobility by testing only CV application alternatives with identical operational conditions (same levels of demand, weather, and crashes).

Table 5. Treatment of Confounding Factors in Scenario Analysis.

Factors	New York City
Weather changes	The weather types and number of levels of each type that are to be assigned specific model scenarios for each CV deployment alternative will be determined via clustering analysis.
Vehicle demand changes due to a variety of causes: economic conditions (e.g., jobs), fuel price, fare/toll changes, weather, season of year, day of week, etc.	The values of demand and the number of levels of demand that are to be tested in specific model scenarios for each CV deployment alternative will be determined via clustering analysis.
Pedestrian demand changes	Depending on the pedestrian data available for each site, one or more levels of pedestrian demand will be identified for testing in each scenario. This will be done only where CV applications are expected to be influenced by pedestrian demands.
Random variation crashes	Scenarios involving operating conditions with crashes will model the same specific crash condition (location, timing, and lanes closed) for all CV deployment (and non-deployment) levels to control for the influence of random variation in crash rates. Non-random variations due to differing CV deployment levels will be treated in post-processing of model results.
Work zone changes	Model runs will use the same work zones for evaluating base and different CV deployment levels.
Economic condition changes	Effects will be included in demand operational conditions.
Fuel price changes	Effects will be included in demand operational conditions.
Planned special event changes	All model scenarios will assume the same planned events.

Note: This table addresses how the confounding effects of these factors will be controlled in the simulation model runs used in the analysis. A later step addresses how the impacts of these factors on CV performance will be determined.

Source: Texas A&M Transportation Institute

Modeling Higher Levels of Market Penetration

For each of the CV pilot deployment sites, the market penetration rates observed are limited by the size of the deployment. The TTI CVPD Evaluation Team will use simulations to estimate potential benefits of higher levels of market penetration, which may be observed in the future, as more vehicles and infrastructure are equipped with communication technology. As alluded to in the previous section, the analysis will test the sensitivity of the conclusions to the following factors: level of market penetration, level of demand, level of poor weather, and presence of and severity level of a crash. Table 6 illustrates the planned framework for the sensitivity analysis.

Table 6. Framework for Presenting Sensitivity Test Results for Each Measure of Effectiveness (MOE).

Scenario	CV Deployment Level	Operational Conditions Demand	Operational Conditions Weather	Operational Conditions Incident	Hypothesis Test Results Impact on MOE
1a	No Deployment	Low	Snow	None	N/A
1b	No Deployment	Medium	Rain	Minor	N/A
1c	No Deployment	High	Fair	Major	N/A
2a	Actual Deployment	Low	Snow	None	+1%, LTS
2b	Actual Deployment	Medium	Rain	Minor	+2%, LTS
2c	Actual Deployment	High	Fair	Major	+3%, LTS
3a	7-Year Expansion	Low	Snow	None	+2%, LTS
3b	7-Year Expansion	Medium	Rain	Minor	+4%, S
3c	7-Year Expansion	High	Fair	Major	+6%, S
4a	Maximum Expansion	Low	Snow	None	+4%, S
4b	Maximum Expansion	Medium	Rain	Minor	+6%, S
4c	Maximum Expansion	High	Fair	Major	+9%, S

Notes:

1. A separate sensitivity analysis results table will be prepared for each mobility MOE tested.
2. N/A = not applicable. This is the base case against which the CV deployment alternatives are compared.
3. +1%, LTS = a 1% increase in the mean value of the MOE was observed, but it was less than significant.
4. +6%, S = a 2% increase in the mean value of the MOE was observed, and it was significant.
5. All entries are illustrative.

Source: Texas A&M Transportation Institute

The number of levels and the specific levels of demand, weather, and incidents to be evaluated in the sensitivity tests will be determined by the cluster analysis. The cluster analysis on the field data may also reveal other factors or additional factors to include in the sensitivity analysis.

For each representative operational condition selected for simulation, the TTI CVPD Evaluation Team will operate the calibrated model to a future scenario in which the market penetration rate is higher for the CV fleet. By increasing the number of CVs in the model, the probability of vehicle-to-vehicle interactions increases, and the number of vehicles that the RSUs detect also increases.

