



CONNECTED VEHICLE PILOT Deployment Program



Performance Measurement and
Evaluation Support Plan
New York City



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ITS Joint Program Office



TODAY'S AGENDA



- Purpose of this Webinar
 - To share the Performance Measurement and Evaluation Support plan from the New York City pilot with the stakeholders of connected vehicle technologies.

- Webinar Content
 - Connected Vehicle Pilot Deployment Program Overview
 - New York City Performance Measurement and Evaluation Support Plan
 - Stakeholder Q&A
 - How to Stay Connected

- Webinar Protocol
 - Please mute your phone during the entire webinar
 - You are welcome to ask questions via chatbox at the Q&A Section
 - The webinar recording and the presentation material will be posted on the CV Pilots website





CONNECTED VEHICLE PILOT DEPLOYMENT PROGRAM

PROGRAM GOALS



PILOT SITES



ICF/Wyoming DOT



NYCDOT



Tampa (THEA)

STAY CONNECTED

- Participate in Concept Development Phase Webinars for the three Pilot Sites (see website for exact dates and times)

Feb 2016	Mar 2016	Apr 2016	May 2016	Jun 2016	Jul 2016	Aug 2016
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Concept of Operations Webinars

Performance Measurement Webinars

Comprehensive Deployment Plan Webinars

- Visit Program Website for Updates: <http://www.its.dot.gov/pilots>
- Contact: Kate Hartman, Program Manager, Kate.hartman@dot.gov



New York City Performance Measurement and Evaluation Support Plan



- Presentation Overview
 - System Overview
 - Goals and Objectives
 - Performance Measures
 - Confounding Factors
 - Impact Evaluation Design
 - Data Collection Plan
 - Performance Reporting and Data Sharing
 - Next Steps





New York City CV Pilot System Overview

Mohamad Talas,

NYC CV Pilot Site Program Management Lead



NYC Primary Focus: *SAFETY*



- New York City is aggressively pursuing its “Vision Zero” initiative:

“Traffic Death and Injury on City streets is not acceptable”

Vision Zero Goal : to eliminate traffic deaths by 2024

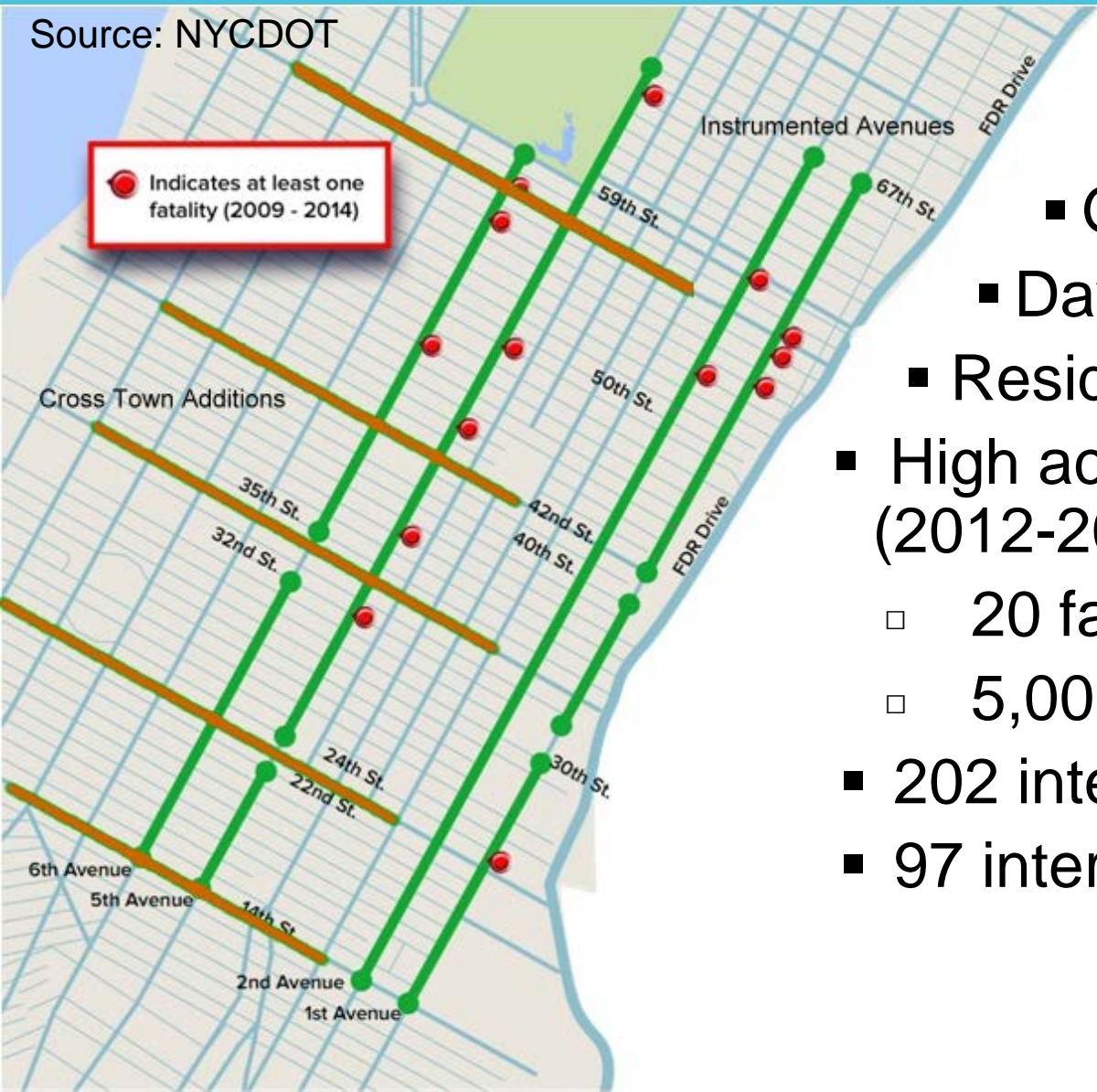
- CV technology is another potential tool for the Vision Zero initiative.
- The project will evaluate the safety benefits and challenges of implementing CV technology with a significant number of vehicles in the dense urban environment.



