CONNECTED VEHICLE PILOT
Deployment Program

New York City Connected Vehicle Performance Highlights

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Agenda

- Project overview
- Fleet description
- Data collection & processing
- Event observations
- Lessons
- Questions?

Program documentation:
https://www.its.dot.gov/pilots/cv_pubs.htm

NYC CV Pilot Deployment Goals

- 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
- Measure System Performance in meeting these goals
  - Data collection system was designed around project performance measures addressing privacy concerns and data collection costs

NYC CV Infrastructure

- Infrastructure: 450 Roadside Units (RSU)
- Vehicles: 3000 (about 200 OBU installs remain)
- Safety applications: 13
- Operations applications: 8
- This is a ***large scale*** deployment with challenges:
  - Location accuracy – urban canyons
  - RSU density
  - Application arbitration/interference
  - DSRC media only – channel management
  - First full-scale security deployment
  - Security boundary expanded to include all ITS communications
- Utilize edge computing concepts to minimize bandwidth

NYC CV Safety Applications

Vehicle-to-Infrastructure (V2I) Pilot Area

- Red Light Violation Warning
- Speed Compliance
- Curve Speed Compliance
- Speed Compliance/Work Zone
- Oversize Vehicle Compliance
  - Prohibited Facilities (Parkways)
  - Over Height
- Vehicle Turning Right in Front of Bus Warning
- Emergency Communications and Evacuation Information (Traveler Information)

Vehicle-to-Vehicle (V2V) Citywide

- Forward Collision Warning
- Emergency Electronic Brake Light
- Blind Spot Warning
- Lane Change Warning/Assist
- Intersection Movement Assist

Pedestrian Applications

- Pedestrian in Signalized Intersection Warning – *to vehicles*
- *Mobile Ped Signal System – Visually Impaired navigation assistance*

Fleet Description

Fleet Description

New York City Pilot (NYCDOT)	Complete	Target
Department of Transportation (DOT)	1,216	1,229
TransCore	1	1
MTA/New York City Transit	11	TBD
Office of Chief Medical Examiner (OCME)	27	52
Parks Dept. (Parks)	275	311
Dept. of Correction (DOC) + Probation	297	297
Dept. of Environmental Protection (DEP)	132	285
DCAS Fleet Share	77	77
TLC Fleet (DCAS)	87	87
Dept. of Homeless Services (DHS)	100	100
Dept. of Design and Construction (DDC)	38	91
Dept. of Buildings (DOB)	69	286
Dept. of Info. Tech. & Telecom. (DOITT)	9	9
Housing Preservation & Development (HPD)	26	55
Dept. of Health (DHMH)	28	58
Administration for Children's Services (ACS)	65	65
Human Resources Administration (HRA)	86	86
Office of Emergency Management (OEM)	12	12
Dept. of Consumer Affairs (DCA)	12	12
Dept. of Education (DOE)	61	47
Anheuser Busch	10	10
MTA Bridges and Tunnels	0	10
NYC TLC Taxis	1	N/A
Total Equipped Vehicles **As of May 31, 2021**	**2,640**	**3,000**

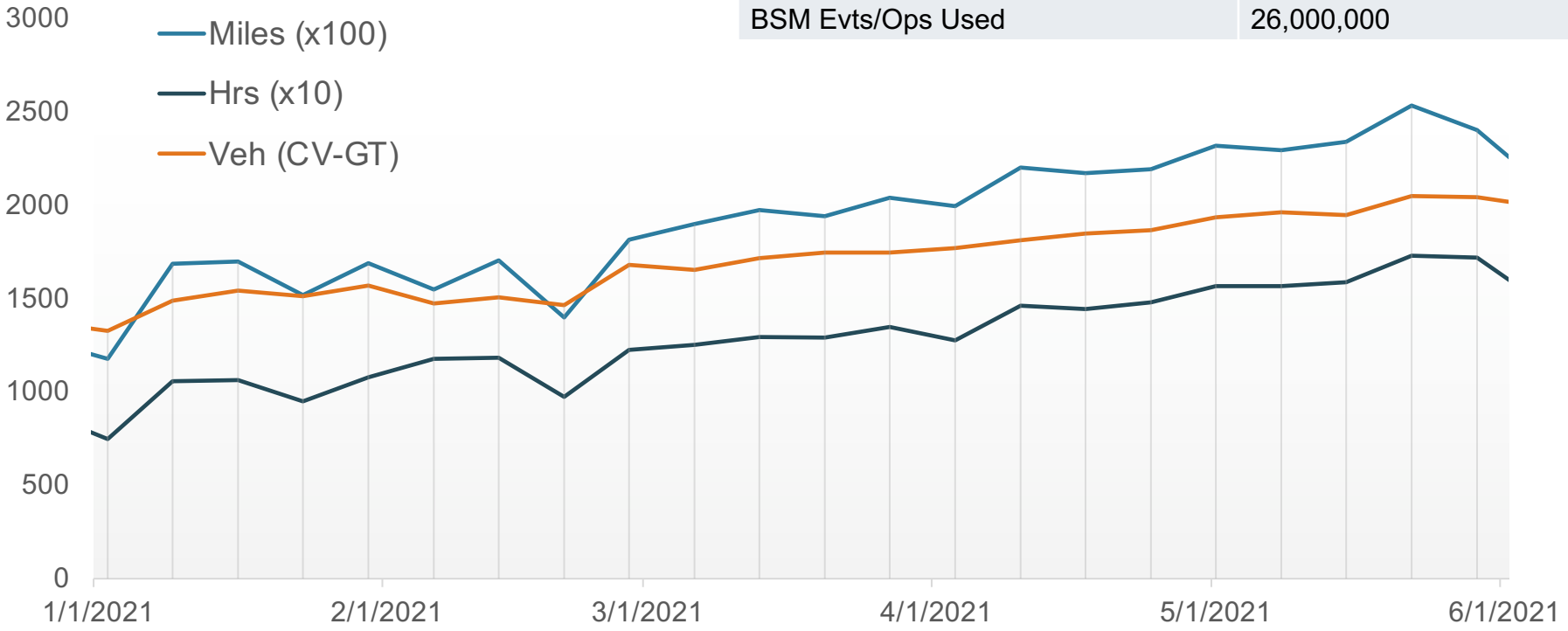
Fleet Description

Vehicle CAN bus interface provides speed data for Dead Reckoning to improve location accuracy

Manufacturer	Models	Years	Range	Quantity
Chevrolet	6	10	2011 – 2020	432
Chrysler	1	1	2019 – 2019	2
Dodge	1	4	2014 – 2017	16
Ford	21	15	2006 - 2021	975
IC Corp	1	7	2009 – 2017	85
International	1	1	2020 – 2020	3
New Flyer	2	2	2017 - 2018	3
Nissan	1	4	2013 – 2017	81
Nova	2	4	2010 – 2019	4
Orion	1	3	2006 – 2009	4
Ram	1	2	2016 - 2017	75
Toyota	7	13	2007 – 2020	959
Total Equipped Vehicles	45		As of May 31, 2021	2,640