Estimation of Mobility Impacts of Safety Applications

While microsimulation models of mobility are designed to predict the mobility effects of specific demand, weather, and crash conditions, they are not designed to predict the weather, demand, or crashes. Therefore, specific demand levels, weather, and crashes commensurate with each specific operational condition cluster to be modeled will be coded into the analysis scenarios. The TTI CVPD Evaluation Team will estimate the mobility effects of reduced crash frequencies by adjusting the probabilities used to weight the scenarios with crashes to estimate annual performance. Since the clustering is not guaranteed to produce clusters that are composed exclusively of crashes or no crashes, the TTI team must deal with mixed clusters, separating out the days with crashes from those without crashes within each cluster. The average VHT for each cluster is a mix of crash and non-crash periods. The average VHT is computed separately for the crash times and the non-crash times within each scenario cluster. The average VHT for each cluster is then recomputed using the Volpe Center's estimated reductions in crash frequencies for the given CV market level. The new crash and non-crash probabilities are applied to the average VHTs for crash days and non-crash days, and the results are combined into a new estimate of average VHT for each cluster.

Extrapolation of System Results to Whole-Year Results

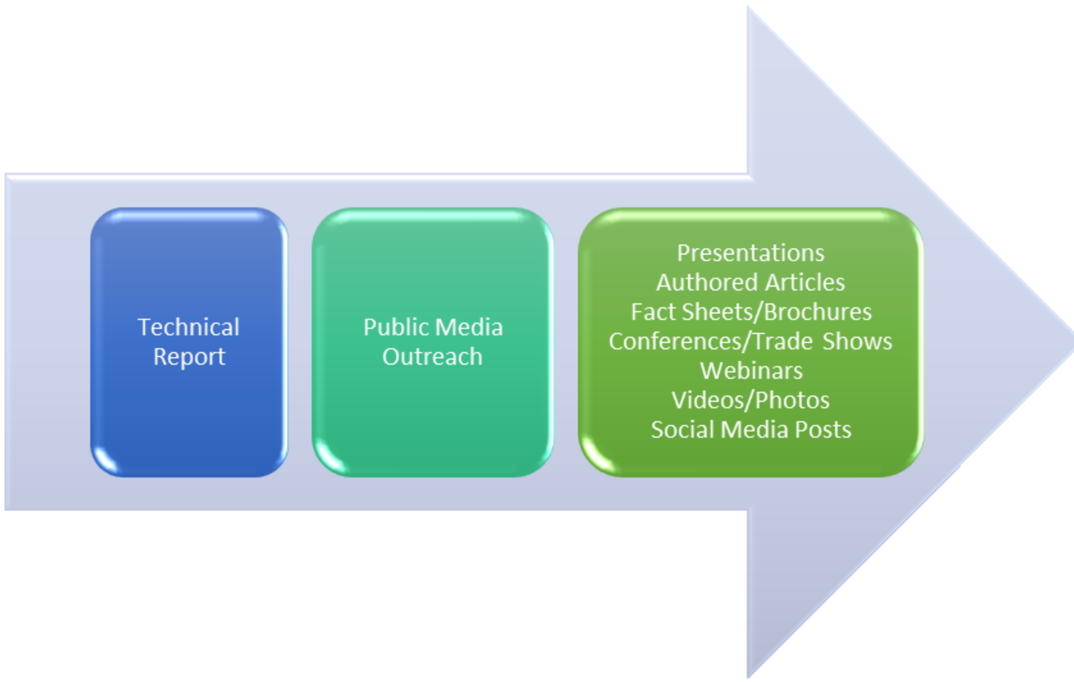
Once the TTI CVPD Evaluation Team has completed the analysis of each operational scenario, the team will extrapolate the result to estimate the system performance for the whole year. The key is to associate each set of integrated operational conditions with a specific future probability for the whole year. The team will accomplish this by examining the cluster data to determine the number of days that the specific integrated operational condition was observed to occur in that cluster for the before and after deployment periods for the site.

Since the pre- and post-deployment periods will probably not cover a full year, the observed probabilities for these periods will be expanded to full-year probabilities. A full year of hourly demands will be gathered from one or more selected permanent count stations representative of the site. A full year of archived crash data will be gathered from agency archives. A full year of weather data will be gathered from a nearby airport. The data by time and day will then be used to construct a full year's worth of daily operational conditions for the site. The TTI team will aggregate weather and traffic data to 15-minute intervals. The full year's probability for each cluster will then be computed by dividing the total number of days in each cluster by the total number of days in the year (may be less than 365 days if the analysis focuses only on non-holiday weekdays and may be less than 24-hour days if the analysis focuses only on the peak periods).