NYC CV Pilot Site: Manhattan – Arterial Grid



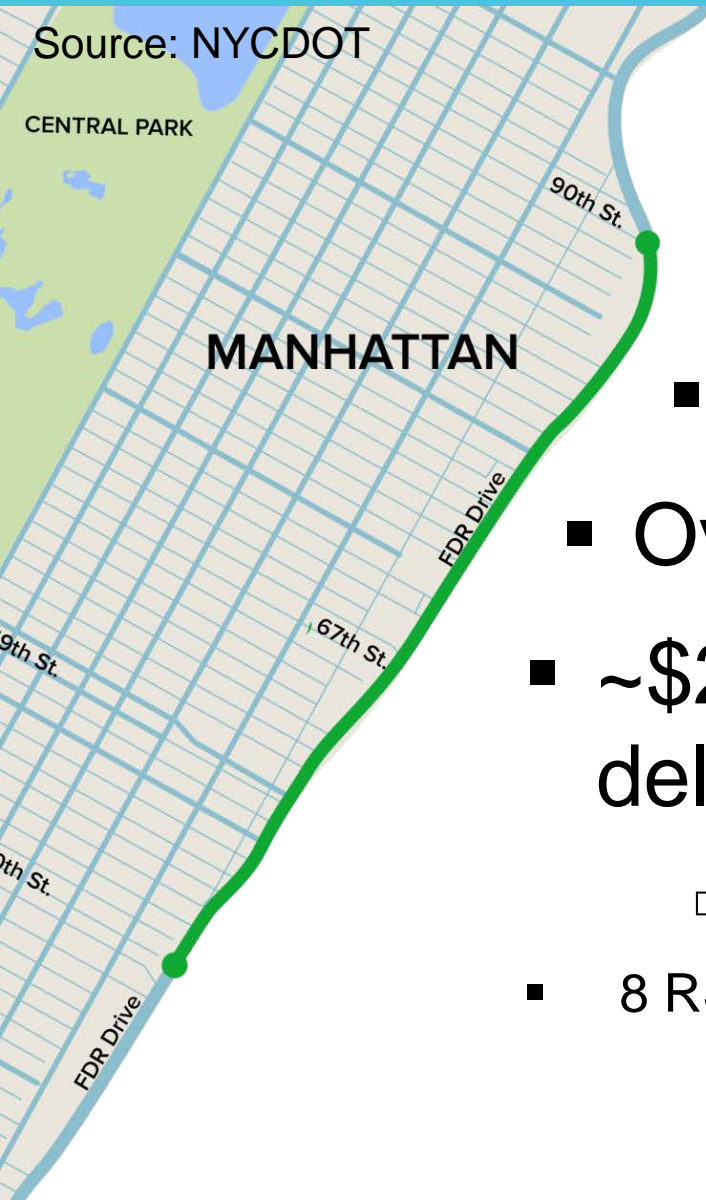
Source: NYCDOT



- Grid (600' x 250')
- Day vs. Night conditions
- Residential/commercial mix
- High accident rate arterials (2012-2014)
 - 20 fatalities
 - 5,007 injuries
- 202 intersections – **avenues**
- 97 intersections – **cross town**



NYC CV Pilot Site: Manhattan - FDR Drive Freeway



- Limited access highway
- Excludes trucks/buses
- Short radius curves
- Over-Height restrictions
- ~\$2M in Over-Height incident delay costs (2014)
 - 24 % of City-wide total
- 8 RSE locations



NYC CV Pilot Site: Brooklyn – Flatbush Avenue



- Over-Height restrictions
 - Tillary St.
 - Manhattan Bridge
- High accident rate arterial 2012-2014 (red dots)
 - 1,128 injuries
 - 8 fatalities
- Average speed 15 mph (AM inbound)
- 28 intersections



New York City CV Pilot Goals and Objectives

Keir Opie,

NYC CV Pilot Site Task 5 Co-Lead



NYC CV Pilot Goals and Objectives



- Primary Goal:
 - Improving safety through the reduction of vehicle and pedestrian crashes, injuries, and fatalities

- Secondary Goal:
 - Improving mobility and reliability through crash prevention and lower crash severity