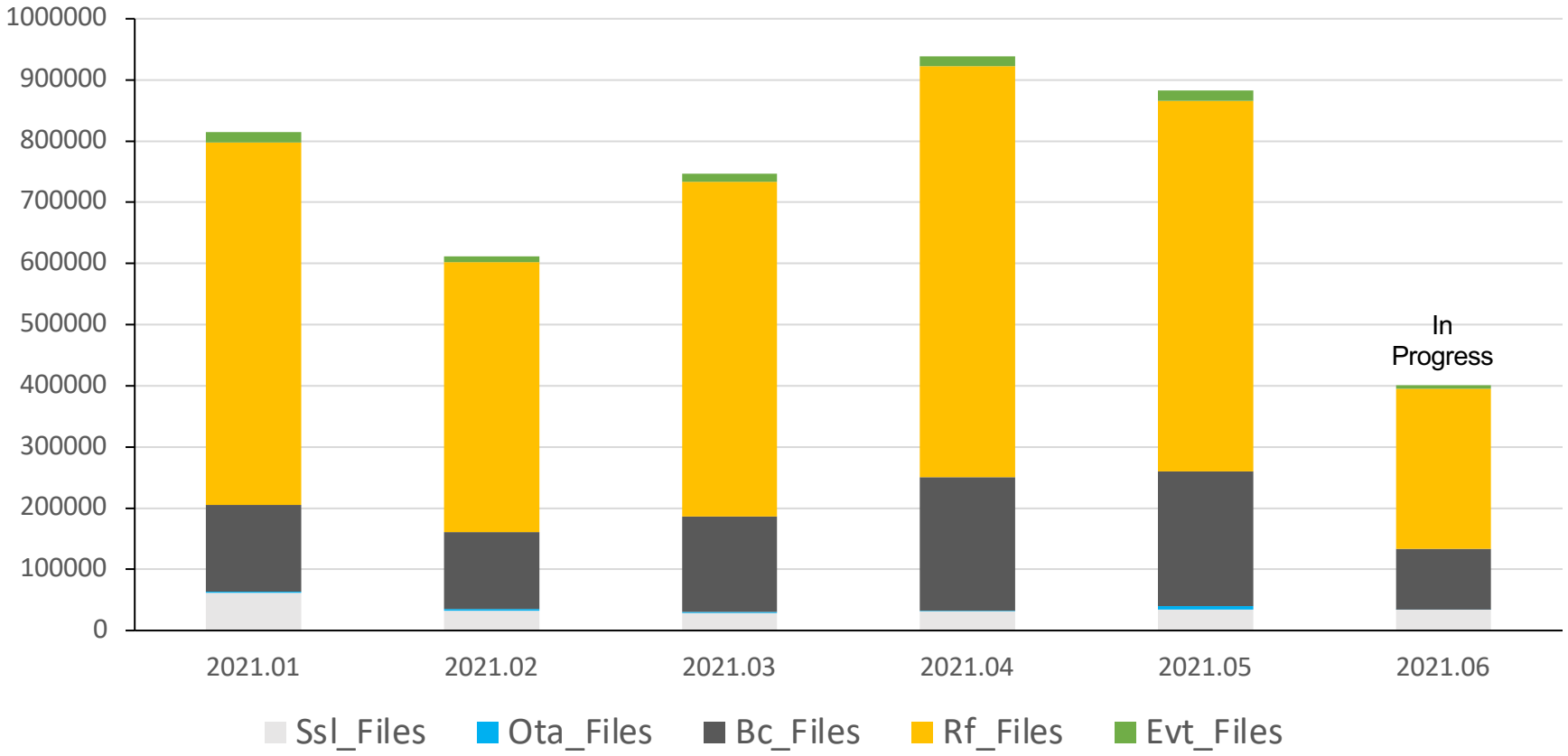
Fleet Weekly Operations

Criteria	Jan 3 – May 29, 2021
VMT	4,138,000
Hrs	277,000
BSM Generated	15,967,000,000
BSM Evts/Ops Used	26,000,000



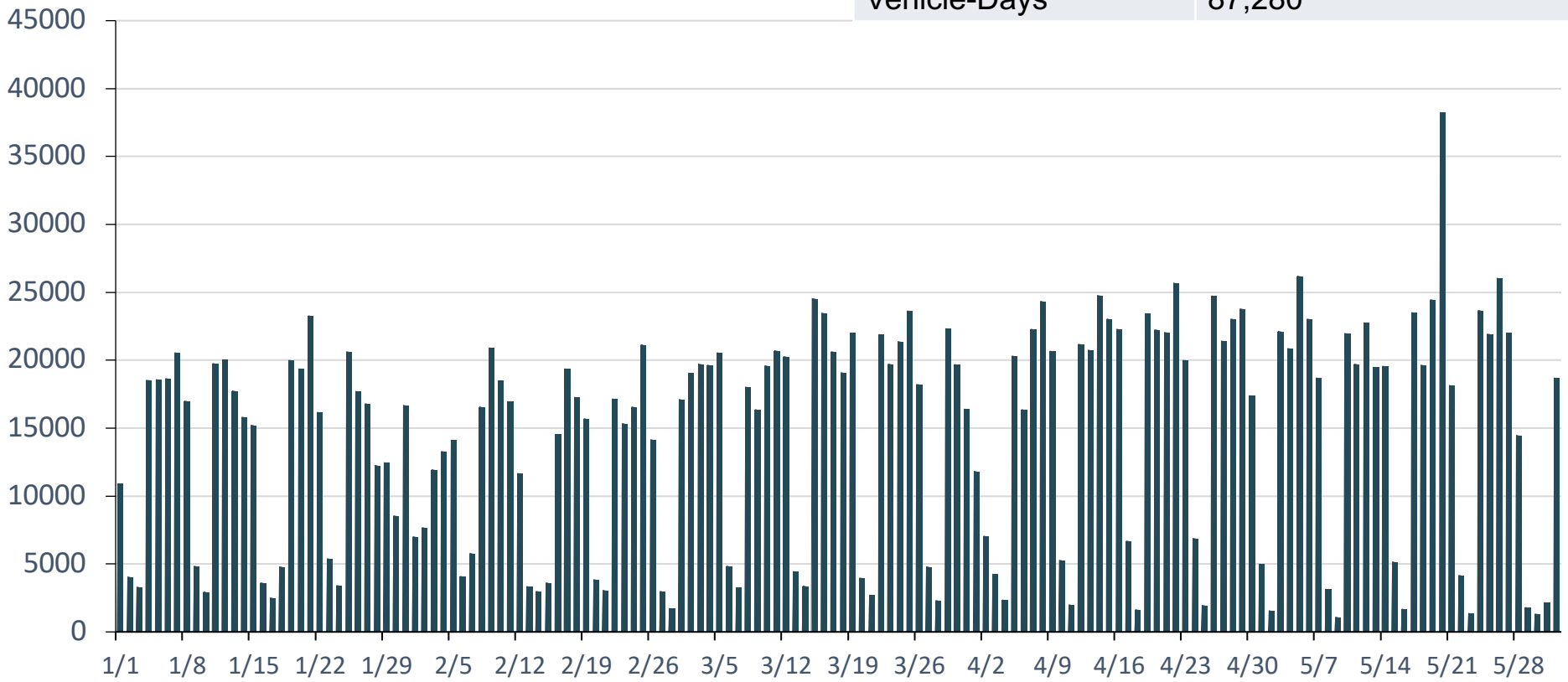
OBU Data Collection (Monthly)

Criteria	Jan 1 – May 31, 2021
Total	3,994,427
Vehicle-Days	87,280



OBU-OBU V2V Contacts (Daily)

Criteria	Jan 1 – May 31, 2021
Total	3,994,427
Vehicle-Days	87,280



Data Processing

Performance Measurement Program

Safety is Job #1.