Once the annual probabilities are obtained for the clusters used in the simulation runs, the model performance results will be translated into estimates of annual performance by multiplying the average performance observed in the repeated model runs by the estimated annual probability for the integrated operational conditions represented in that scenario.

Chapter 7. Outreach

Throughout the outreach effort, the TTI CVPD Evaluation Team will undertake a comprehensive outreach process that ensures that each target audience group is exposed to the research results in various formats. The *Connected Vehicle Pilot Deployment Program Independent Evaluation: Outreach Plan* (*14*) describes the process that TTI plans to follow to provide outreach on the analysis status and results. This process, displayed in figure 2, begins with the development of a technical report, follows with public media outreach, and expands to include the variety of outreach products listed in table 7.



Source: Texas A&M Transportation Institute

Figure 2. Proposed Outreach Process.

The TTI CVPD Evaluation Team will work closely with the CVPD Outreach Roundtable Team to coordinate efforts on an ongoing basis to ensure specific activities are complementary and not duplicative in nature. The TTI team will develop a master outreach calendar, inventory of resources available and under development, and list of specific outreach activities underway or planned by the team, sharing these documents with the Outreach Roundtable Team and providing updates during the regularly scheduled meetings.

Table 7. Outreach Methods.

Method	Frequency	Primary Purpose	Dissemination
Technical Reports	Throughout project	Promote project results Share information	Post on website Press releases
Authored Articles	Throughout project	Promote project results Share information	Post on website Press releases
Presentations	Throughout project	Provide inputs to other outreach deliverables such as brochures, website, social media posts, etc.	Post on website Webinars Conferences Trade shows
Conferences	As available	Promote project visibility Share information	Post on website after event
Trade Shows	As available	Promote project visibility Share information	Post on website after event
Webinars	Timed with key evaluation reports	Determined by USDOT	Attendees will be dependent on webinar focus
Videos	Throughout project	Provide project explanation and benefits	Post on website Press conferences Conferences Trade shows
Photos	Throughout project	Use for all other outreach efforts	May need approval prior to use
Fact Sheets	Timed with key evaluation reports	Help ensure consistent message through all outreach	Conferences Trade shows Handouts at meetings, events, etc.
Brochures	Timed with key evaluation reports	Help ensure consistent message through all outreach	Conferences Trade shows Handouts at meetings, events, etc.
Articles	Throughout project	Share consistent message	Website Handouts at meetings, events, etc.
Press Releases	Timed with key evaluation reports	Provide public education on CVPD purpose and outcomes	All press releases will be shared with USDOT prior to release
Local Press	Timed with key evaluation reports	Provide public education on CVPD purpose and outcomes	Will use the local media channels to handle all information requests from local press

Method	Frequency	Primary Purpose	Dissemination
National Press	Timed with key evaluation reports	Provide public education on CVPD purpose and outcomes	Will use the local media channels to handle all information requests from national press
Social Media Posts	Post progress Post scheduled events	Increase project presence and visibility with Facebook, Twitter, YouTube, etc.	Produce spontaneous, unplanned content as needed
Website	Content update at each project milestone	Serve as main point for project information dissemination	—
	Frequent updates for project news, upcoming events, and status	Inform all stakeholders and interested parties	

— No data.
Source: Texas A&M Transportation Institute (*14*).

The TTI CVPD Evaluation Team will work with the Federal Highway Administration (FHWA) to organize a series of webinars throughout the course of the evaluation project to disseminate research results to a broad stakeholder audience. The TTI team anticipates that FHWA will host the webinars through either internal means or external collaborative relationships with ITS America per its contract with the Intelligent Transportation Systems Joint Program Office (ITS JPO) to host webinars. The TTI team will be responsible for delivering the webinars. The webinars will be recorded and posted on the evaluation project website for those who may have missed the live version. Webinars will be publicized through the website, e-newsletter, conferences, trade shows, and other products and distribution methods described in this outreach plan.

Chapter 8. Detailed Evaluation Cost Estimate

Table 8 provides a cost breakdown for each of the major work activities. For this assessment, the TTI CVPD Evaluation Team divided the entire planned independent evaluation into a series of precursor and analysis activities. The precursor activities involve work effort that must be completed before the analysis activities begin. Precursor activities include tasks such as preparing data sets, conducting a cluster analysis, and preparing the models for execution. Analysis activities include work efforts such as analyzing the field data, performing a modeling analysis of identified operational scenarios, performing benefit-cost analyses, and so forth. The TTI team then estimated the costs associated with completing each activity and analysis.