- User Needs related to Performance Measurement
 - Maintain privacy of users throughout pilot and data collection
 - No enforcement
 - No driver evaluation



Deployment Objectives



- Deployment of CV Technology in a Dense Urban Environment
 - Up to 10,000 **fleet** vehicles with After Market Safety Devices (ASDs):
 - ~7,500 Taxis (Yellow Cabs)
 - ~1,500 MTA Buses
 - ~500 Sanitation & DOT vehicles
 - ~500 UPS vehicles
 - Pedestrian ASDs ~100 units
 - Roadside Equipment at ~280 Locations
 - ~8 on FDR
 - ~28 on Flatbush
 - ~204 Manhattan
 - ~38 Other locations



Identified Use Cases



1. Manage Speeds
2. Reduce Vehicle to Vehicle Crashes
3. Reduce Vehicle to Pedestrian Crashes
4. Reduce Vehicle to Infrastructure Crashes
5. Inform Drivers of Serious Incidents
6. Provide Mobility Information
7. Manage System Operations



Use Case #1: Manage Speeds



- Encourage safe operations on the city's roadways by:
 - Reducing speeding and increasing adherence to posted speed limits
 - Reducing crashes on sharp reduced speed curves on roadways
 - Improving work zone safety

Improvement Category	NYCDOT Needs	CV Application(s)
Safety, Mobility	Discourage Spot Speeding	Speed Compliance (SPD-COMP)
Safety	Improve Truck Safety	Curve Speed Compliance (CSPD-COMP)
Safety	Improve Work Zone Safety	Speed Compliance / Work Zone (SPDCOMPWZ)



Use Case #2: Reduce Vehicle to Vehicle Crashes



- Reduce the number fatalities and injuries from crashes on NYC's roadways from vehicle to vehicle crashes

Improvement Category	NYCDOT Needs	CV Application(s)
Safety	Reduce Number of Crashes and Reduce Severity of Crashes	Forward Collision Warning (FCW) Emergency Electronic Brake Light (EEBL) Blind Spot Warning (BSW) Lane Changing Warning/Assist (LCW) Intersection Movement Assist (IMA)
Safety	Reduce Crashes at High Incident Locations	Red Light Violation Warning (RLVW)
Safety	Reduce Vehicle to Bus Crashes	Vehicle Turning Right in Front of Bus Warning (VRTW)



Use Case #3: Reduce Vehicle to Pedestrian Crashes



- Reduce the number pedestrian fatalities and injuries from crashes on NYC's roadways from pedestrian-involved crashes

Improvement Category	NYCDOT Needs	CV Application(s)
Safety	Improve Pedestrian Safety and Reduce Pedestrian-Involved Crashes	Pedestrian In Signalized Crosswalk Warning (PEDINXWALK)
Safety	Improve Safety of Visually Impaired Pedestrians	Mobile Accessible Pedestrian Signal System (PED-SIG)



Use Case #4: Reduce Vehicle to Infrastructure Crashes



- Reduce the fatalities and injuries from truck crashes on NYC's roadways with low clearance bridges
- Improve operations created by lengthy clearance times of truck / bridge strike crashes

Improvement Category	NYCDOT Needs	CV Application(s)
Safety, Mobility	Address Bridge Low Clearance Issues & Enforce Truck Routes	Oversize* Vehicle Compliance (OVC) (*overheight only)

Use Case #5: Inform Drivers of Serious Incidents



- Improve safety and mobility for the traveling public through improved information dissemination during serious incidents

Improvement Category	NYCDOT Needs	CV Application(s)
Safety, Mobility	Inform Drivers of Serious Incidents	Emergency Communications and Evacuation Information (EVACINFO)



Use Case #6: Provide Mobility Information



- Collect mobility information from CV technologies and compare to speed and travel time data collection from existing data collection technologies to support NYC's adaptive signal control system

Improvement Category	NYCDOT Needs	CV Application(s)
Mobility	Replace Legacy Data Collection	CV Data for Intelligent Traffic Signal System (I-SIGCVDAT)



Use Case #7: Manage System Operations



- Manage System Operations and ensure proper operations of the NYC CV Pilot system

Improvement Category	NYCDOT Needs	CV Application(s)
System Operations	Ensure Proper Operations of the CV Deployment	RF Monitoring (RFMON) OTA Firmware Update (FRMWUPD) Parameter Up/Down Loading (PARMLD) Traffic Data Collection (TDC) Event History Recording (EVTRECORD) Event History Upload (EVTCOLLECT)