- Once alerts are activated in a vehicle, they won't be silenced.

User Needs related to Performance Measurement

- ***Maintain privacy of users throughout pilot and data collection***
- ***No enforcement***
- ***No driver evaluation***

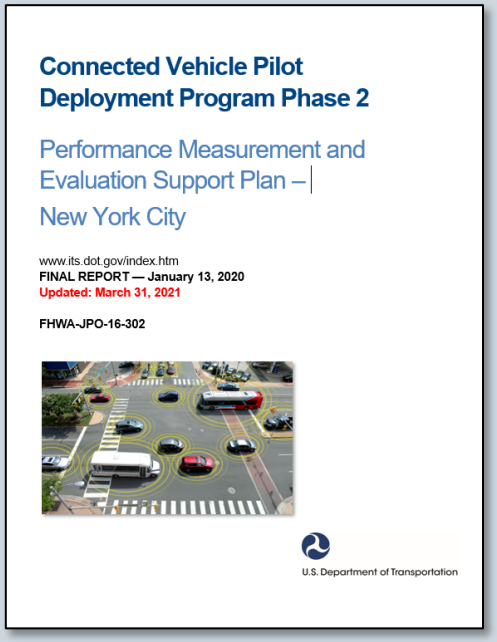
Performance Measurement Program considers:

- Consider impacts of CV data combined with data from other sources.
- Approach to collecting the performance information.
- Approach to using data collection bins of performance information.
- Control Group vs Treatment Group