Table 9 provides the value/risk cost assessment for the analysis tasks of the independent evaluation of the NYC CVPD. The Appendix provides the justifications associated with the value and risk scores associated with each work activity.

The TTI CVPD Evaluation Team assigned a value and risk score to each analysis activity. Scores ranged from 1 to 5, with 5 being the highest value/risk, for each risk and value. The TTI team assigned a value score based on how critical the activity is expected to be to the independent evaluation, considering the nature of the analysis, the potential observability of the results, and the scope and extensibility of the analysis. High value scores indicate that the analyses are essential to the overall assessment of the deployment. The TTI team also assigned a risk score for each analysis activity. Risk scores represent the TTI team's opinions about level of uncertainty associated with an analysis activity. Risk scores reflect the overall level of difficulty, availability of data, and potential issues associated with performing the analysis. High risk values represent activities that have a high risk associated with them.

The TTI CVPD Evaluation Team then computed a weighted score for each analysis activity by dividing the value score by the risk score. The TTI team plans to use the weighted value/risk score to prioritize and manage the work activities throughout the analysis period, with activities receiving high value/risk scores being completed first and activities receiving lower value/risk scores being performed based on the availability of funds.

Table 8. Estimated Cost Breakdown of Work Activities for the Independent Evaluation of the NYC CVPD.

ID	Task	Task Type	Precursor Task(s)	Cost
10	**Project Management**	**Precursor**	**None**	**$118,108**
11	Project Administration[1]	Precursor	None	$70,498
12	Coordination with FHWA	Precursor	None	$9,916
13	Internal Coordination	Precursor	None	$14,348
14	Site Visit[2]	Precursor	None	$23,346
20	**Data Preparation[3]**	**Precursor**	**None**	**$13,501**
30	**Support Safety Analysis**	**Precursor**	**None**	**$59,931**
31	Data Analysis	Precursor	20	$26,679
32	Safety Data Collection	Precursor	None	$33,252
50	**Perform Cluster Analysis—NYC CVPD**	**Precursor**	**20**	**$161,014**
51	Cluster Analysis—Pre-Deployment	Precursor	20	$71,663
52	Cluster Analysis—Post-Deployment	Precursor	20	$89,351
60	**AMS Model Prep**	**Precursor**	**50**	**$48,687**
61	Software Site License	Precursor	50	71,550
62	Model Prep—Midtown[4]	Precursor	61	$29,212
63	Model Prep—Flatbush[4]	Precursor	61	$19,475
64	Software Annual Renewal (1 yr)	Precursor	61	28,620
100	**Mobility—Speed Compliance**	**Analytical—Observed**	**50**	**$30,353**
110	Mobility—Curve warning	Analytical—Observed	50	$15,117
120	Mobility—Work Zones	Analytical—Observed	50	$15,117
200	**Mobility—Travel Reliability**	**Analytical—Observed**	**50**	**$121,413**
210	Mobility—Travel Reliability—Midtown	Analytical—Observed	50	$98,648
220	Mobility— Travel Reliability—Flatbush	Analytical—Observed	50	$22,765
300	**AMS—Mobility Impact of Crash Reduction**	**Analytical—Observed**	**50**	**$214,409**
310	Mobility—Crash Reduction—Midtown	Analytical—Observed	50	$119,973
320	Mobility— Crash Reduction—Flatbush	Analytical—Observed	50	$94,436

ID	Task	Task Type	Precursor Task(s)	Cost
500	**AMS-Market Penetration Analysis**	**Analytical—Modeled**	**50, 62**	**$98,958**
510	AMS-Market Penetration—Midtown (3 levels)	Analytical—Modeled	50, 62	$49,479
520	AMS-Market Penetration—Flatbush (3 levels)	Analytical—Modeled	50, 62	$49,479
600	**Environment Assessment**	**Analytical—Modeled**	**300–400**	**$31,616**
610	Environment—Midtown	Analytical—Modeled	300	$23,712
620	Environment—Market Penetration	Analytical—Modeled	400	$7,904
700	**Public Agency Efficiency (PAE) Assessment**	**Analytical—Survey**	**20**	**$45,063**
710	PAE—Logs	Analytical—Survey	20	$45,063
720	PAE—Stakeholder Perspectives*	Analytical—Survey	20	$—
800	**Benefit-Cost Analysis (BCA)**	**Analytical—Computed**	100–600	**$33,382**
810	BCA—Deployment	Analytical—Computed	100–600	$22,032
820	BCA—Market Penetration	Analytical—Computed	500	$11,350
1000	**End User Survey***	**Analytical—Survey**	20	**$—**
1010	End User Survey—Mobility*	Analytical—Survey	20	$—
1020	End User Survey—Technology*	Analytical—Survey	20	$—
1200	**Lesson Learned**	**Analytical—Survey**	**20**	**$45,325**
1210	Lesson Learned5	Analytical—Survey	20	$45,325
1300	**Outreach/Report Preparation**[6]	**Outreach**	**100–1200**	**$33,211**