New York City CV Pilot Performance Measures

NYC CV Pilot Performance Measurements



User Need	Category	NYCDOT Needs	CV App.	No.	Performance Measure Metrics	Question for Evaluation
Manage Speeds	Safety, Mobility	Discourage Spot Speeding	Speed Compliance	1a	Number of stops (average and distribution measures)	Does speed limit adherence and speed variability within the vehicle fleet on a given study roadway segment for a given time period (cycle length basis) decrease? Is this accompanied by an overall increase, decrease or no change in average segment speed?
				1b	Speeds (average and distribution measures)	
				1c	Emissions	
				1d	Reduction in speed limit violations	
				1e	Speed variation	
				1f	Vehicle throughput (average and distribution measures)	
				1g	Driver actions and/or impact on actions in response to issued warnings	
	Safety	Improve Truck Safety	Curve Speed Compliance	2a	Speed related crash counts, by severity	Do the number of curve speed violations on each applicable studied roadway segment decrease?
				2b	Vehicle speeds at curve entry	
				2c	Lateral acceleration in the curve	
				2d	Driver actions and/or impact on actions in response to issued warnings	
				2e	Number of curve speed violations at each instrumented location	
	Safety	Improve Work Zone Safety	Speed Compliance / Work Zone	3a	Speed in work zone (average and distribution measures)	Do the number of work zone speed violations on each applicable studied roadway segment decrease?
				3b	Speed variation (distribution) at work zone	
				3c	Number of vehicle speed limit violations in variable speed zone areas	
3d				Work Zone-related crash counts in reduced speed zones, by severity		
3e				Driver actions and/or impact on actions in response to issued warnings		



NYC CV Pilot Performance Measurements



User Need	Category	NYCDOT Needs	CV App.	No.	Performance Measure Metrics	Question for Evaluation
Reduce Vehicle to Vehicle Crashes	Safety	Reduce Crashes	FCW EEBL BSW LCW IMA	4a	Fatality crash counts	Do the number of reportable crashes decrease?
				4b	Injury crash counts	
				4c	Property damage only crash counts	
				4d	Time to Collision (vehicle to vehicle)	
	Safety	Reduce Accidents at High Incident Intersections	Red Light Violation Warning	5a	Red light violation counts	Do the number and severity of red light violations at each studied intersection decrease?
				5b	Red light violation related crash counts, by severity	
				5c	Time To Collision (vehicle to cross vehicle path) at the intersection	
				5d	Driver actions and/or impact on actions in response to issued warnings	
	Safety	Reduce Incidents, Improve Safety	Vehicle Turning Right in Front of Bus Warning	6a	Bus and right turn related crash counts, by severity	Do the number of bus / right turn vehicle crashes decrease?
				6b	Right-turning related conflicts	
				6c	Time to collision (vehicle to bus)	
				6d	Number of warnings generated	
6e				Driver actions and/or impact on actions in response to issued warnings		



NYC CV Pilot Performance Measurements



User Need	Category	NYCDOT Needs	CV App.	No.	Performance Measure Metrics	Question for Evaluation
Reduce Vehicle to Ped Crashes	Safety	Improve Pedestrian Safety	Pedestrian in Signalized Crosswalk Warning	7a	Pedestrian related crash counts, by severity	Do the number of pedestrian related crashes decrease?
				7b	Number of warnings generated	
				7c	Pedestrian-related conflicts/hard braking events	
				7d	Time to collision (vehicle to pedestrian)	
				7e	Driver actions and/or impact on actions in response to issued warnings	
	Safety	Improve Safety of Visually Impaired Pedestrians	Mobile Accessible Pedestrian Signal System (PED-SIG)	8a	Number of pedestrian crossing violation reductions	Do the number of pedestrian related crashes decrease?
				8b	Visually-impaired pedestrian-related crash counts, by severity	
				8c	Conflicts with visually impaired pedestrians	
				8d	Time to collision (vehicle to pedestrian)	
				8e	Waiting time at intersection for crossing	
Reduce Vehicle to Infra. Crashes	Mobility	Bridge Low Clearance & Truck Routes	Oversized Vehicle Compliance	9a	Number of Warnings generated	Do the number of low clearance violations decrease?
				9b	Number of truck route violations	
Inform Drivers Serious Incidents	Mobility	Inform Drivers	EVACINFO	10a	Number of vehicles receiving information when generated	Do CV vehicles receive the information warnings when generated?
Provide Mobility Info	Mobility	Replace Legacy Data Collection	I-SIG CVDATA	11a	Segment speed (average and distribution measures) from CV compared to legacy detection systems	Do the CV based mobility metrics compare favorably to legacy detection systems or provide better information?
				11b	Travel time (average and distribution measures) from CV compared to legacy detection systems	
Manage System Ops	System Operations	Ensure Operations	Several	12a	System performance statistics (system activity, down time, radio frequency monitoring range on ASD's and RSU's, number of event warnings by app)	Does the system operate reliably?





New York City CV Pilot Confounding Factors

NYC CV Pilot Confounding Factors



Confounding Factor	Impact on System Performance	Relative Difficulty to Quantify
Traffic Demand Variations	High	High
Weather	Medium	Low
Accidents and Incidents	Medium	Medium
Traffic Signal Timing Updates	Medium	Low
Work Zones (Short Term or Unplanned)	Medium	High
Work Zones (Long Term or Planned)	Medium	Low
Planned Special Events	High	Low
Economic Conditions	Low	Medium
Fuel Prices	Low	Low
E-Hail and For Hire Vehicles	Medium	Medium
Citi Bike	Low	Low
Changes in Transit – New SBS / BRT Routes	Medium	Medium
Changes in Transit – 2 nd Avenue Subway	High	Medium
Changes in Transit – Canarsie Tube	High	Medium
6 th Avenue Reconstruction	High	Medium
Vision Zero Projects	Medium	Low