FHWA-JPO-16-302,
Performance Measurement and Evaluation Support Plan - NYCDOT

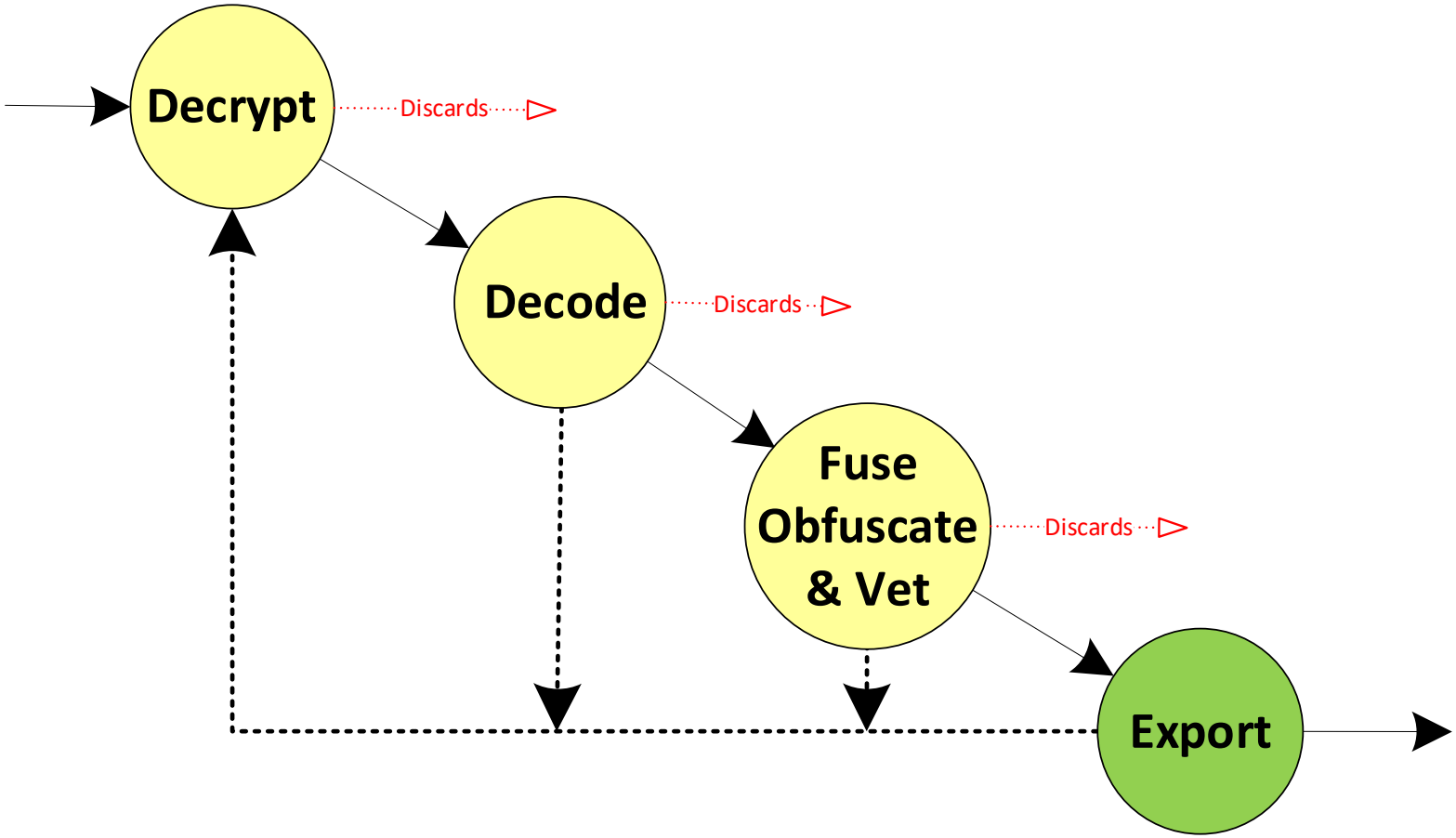
Performance Measures

FHWA-JPO-16-302

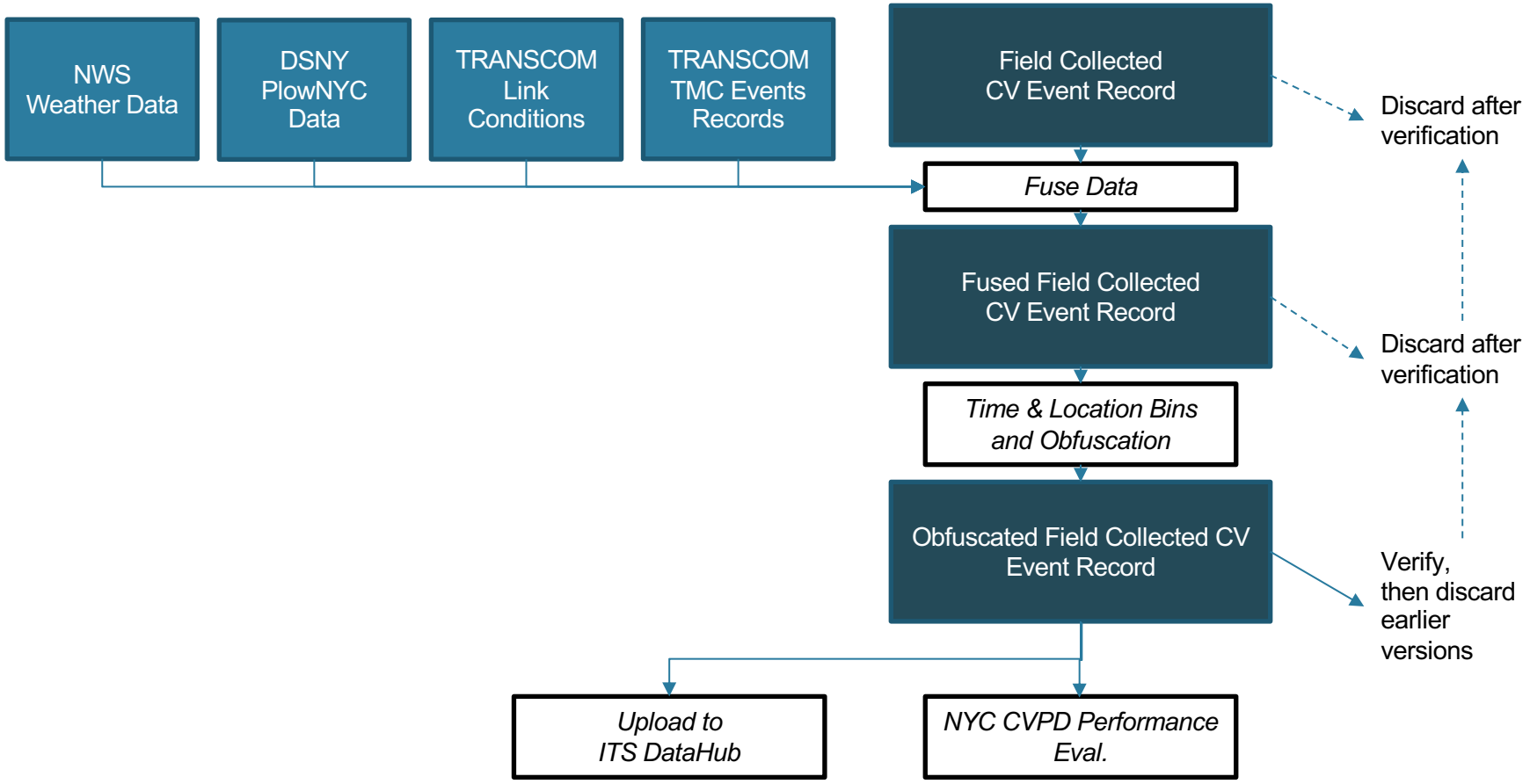


User Need	Category	NYCDOT Needs	CV Application	No.	Performance Measure Metrics	Question for Evaluation
Manage Speeds	Safety, Mobility	Discourage Spot Speeding	Speed Compliance	1	1a. Number of stops (average and distribution measures) 1b. Speeds (average and distribution measures) 1c. Emissions 1d. Reduction 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	Does speed limit adherence increase and speed variability decrease within the vehicle fleet on a given study roadway segment for a given time period (cycle length basis) from the Before period to the Pilot period, and from control group to the treatment group? Is this accompanied by an overall increase, decrease or no change in average segment speed?
Manage Speeds	Safety	Improve Truck safety	Curve Speed Compliance	2	2a. Speed related crash counts, by severity 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	Do the number of curve speed violations on each applicable studied roadway segment decrease from the Before period to the Pilot period, and from control group to the treatment group?
Manage Speeds	Safety	Improve Work Zone Safety	Speed Compliance / Work Zone	3	3a. Speed in work zone (average and distribution measures) 3b. Speed variation (distribution) at work zone 3c. Number of vehicle speed limit violations in variable speed zone areas 3d. Driver actions and/or impact on actions in response to issued warnings	Do the number of work-zone speed violations on each applicable studied roadway type decrease from the Before period to the Pilot period, and from control group to the treatment group?
Reduce Vehicle to Vehicle Crashes	Safety	Reduce Vehicle to Vehicle Accidents	FCW EEBL BSW LCW IMA	4	4a. Fatality crash counts 4b. Injury crash counts 4c. Property damage only crash counts 4d. Time to Collision (vehicle to vehicle)	Do the number of reportable crashes decrease from the Before period to the Pilot period, and from control group to the treatment group?
Reduce Vehicle to Vehicle Crashes	Safety	Reduce Accidents at High Incident Intersections	Red Light Violation Warning	5	5a. Red light violation counts 5b. Time To Collision (vehicle to cross vehicle path) at the intersection 5c. Driver actions and/or impact on actions in response to issued warnings	Do the number and severity of red-light violations at each studied intersection decrease from the Before period to the Pilot period, and from control group to the treatment group?
Reduce Vehicle to Vehicle Crashes	Safety	Reduce Bus Incidents, Improve Safety	Vehicle Turning Right in Front of Bus Warning	6	6a. Right-turning related conflicts 6b. Time to collision (vehicle to bus) 6c. Number of warnings generated 6d. Driver actions and/or impact on actions in response to issued warnings	Do the number of bus / right turn vehicle crashes decrease from the Before period to the Pilot period, and from control group to the treatment group?
Reduce Vehicle to Pedestrian Crashes	Safety	Improve Pedestrian Safety on Heavily Traveled Bus Routes	Pedestrian in Signalized Crosswalk Warning	7	7a. Pedestrian related crash counts, by severity 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	Do the number of pedestrian related crashes decrease from the Before period to the Pilot period, and from control group to the treatment group?
Reduce Vehicle to Pedestrian Crashes	Safety	Improve Safety of Visually and Audibly-impaired pedestrians	Mobile Accessible Pedestrian Signal System (PED-SIG)	8	8a. Qualitative Operator Feedback 8b. Pedestrian Crossing Speed and Crossing Travel Time 8c. Times Out of Crosswalk 8d. Waiting time at intersection for crossing	Does the mobile app improve participants' perceived safety when crossing signalize intersection?
Reduce Vehicle to Infrastructure Crashes	Safety	Address Bridge Low Clearance Issues/Enforce Truck Route Restriction	Oversized Vehicle Compliance	9	9a. Number of Warnings generated 9b. Number of truck route violations	Do the number of low clearance violations decrease from the Before period to the Pilot period, and from control group to the treatment group?
Inform Drivers of Serious Incidents	Mobility	Inform Drivers	Emergency Communications and Evacuation Information	10	Number of vehicles receiving information when generated	Do CV vehicles receive the information warnings when generated?
Provide Mobility Information	Mobility	Replace Legacy Measurements	Intelligent Traffic Signal System Connected Vehicle Data (I-SIGCVDATA)	11	11a. Segment speed (average and distribution measures) from CV compared to legacy detection systems 11b. Travel time (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?
Manage System Operations	System Operations	Ensure Operations of the CV Deployment	NA	12	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?