Total (Precursor Tasks)	**$501,411**
Total (Analysis Tasks)	**$665,411**
TOTAL	**$1,166,492**

* This analysis task will be funded through a separate work order.

[1]This cost includes activities by the whole project team such as participating in Sprint meetings and other activities associated specific to the Wyoming deployment. Task order A supports the PM in performing overall project management activities associated with all the task orders.

[2]The costs assumes one site visit for 5 members of the evaluation team, one from each of the major analysis leads for the evaluation. This cost includes both travel costs and salary costs associated with the site visit.

[3]This cost includes the time required to resolve issues associated with the SDC, such as uploading the modeling software in the SDC, working with Volpe to install the appropriate software, etc.

[4]The following costs have been estimated for each scenario: Calibration $25735; baseline model execution = $17934, scenario execution = $17934. This includes multiple iterations (5 random seeds), error checking, and analysis of the results.

[5]This cost assumes that there may be a needed in preparing the final report to bring in lesson learned while doing the evaluation. Examples might include lesson learned about the SDC, data preparation, analysis techniques, etc.

[6]The cost includes the time for preparing, editing, and generating 508-compliant reports for the evaluation. All other outreach efforts in included in Task Order A.

Source: Texas A&M Transportation Institute

Table 9. Value/Risk Assessment of Analysis Activities Associated with Independent Evaluation of NYC CVPD.

ID	Task	Value	Risk	Value/ Risk	Cost	Hypothesis Map
1300	Outreach/Report Preparation	5	1	5	$33,211	Outreach
1210	Lesson Learned	5	2	2.5	$45,325	12. Stakeholder goals met
210	Mobility—Travel Reliability—Midtown	5	2	1.67	$15,581	2. Improve travel reliability
720	PAE—Stakeholder Perspectives*	2	1	2	$—	7. Improved public agency decision-making
810	BCA—Deployment	4	2	2	$22,032	8. Benefits exceed costs
120	Mobility—Speed Compliance—Work Zones	3	2	1.5	$15,177	1. Improve speed compliance
310	AMS—Crash Reduction—Midtown	4	3	1.33	$18,536	3. Reduce impacts of crashes on mobility
220	Mobility—Travel Reliability—Flatbush	4	3	1.33	$22,765	2. Improve travel reliability
1010	End User Survey—Mobility*	3	3	1	$—	10. End user acceptance of impacts
610	Environment—Midtown	2	2	1	$40,471	6. Reduce negative environmental impacts
320	AMS—Crash Reduction—Flatbush	3	4	0.75	$102,910	3. Reduce impacts of crashes on mobility
410	AMS—Market Penetration—Midtown	3	4	0.75	$49.479	4, 5. Market penetration (equipped, uneq.)
1020	End User Survey -- Technology*	3	4	0.75	$—	11. End user acceptance of technology
110	Mobility—Speed Compliance—Curve	2	4	0.5	$15,177	1. Improve speed compliance
420	AMS-Market Penetration -- Flatbush	2	4	0.5	$49.479	4, 5. Market Penetration (equipped, uneq.)
710	PAE – Logs	2	4	0.5	$45,063	7. Improve public agency decision-making
820	BCA - Market Penetration	2	5	0.5	$11,350	8. B/C Changes with market penetration
620	Environment—Flatbush`	1	2	0.5	$7,904	6. Reduce negative environmental impacts
Total (Analysis Tasks)		**$768,487**				

* Analysis activity funded through a different task order.
Source: Texas A&M Transportation Institute

Chapter 9. Risks and Uncertainties

The TTI CVPD Evaluation Team has identified the potential confounding factors and risks that may affect the evaluation of the NYC CVPD. This section discusses key risks and uncertainties that may impact the evaluation effort.