NYC CV Pilot Confounding Factors



Confounding Factor	Current Data Available to NYC DOT	Supplemental Data Proposed for CV Pilot
Traffic Demand Variation	Semi-annual, two-week counts at NYC DOT screenlines, bridges and county crossings (coverage of continuous traffic monitoring devices is very limited in the study area) Traffic flow conditions along study corridors from segment travel time information (Midtown in Motion, MTA Bus Time, taxi GPS data)	Deploy continuous count locations
Weather	Central Park Weather station (KNYC) current conditions; snow plow clearing status from Department of Sanitation	Record windshield wiper status
Accidents and Incidents	NYPD Crash Database; including type, vehicle type(s), severity, location and time	None
Signal Retiming	NYC DOT official timing sheets with retiming dates	None
Work Zones (short)	Incident reporting in TRANSCOM OpenReach; work under emergency permits (ConEd, Verizon) not captured	Deploy NYCDOT monitoring vehicle(s)
Work Zones (long)	Incident reporting in TRANSCOM OpenReach; permit database (NYC DOT OCMC)	Deploy NYCDOT monitoring vehicle(s)
Planned Special Events	City Hall Street Activity Permit Office (SAPO) calendar and event details; calendar of street closures (NYPD)	None
E-Hail and For-Hire Vehicles	TLC trips and GPS breadcrumbs, including spatial/temporal routing and activity patterns for all yellow and green taxis	None
Changes in Transit	Project details, extents and implementation dates; ridership data (NYC DOT & MTA)	None
6 th Avenue Reconstruction	Project details, extents and implementation dates (NYC DOT & DDC)	Deploy NYCDOT monitoring vehicle(s)
Vision Zero Projects	Project details, extents and implementation dates for design/safety improvements (NYC DOT); locations and implementation dates of new enforcement measures (NYPD); findings of Years 1 and 2 “after” analyses (City Hall)	None





New York City CV Pilot Impact Evaluation Design

With and Without CV Data Collection



Two Modes of Operation for ASDs

- **Silent Mode** (or Without CV): System fully deployed and operational but **without** user notification of ASD perceived warnings.
 - In silent mode, the ASDs will record normal driver behaviors and reactions during conditions that the ASDs would have issued a warning if active.

- **Active Mode** (or With CV): System fully deployed and operational but **with** user notification of ASD perceived warnings.
 - In active mode, the ASDs will record the normal driver behaviors before the issue of the ASD warning and the modified or revised behavior and actions following that warning.



NYC CV Pilot Impact Evaluation Design Considerations



- Maximize potential for reducing accidents and saving lives
- Maximize market penetration of active CV devices
- Account for nature of fleet operations
 - Regular shifts of drivers between vehicles
- Account for confounding factors

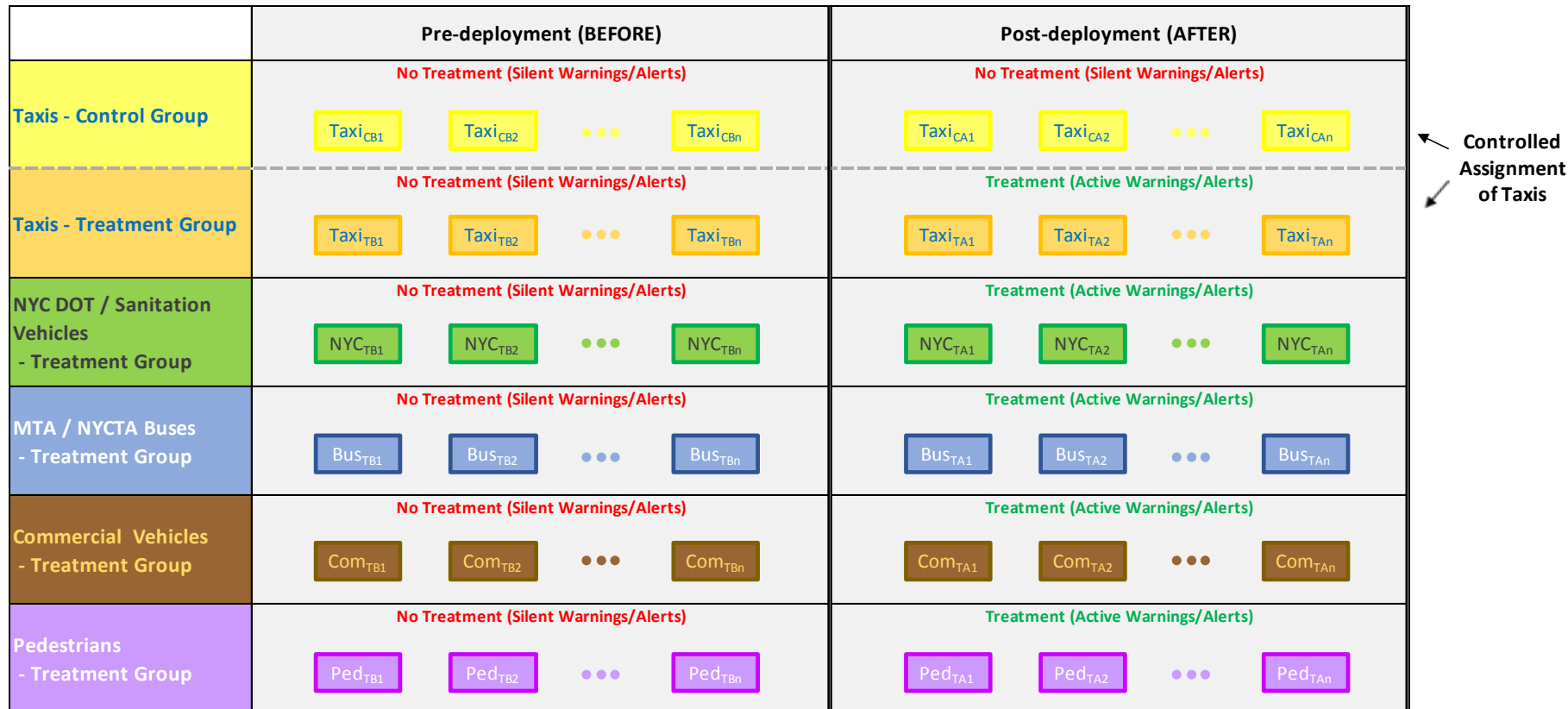
- Considered Options:
 - Before and After - Selected
 - Control and Treatment Groups – Selected for Taxis only