Data Processing

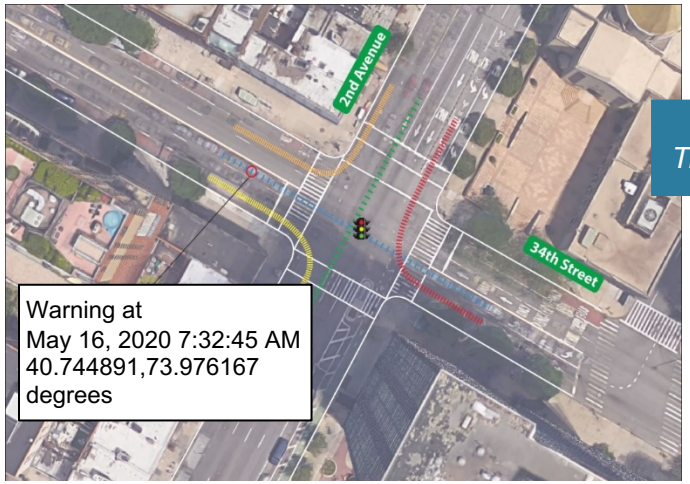


CV Event Record Obfuscation Process



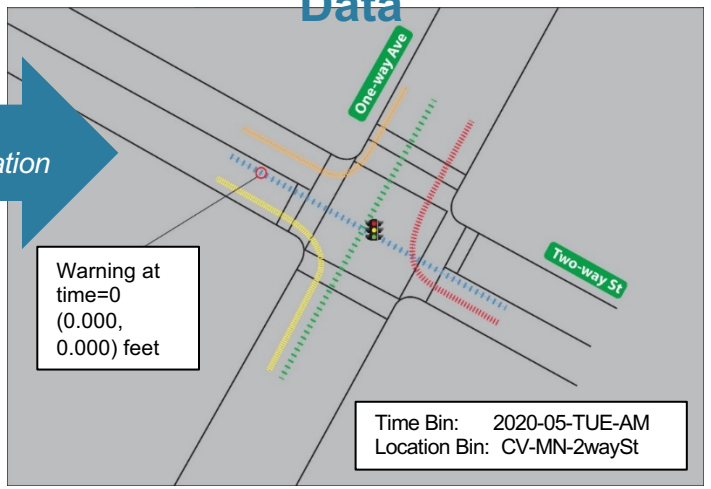
ASD Event Log Obfuscation

Raw ASD Action Log Data

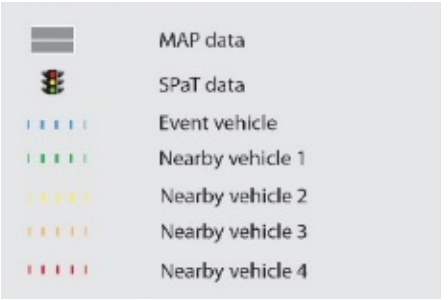


Obfuscate Time and Location

Obfuscated ASD Action Log Data



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



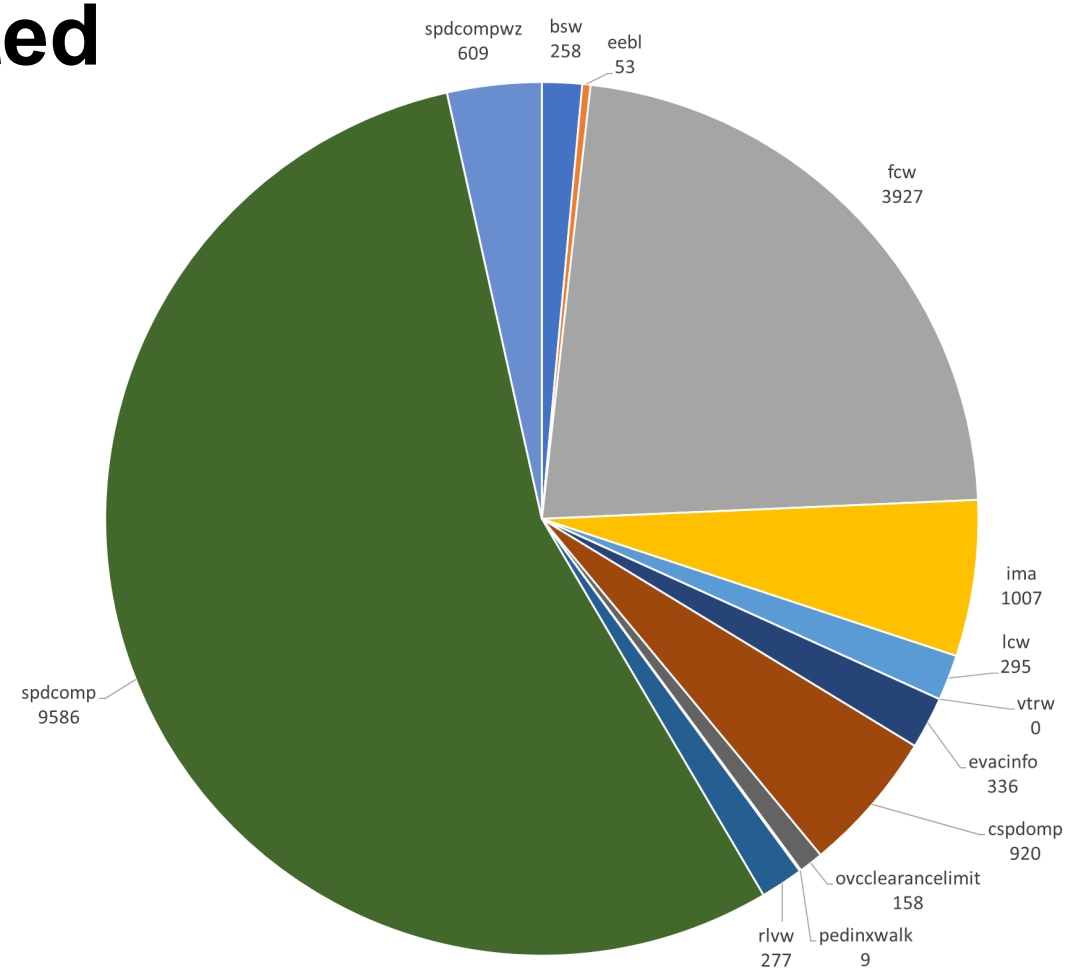
Event observations so far …

CV Events by Type

May 2021: Ingested

- 17,435 Total Fleet Events
- 2640 Installed Vehicles
- May VMT: 957,000 (Est)
- May Hrs: 66,000 (Est)

- Notes:
  - All collected events
  - May 20 treatment begins
  - Includes early ASD firmware versions
  - Includes test vehicle events
  - Includes silent & treatment events