Potential confounding factors include the following:

- Variations in vehicular and pedestrian travel demands.
- Potential major weather events occurring during the evaluation period.
- Major accidents and special events occurring in the deployment corridors.
- Unusually high or low frequencies of crashes or incidents.
- Changes in economic conditions, either locally or nationally.
- Changes in fuel prices.
- Major planned reconstruction of 6th Avenue.
- Ridesharing programs impacting taxi utilization.
- Changes in Transit Routes and Schedules.
- Implementation of other Vision Zero Projects.

Major risks to the independent evaluation include the following:

- Intentional obfuscation of CV data may limit usefulness of data.
- Ongoing maintenance of the devices and applications.
- Technical capabilities of equipment in dense urban environment.
- Data limitation for safety analysis.
- Insufficient CV traveling in the downtown area to influence mobility.
- Participant attrition.

The *Connected Vehicle Pilot Deployment Program Independent Evaluation Team: Mobility, Environment, and Public Agency Efficiency Refined Evaluation Plan—New York City* (*4*) identifies actions that the TTI CVPD Evaluation Team can implement, in concert with the NYC CVPD Team, to avoid, control, or mitigate these risks. These are the minimum confounding factors and risks; additional ones may arise at later stages of the evaluation. Thus, confounding factors and risks should be identified and assessed at the outset of the evaluation effort and tracked throughout the project.

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Appendix. Initial Value/Risk Assessment Scores

This appendix provides the justifications for the scores that the TTI CVPD Evaluation Team assigned to assess the values and risks for each major work activity proposed in the independent evaluation. The scores are intended to provide an initial weighting to the analysis and may change as work progresses in Phase II of the independent evaluation.

110—Mobility—Speed Compliance Curve

Directly related to hypothesis #1: Speed compliance increases (max speed).

<u>Value</u>		*Score: 2*
Nature:	Quantitative assessment.	
Observability:	Assessments based on observed data for the most part.	
Scope:	Limited to specific locations.	
Extensibility:	Goal is to be generalized to determine if these applications should be broadly applied	

<u>Risk</u>		*Score: 4*
Traffic Data:	Unknown as to the extent that this is an issue.	
Curve Data:	Only issue for limited vehicle types (trucks).	

120—Mobility—Speed Compliance in Work Zones

Directly related to hypothesis #1: Speed compliance increases (max speed).

<u>Value</u>		*Score: 2*
Nature:	Quantitative assessment.	
Observability:	Assessments based on observed data for the most part.	
Scope:	Comprehensive assess—covers most of the entire project	
Extensibility:	Goal is to be generalized to determine if these applications should be broadly applied.	

<u>Risk</u>		*Score: 2*
Traffic Data:	Low risk as agencies likely to have good traffic data (speed, travel time, throughput, queue delay).	
Work Zone Data:	Unknown the extent of work zones in evaluation corridor. Many unreported temporary work zones	

210— Mobility—Travel Reliability—Midtown

Directly related to hypothesis #2: Observed mobility improvements (queue, delay, travel time speeds and throughput).

<u>Value</u>	*Score: 5*
Nature:	Quantitative assessment.
Observability:	Assessments based on observed data for the most part.
Scope:	Comprehensive assessment—covers most of the entire project.
Extensibility:	Goal is to be generalized to determine if these applications should be broadly applied.

<u>Risk</u>	*Score: 2*
Traffic Data:	Moderate risk that agencies will not have all traffic data for analysis.

200—Mobility—Travel Reliability—Flatbush

Directly related to hypothesis #2: Observed mobility improvements (queue, delay, travel time speeds and throughput).

<u>Value</u>	*Score: 4*
Nature:	Quantitative assessment.
Observability:	Assessments based on observed data for the most part.
Scope:	Comprehensive assessment—covers most of the entire project.
Extensibility:	Goal is to be generalized to determine if these applications should be broadly applied.

<u>Risk</u>	*Score: 2*
Traffic Data:	Moderate risk that agencies will not have all traffic data for analysis.

310—Mobility—Crash Reduction—Midtown

Directly related to hypothesis #3: Observed mobility improves due to crash frequency reduction.

<u>Value</u>	*Score: 4*
Nature:	Quantitative assessment.
Observability:	Assessments based on simulated crash reductions.
Scope:	Comprehensive assessment—covers most of the entire project.
Extensibility:	Goal is to be generalized to determine if these applications should be broadly applied.

<u>Risk</u>	*Score: 3*
Traffic Data:	Low risk that agencies will have good traffic data (speed, travel time, throughput, queue, delay). Data may be incomplete.
Crash Data:	Medium risk as crash data may be incomplete (due to underreporting) and CV location data may not be correlated to traffic or crash data locations due to obfuscation.
Calibration Data	Medium risk as CV location data may not be correlated to traffic or crash data locations due to obfuscation.