NYC CV Pilot Impact Evaluation Design



Recommended Experimental Design



LEGEND

- CB1, CB2, ..., CBn: BEFORE data collection/measurement for control group
- TB1, TB2, ..., TBn: BEFORE data collection/measurement for treatment group
- CA1, CA2, ..., CAn: AFTER data collection/measurement for control group
- TA1, TA2, ..., TAn: AFTER data collection/measurement for treatment group

↑
Calculate
BEFORE
Perf. Measures

↑
Calculate
AFTER
Perf. Measures



Before and After Comparison of Crash Records



- Traditional before / after comparison of crash records
- Empirical Bayes methods

- Before Period:
 - Extend back to November 7, 2014 (citywide speed limit change) for larger before period
- After Period
 - CV post-deployment (only when treatment group have ASDs in active mode)

- Comparison groups:
 - Complicated by city-wide V2V deployment
 - V2I instrumented vs non-instrumented corridors



Safety Impacts: Safety Surrogate Measures (SSM) Simulations



- Assess changes in driver behavior from CV deployment and estimate changes in risk of crashes

- Small scale very-detailed microsimulations needed building on existing SSM simulation research
 - Customize driver behavior models based on observed changes in driver behavior and reactions from observed ASD datasets
 - Calibration of vehicle movements (trajectory level calibration)

- Multiple simulation scenarios under pre- and post-CV deployment for:
 - Different geometric conditions
 - Confounding factors (demands, weather, etc.)
 - Stochastic Randomness



Non-Safety Impacts: Systemwide Simulation



- Assess impacts on mobility and reliability of reduced number and/or severity of crashes from the CV deployment

- Use the Manhattan Traffic Model (MTM)
 - An Aimsun microsimulation of Midtown Manhattan
 - 14th Street to 66th Street, Hudson River to East River
 - Incorporate changes on mobility from ASD datasets
 - Reduced speeding or speed variation on roadways

- Multiple simulation scenarios under pre- and post-CV deployment for:
 - Multiple types, locations, and severity of crashes
 - Prevented crashes or reduced severity crashes (faster clearance)
 - Assess differences in system user impacts of each scenario
 - Assessment of mobile emissions using simulation outputs



New York City CV Pilot Data Collection Plan

CV Device Based Data Collection



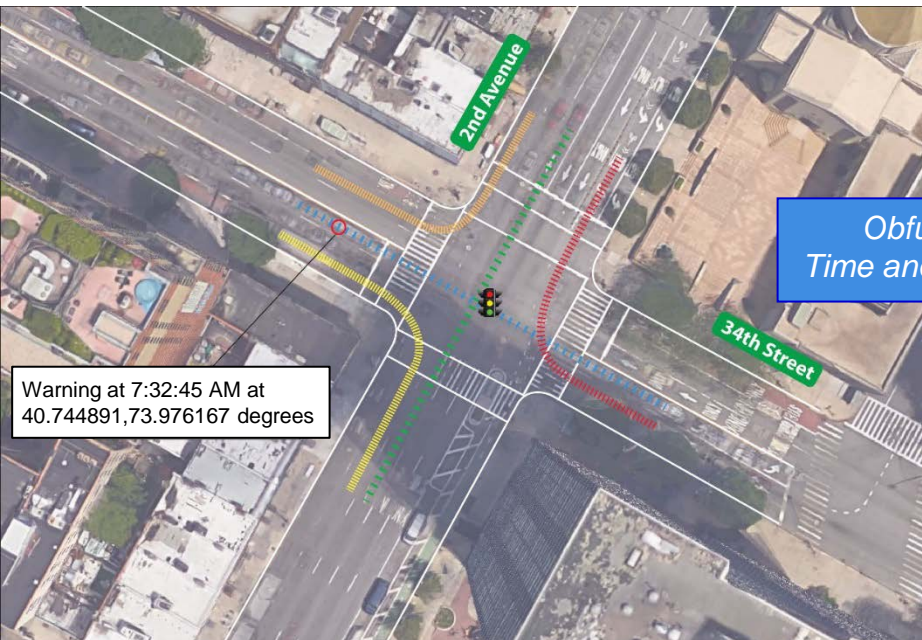
- In-vehicle ASDs:
 - ASD 'Action Log' Datasets
 - 10Hz BSMs from host and nearby vehicles
 - MAP and SPaT messages received by ASD
 - Recorded for time period surrounding an issued warning/advisory/alert (an 'event') from the ASD
 - Preserve time and location anonymity of records: **Obfuscation**
 - ASD Breadcrumb Data
 - Periodic (1-5 second) locations data to calculate speed/travel time data
- Pedestrian ASDs:
 - Details under development
 - Preserve time and location anonymity of records
- Roadside Equipment:
 - RF monitoring
 - ASD data uploads over DSRC