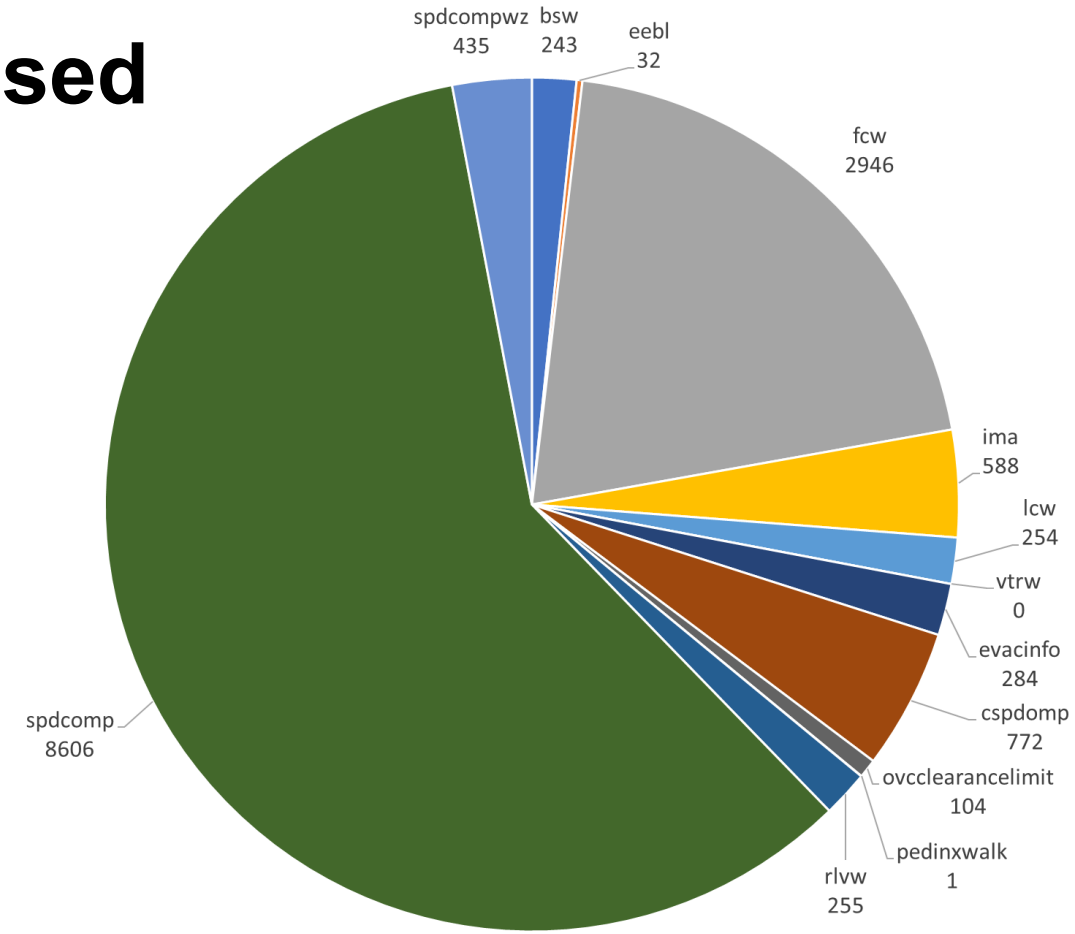


CV Events by Type

May 2021: Released

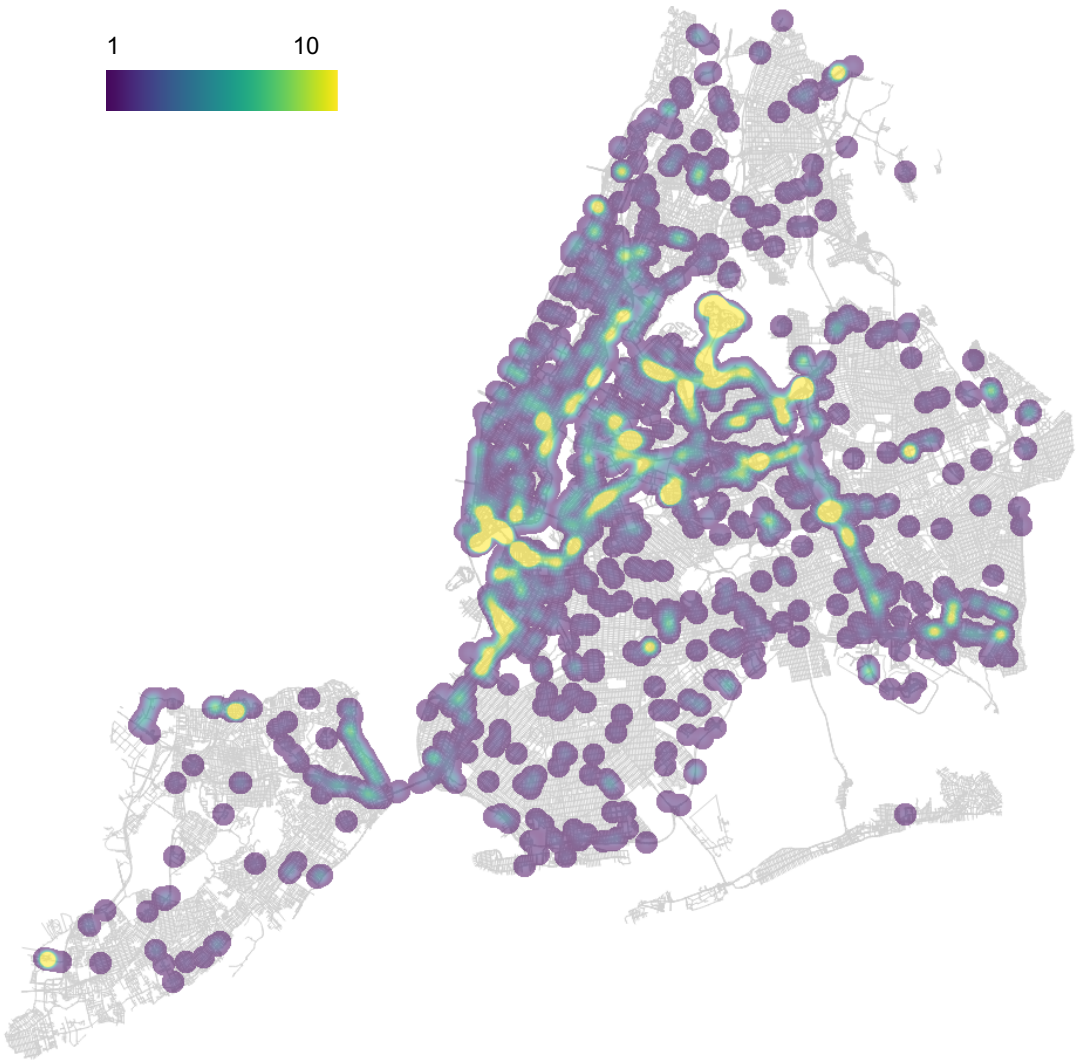
- 14,520 Fleet Events
- Includes both Silent and Active Alerts

- Notes:
  - Disregards early ASD firmware versions
  - Disregards Test Vehicle Events
  - Includes Events passing error tests
  - Includes Treatment and Control Vehicles