320—Mobility— Crash Reduction—Flatbush

Directly related to hypothesis #3: Observed mobility improves due to crash frequency reduction.

Value	*Score: 3*
Nature:	Quantitative assessment.
Observability:	Assessments based on simulated crash reductions.
Scope:	Comprehensive assessment—limited to Flatbush
Extensibility:	Goal is to be generalized to determine if these applications should be broadly applied.

Risk	*Score: 4*
Traffic Data:	Moderate risk that agencies will not have good traffic data (speed, travel time, throughput, queue, delay). Data may be incomplete.
Crash Data:	Medium risk as crash data may be incomplete (due to underreporting) and CV location data may not be correlated to traffic or crash data locations due to obfuscation.
Calibration Data	Medium risk as CV location data may not be correlated to traffic or crash data locations due to obfuscation.

410—AMS—Market Penetration—Midtown

Directly related to hypothesis #4: Increased market penetration will decrease queues, delays, and increase vehicle throughput and travel time reliability [for CVs]. #5: Increased market penetration will improve #4 mobility benefits for non-CVs.

Value	*Score: 3*
Nature:	Quantitative assessment but based on simulation.
Observability:	Assessments based on simulated and predicted data.
Scope:	Comprehensive assessment—covers most of the entire project.
Extensibility:	Goal is to be generalized to determine if these applications should be broadly applied.

Risk	*Score: 4*
Traffic Data:	Low risk since agencies should have excellent current traffic data (speed, travel time, throughput, queue, delay).
Location Data:	Medium risk since simulation calibration is needed, which would rely on knowing the location of the CVs.
Calibration Data:	Medium risk since CV location data may not be correlated to traffic data locations due to obfuscation.

420— AMS—Market Penetration—Flatbush

Directly related to hypothesis #4: Increased market penetration will decrease queues, delays, and increase vehicle throughput and travel time reliability [for CVs]. #5: Increased market penetration will improve #4 mobility benefits for non-CVs.

Value	*Score: 3*
Nature:	Quantitative assessment but based on simulation.
Observability:	Assessments based on simulated and predicted data.
Scope:	Comprehensive assessment—covers most of the entire project.
Extensibility:	Goal is to be generalized to determine if these applications should be broadly applied.

Risk *Score: 4*

Traffic Data: Low risk since agencies should have excellent current traffic data (speed, travel time, throughput, queue, delay).

Location Data: Medium risk since simulation calibration is needed, which would rely on knowing the location of the CVs.

Calibration Data: Medium risk since CV location data may not be correlated to traffic data locations due to obfuscation.

610—Environmental Analysis of Project as Delivered

Directly related to hypothesis #6: Observed environmental impacts reduce due to reduction in crashes and increase in speed adherence.

Value *Score: 2*

Nature: Quantitative assessment.

Observability: Assessments based on combination of observed and simulated data for the most part; significant congestion already exists.

Scope: Likely to be small percentage of vehicles.

Extensibility: Because of vehicles where applications are to be deployed, may not be representative of other locations.

Risk *Score: 2*

Fleet Data: Medium risk since agencies should have reasonable fleet data (vehicle type distribution, vehicle age, etc.).

Mobility Data: Will be the same as the risk associated with each input (travel time, crashes, emissions, etc.).

620—Environmental Analysis at Different Market Penetration Rates

Directly related to hypothesis #4: Increased market penetration will reduce emissions [for CVs] and #5: Increased market penetration will reduce emissions for non-CVs.

Value *Score: 1*

Nature: Quantitative assessment.

Observability: Assessments based on simulated and predicted data.

Scope: Comprehensive assessment—covers most of the midtown area where significant volumes exist.

Extensibility: Not extensible beyond limits of Flatbush. Highly dependent on background travel in deployment corridor

Risk *Score: 2*

Fleet Data: Medium risk since agencies should have reasonable fleet data (vehicle type distribution, vehicle age, etc.).

Mobility Data: Will be the same as the risk associated with each input (travel time, crashes, emissions, etc.).

710—Public Agency Efficiency Analysis of Project as Delivered

Directly related to hypotheses #1: Improved public agency efficiency and decision making, and #2: Agencies find their SMEP goals were met.