Obfuscation of ASD Action Logs

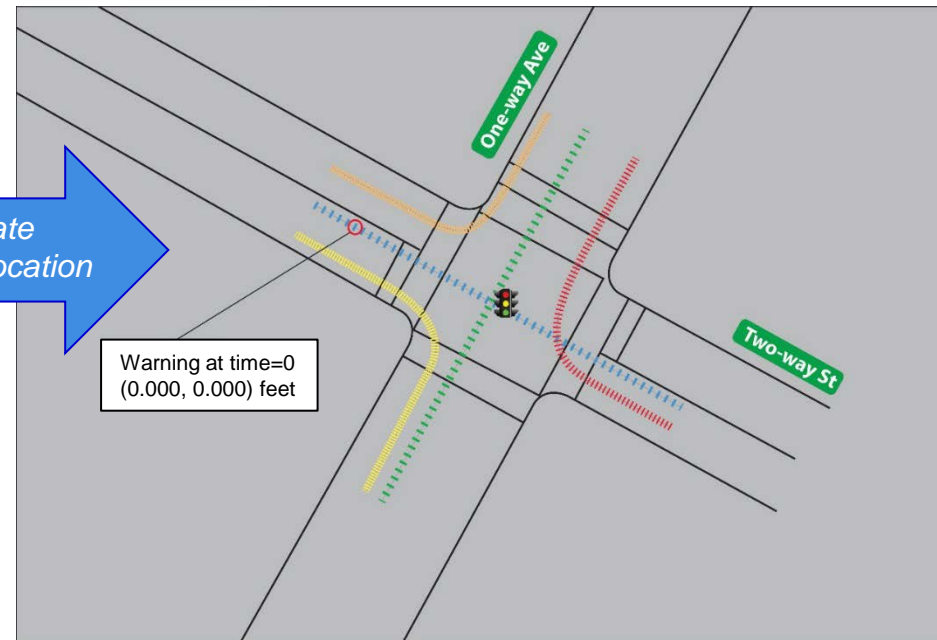


Raw ASD Action Log Data



Obfuscate
Time and Location

Obfuscated ASD Action Log Data



- Obfuscation process to scrub precise time and location data and to represent in bins
- Non-obfuscated data will be destroyed following the obfuscation process

	MAP data
	SPaT data
	Event vehicle
	Nearby vehicle 1
	Nearby vehicle 2
	Nearby vehicle 3
	Nearby vehicle 4



Non-CV Based Data Collection

- Confounding dataset quantifications
 - Real-time
 - Non-real-time

- Crash reports and databases (police report generated)

- Other Mobility Data Collection Sources
 - Volume monitoring
 - Travel time monitoring from Midtown-in-Motion adaptive signals
 - Travel time monitoring from Taxi and Bus GPS-based datasets