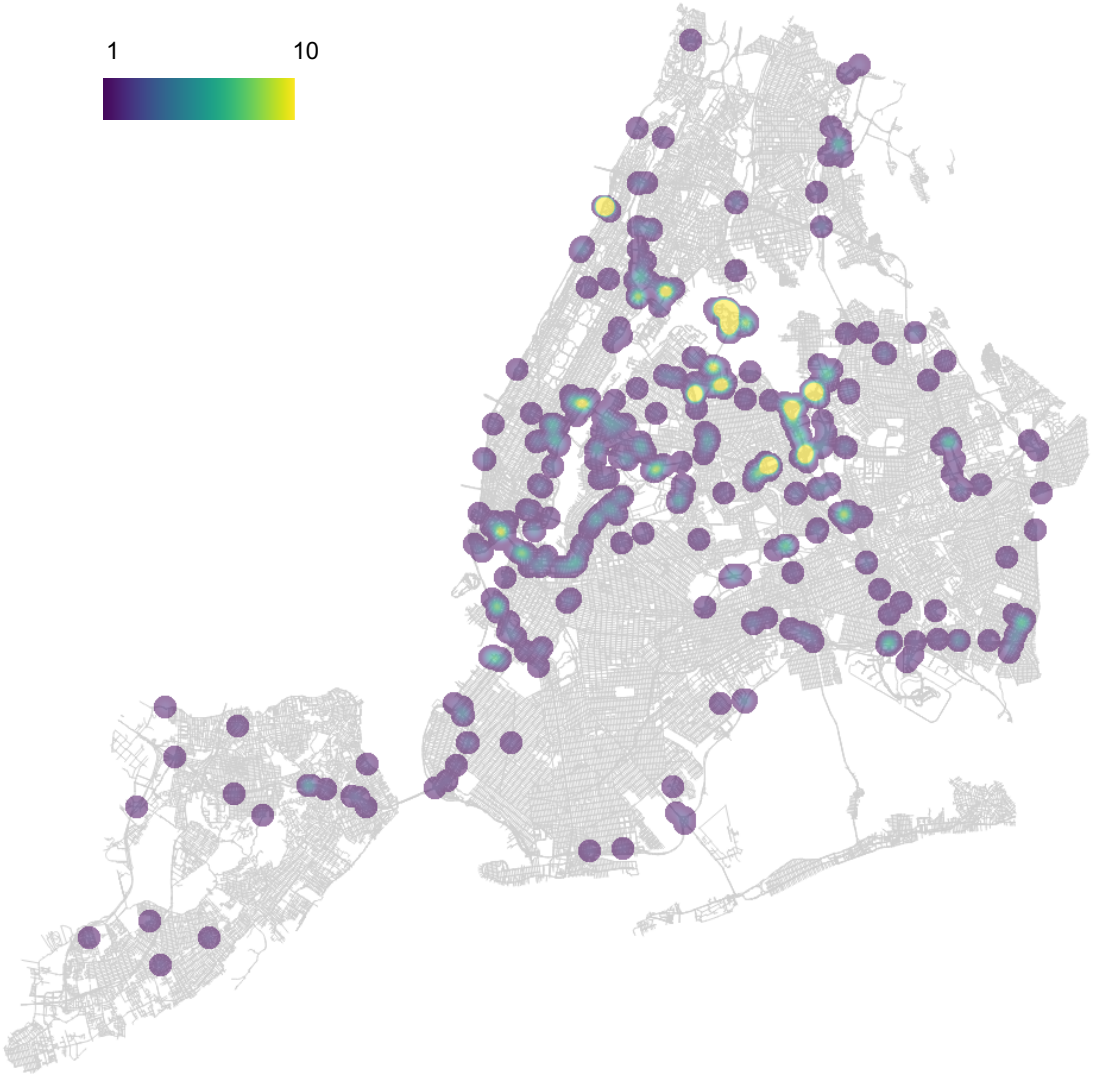
Forward Collision Warning (fcw) Events

May 2021: 2,946 Events



Intersection Movement Assist (ima) Events

May 2021: 588 Events



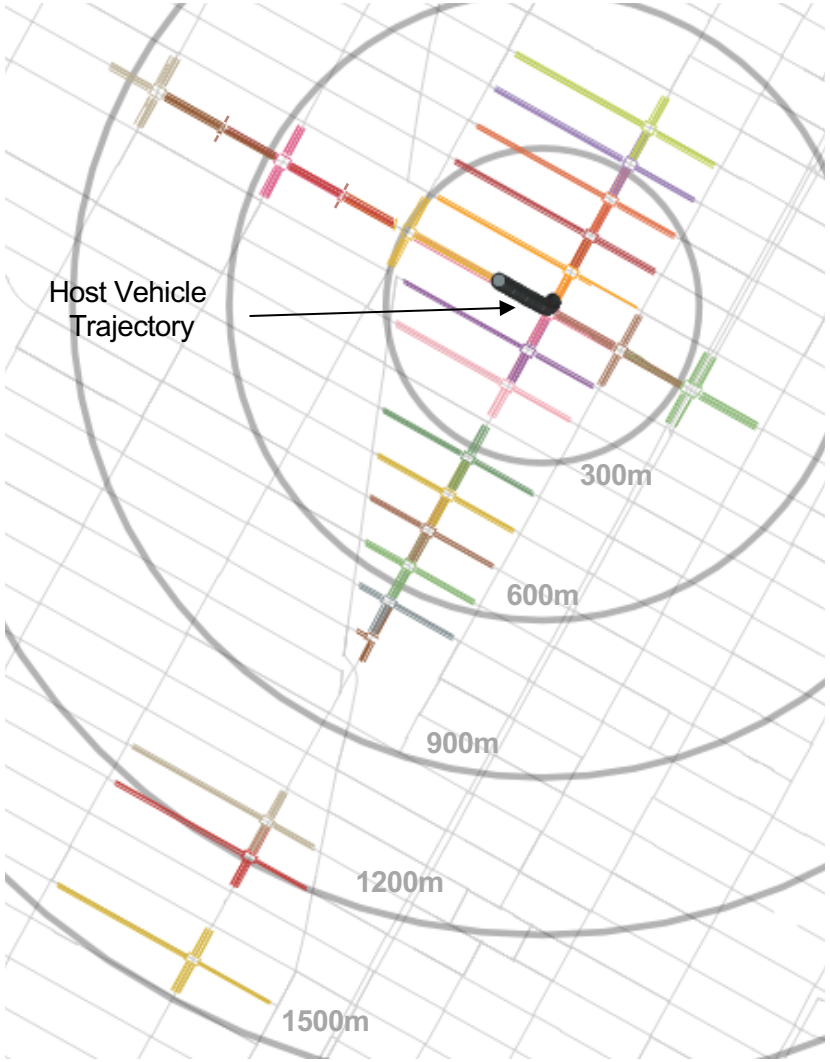
Speed Compliance (spdcomp) Events

May 2021: 8,606 Events

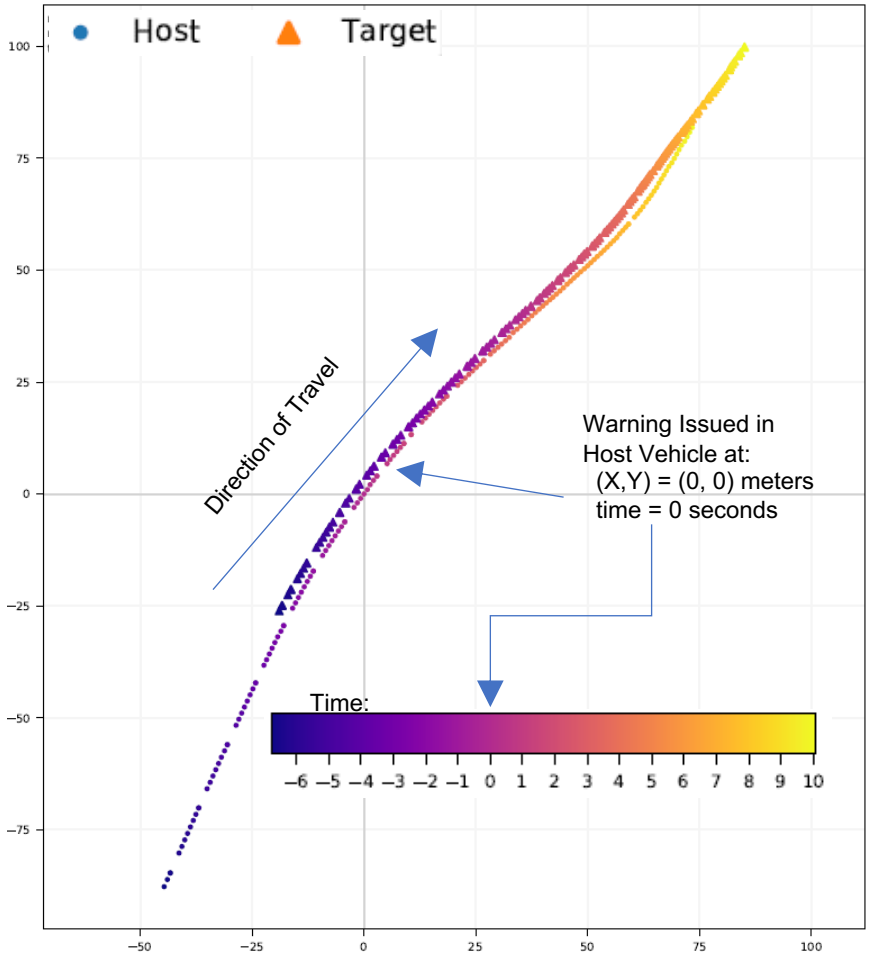
V2I areas only

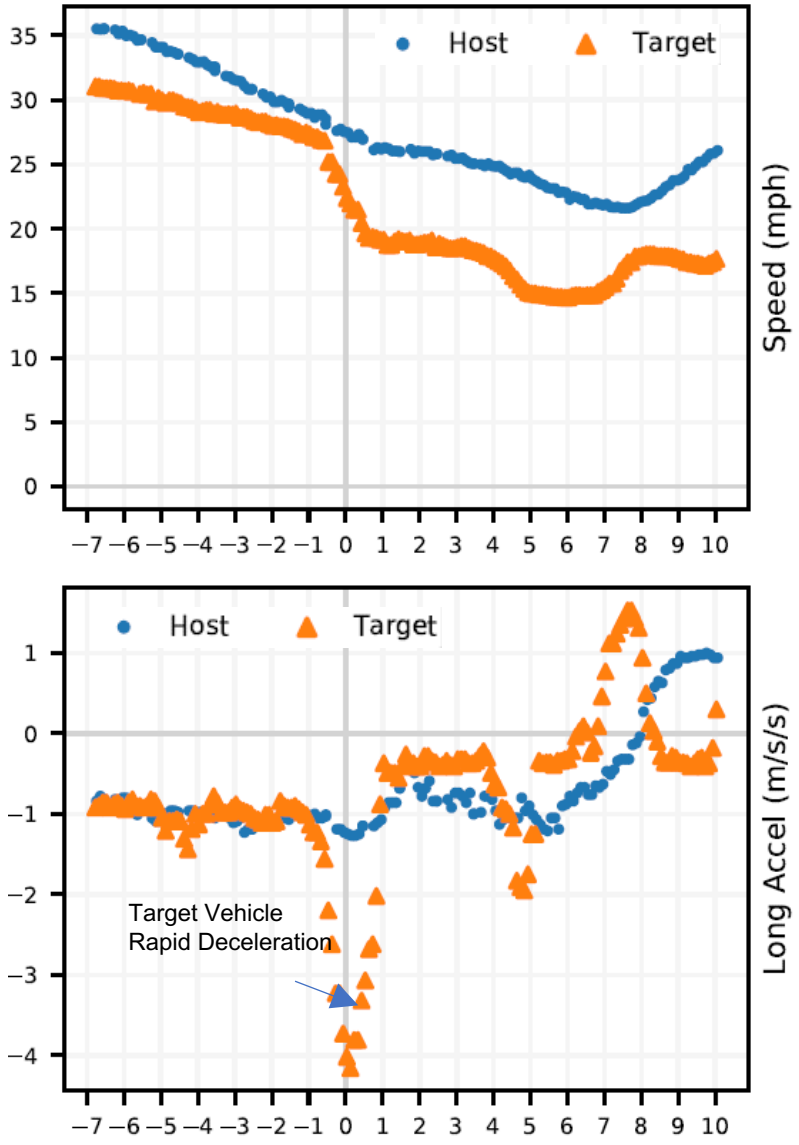
Red Light Violation Warning (rlvw) Events: Many Maps

- Sample RLVW Event
- 24 Different MAP messages heard in 17 seconds
- MAPs heard as far as nearly 1.5km from host vehicle



Obfuscated Event Analysis
Sample: EEBL Warning





Breadcrumb Analysis

CV Project Lessons

Lessons

- **Location accuracy remains a challenge in the urban canyon environment.** Urban location accuracy requires more than GPS.
- **Grade separation is a challenge** in dealing with elevation element of location accuracy. Elevation is an essential component of the safety applications in the urban environment.
- The number of FCW and SPDCOMP events dominate the data collected and tend to skew any analysis of events spanning multiple types.
- **Breadcrumb were essential to analyzing anomalies and operational issues**.
- O&M data collected confirms RF data reception ranges impact OBU & RSU device loading due to device density.
- **Need to collect additional data:** Until we began analyzing events, we couldn't determine that there is additional information that would make analysis easier. For example, for RLVW, adding the specific intersection identification triggering the alert in the event header would make analysis easier. Also, when analyzing BSMs, the MAP/SPaT/TIM being heard would impact interpretation of driver behavior.