Value	Score: 2
Nature:	Qualitative assessment.
Observability:	Assessments based on observed data such as response times; quality of data suspect, though.
Scope:	Comprehensive assessment—unknown coverage area, coverage area may not be representative.
Extensibility:	Only applicable to NYC deployment.

Risk	*Score: 4*
Observed Data:	Sites may not have level of data needed to support assessment.
Survey Data:	High likelihood that data not collected by sites; agency responses and associated event conditions not collection.

720—Public Agency Efficiency Analysis of Project as Delivered (Stakeholder Perspective)

Directly related to hypothesis #7: Improved public agency efficiency and decision making, and #12: Agencies find their SMEP goals were met.

Value	*Score: 2*
Nature:	Qualitative assessment based on log data (reductions in detection times, changes in response times, etc.).
Observability:	Assessments based on survey data for the most part.
Scope:	Comprehensive assessment—covers most of the entire project.
Extensibility:	Goal is to be generalized to determine if these applications should be broadly applied.

Risk	*Score: 1*
Survey Data:	Low risk since survey data should be easily collected from site agency participants.
Observed Data:	Medium risk associated with the reliability and thoroughness of reported agency responses and associated event conditions.

810—Benefit-Cost Analysis of Project as Delivered

Directly related to hypothesis: Benefits exceed costs.

Value	*Score: 4*
Nature:	Quantitative assessment.
Observability:	Assessments based on combination of observed data for the most part, augmented by simulation data.
Scope:	Comprehensive assessment—covers most of the entire project.
Extensibility:	Goal is to be generalized to determine if these applications should be broadly applied.

<u>Risk</u> *Score: 2*

Cost Data: Low risk since agencies should have excellent current costs and reasonable predictions of future costs.

Benefit Data: Will be the same as the risk associated with each input (travel time, crashes, emissions, etc.).

820—Benefit-Cost Analysis at Different Market Penetration Rates

Directly related to hypothesis: B/C changes with market penetration.

<u>Value</u> *Score: 2*

Nature: Quantitative assessment.

Observability: Assessments based on simulated and predicted data.

Scope: Comprehensive assessment—covers most of the entire project.

Extensibility: Goal is to be generalized to determine if these applications should be broadly applied.

<u>Risk</u> *Score: 4*

Cost Data: Medium risk since agencies should have excellent current costs and reasonable predictions of future costs and costs for more/less penetration.

Benefit Data: Will be similar as the risk associated with each input (travel time, crashes, emissions, etc.) but even higher since these are predictions for CV penetration rates that do not exist.

1010—End User Satisfaction Analysis (Mobility)

Directly related to hypothesis #10: End users are satisfied with deployment impacts on travel, and #11: End users are satisfied with performance of CV devices.

<u>Value</u> *Score: 3*

Nature: Qualitative assessment.

Observability: Assessments based on survey data for the most part.

Scope: Comprehensive assessment—covers most of the entire project.

Extensibility: Goal is to be generalized to determine if these applications should be broadly applied.

<u>Risk</u> *Score: 3*

Survey Data: Medium risk since survey data may not be easily collected from all public participants or may be reported by fleet managers rather than individual drivers.

Observed Data: Medium risk associated with the reliability and thoroughness of reported agency responses and associated event conditions.

1020—End User Satisfaction Analysis (Technology)

Directly related to hypothesis #11: End users are satisfied with performance of CV devices.

<u>Value</u> *Score: 3*

Nature: Qualitative assessment.

Observability: Assessments based on survey data for the most part. Deployment limited to audible alerts only.

Scope: Comprehensive assessment—covers most of the entire project.

Extensibility: Goal is to be generalized to determine if these applications should be broadly applied. Deployment limited to audible alerts only.

Risk	*Score: 4*
Survey Data:	Medium risk since survey data may not be easily collected from all public participants or may be reported by fleet managers rather than individual drivers.
Observed Data:	Medium risk associated with the reliability and thoroughness of reported agency responses and associated event conditions.

1210—Lesson Learned

Value is assessed based on task relationship to hypotheses—important to capture for other deployments.

Value	*Score: 5*
Nature:	Qualitative assessment.
Observability:	Assessments based on survey data for the most part.
Scope:	Comprehensive assessment—covers most of the entire project.
Extensibility:	Goal is to be generalized to determine if these applications should be broadly applied.

Risk	*Score: 2*
Survey Data:	Medium risk as survey data may not be easily collected from all public participants or may be reported by fleet managers rather than individual drivers.
Observed Data:	Medium risk associated with the reliability and thoroughness of reported agency responses and associated event conditions.

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