- Qualitative Operator/Driver Feedback Surveys



New York CV Pilot Performance Reporting and Data Sharing

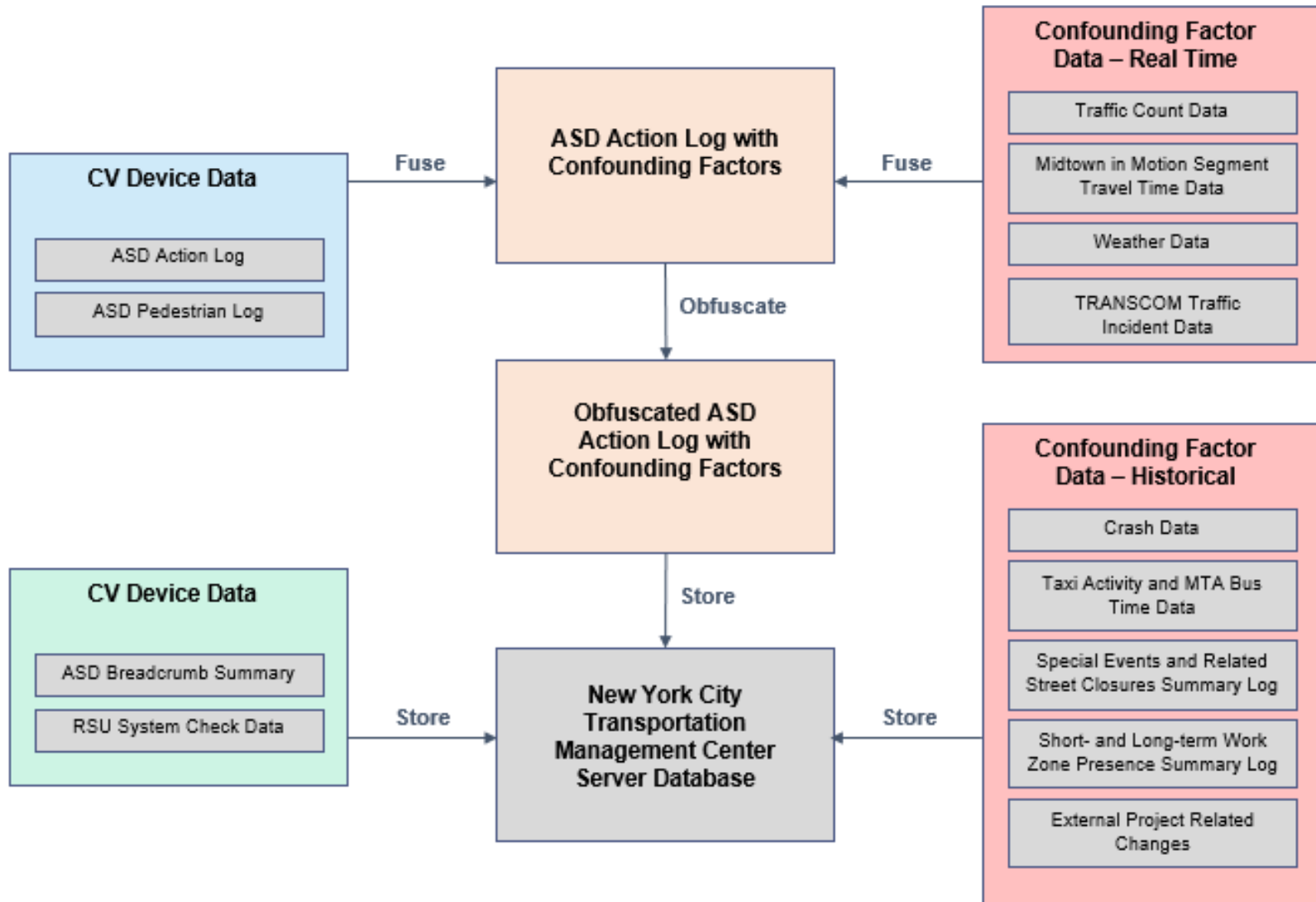
Methods for Evaluating Performance of the CV Deployment



- ASD Action Log Data (10 Hz datasets around events)
- Other CV-based System Data (less than 10 Hz data)
 - Assess changes in driver behavior and actions
 - Before/after comparisons
 - Control/treatment comparisons for taxis
- Non-CV device generated data ('Field Data')
 - Before and After Comparisons of Crash Data
- Simulation Modeling Assessments
 - Safety Surrogate Measures Simulation: Safety benefits
 - System Performance Simulation: Non-safety benefits



Fusion of Confounding Data in Obfuscation Process



Performance Reporting



- Performance Reporting of CV Impacts

- Dashboards of System Performance for DOT and Stakeholders
 - NYCDOT TMC Operators
 - NYCDOT TMC Managers
 - NYCDOT Engineers
 - NYCDOT Decision Makers
 - Stakeholders



Data Sharing



- Obfuscated Data will be shared with USDOT for evaluation by the selected independent evaluator contractor

- Selected subsets of obfuscated data will be uploaded to the Research Data Exchange for research community use
 - Subsets to be reviewed for time and location anonymity first





New York City CV Pilot Next Steps

NYC CV Pilot Next Steps



- Phase 1 Additional Tasks:
 - Finalize System Requirements
 - Develop Deployment Plans
 - Finalize Partnership MOUs
 - Preliminary testing of ASDs and RSEs

- Phase 2 Performance Measures Related:
 - Develop the obfuscation time and location binning protocols
 - Develop the data warehouse and data handling protocols
 - Develop simulation work plans



STAKEHOLDER Q&A



- Please keep your phone muted
- Please use chatbox to ask questions
- Questions will be answered in the order in which they were received



STAY Connected



Contact for CV Pilots Program:

Kate Hartman, Program Manager

Kate.Hartman@dot.gov

Join us for the *Getting Ready for Deployment Series*

- Discover more about the CV Pilot Sites
- Learn the Essential Steps to CV Deployment
- Engage in Technical Discussion



Website: <http://www.its.dot.gov/pilots>

Twitter: [@ITSJPODirector](https://twitter.com/ITSJPODirector)

Facebook:

<https://www.facebook.com/USDOTResearch>

CV Pilot Sites' Performance Measurement Webinars

- 6/6/2016, 2:00 pm – 3:00 pm ET
ICF/WYDOT Performance Measurement Webinar
- 6/6/2016, 3:30 pm – 4:30 pm ET
NYCDOT Performance Measurement Webinar
- 6/7/2016, 12:00 pm – 1:00 pm ET
Tampa (THEA) Performance Measurement Webinar

Please visit the CV pilots website for the recording and the briefing material of the previous webinars.