Conclusions

- Effective CV operations **don't require every BSM to be recorded**.
- **Equipping a fleet** requires cooperation beyond normal IOO organizational knowledge. **Consider costs of vehicle & driver time** – scheduling, maintenance, vehicle policies of the agency, etc.
- **MAP message maintenance requires on-going resources**. (Bus Lanes, bike lanes, phase sequences, lane markings, turn policies, speed limits, …)
- If we were starting over …
  - **Budget for Vehicle CAN integration** for improving location accuracy; **required far more resources** than estimated (money, time, people). Function (vehicle make, model, year) – NYC has 45 combinations – differences year to year, model to model, as well as Mfr.
  - Recognize the **ACTUAL maturity of the devices and applications**. The project spent considerable efforts Investigating fundamental protocol issues, re-boot frequency, anomalies with edge and corner cases, impact of density (RSU, OBU) , RF range, ripple effect of security requirements for the ITS infrastructure, SCMS access, standards ambiguities, . . .

STAY CONNECTED

Contact for CV Pilots Program:

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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

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CV Pilot Sites Document Repository
http://www.its.dot.gov/pilots/cv_pubs.htm

Please visit the CV pilots website for the recording and the briefing material of the previous webinars: http://www.its.dot.gov/pilots/technical_assistance_events.htm

Questions?

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