# NEW YORK CITY CONNECTED VEHICLE PILOT PROJECT


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NYC Connected Vehicle Project

*For Safer Transportation*

# Project Goals

New York City is aggressively pursuing "Vision Zero"

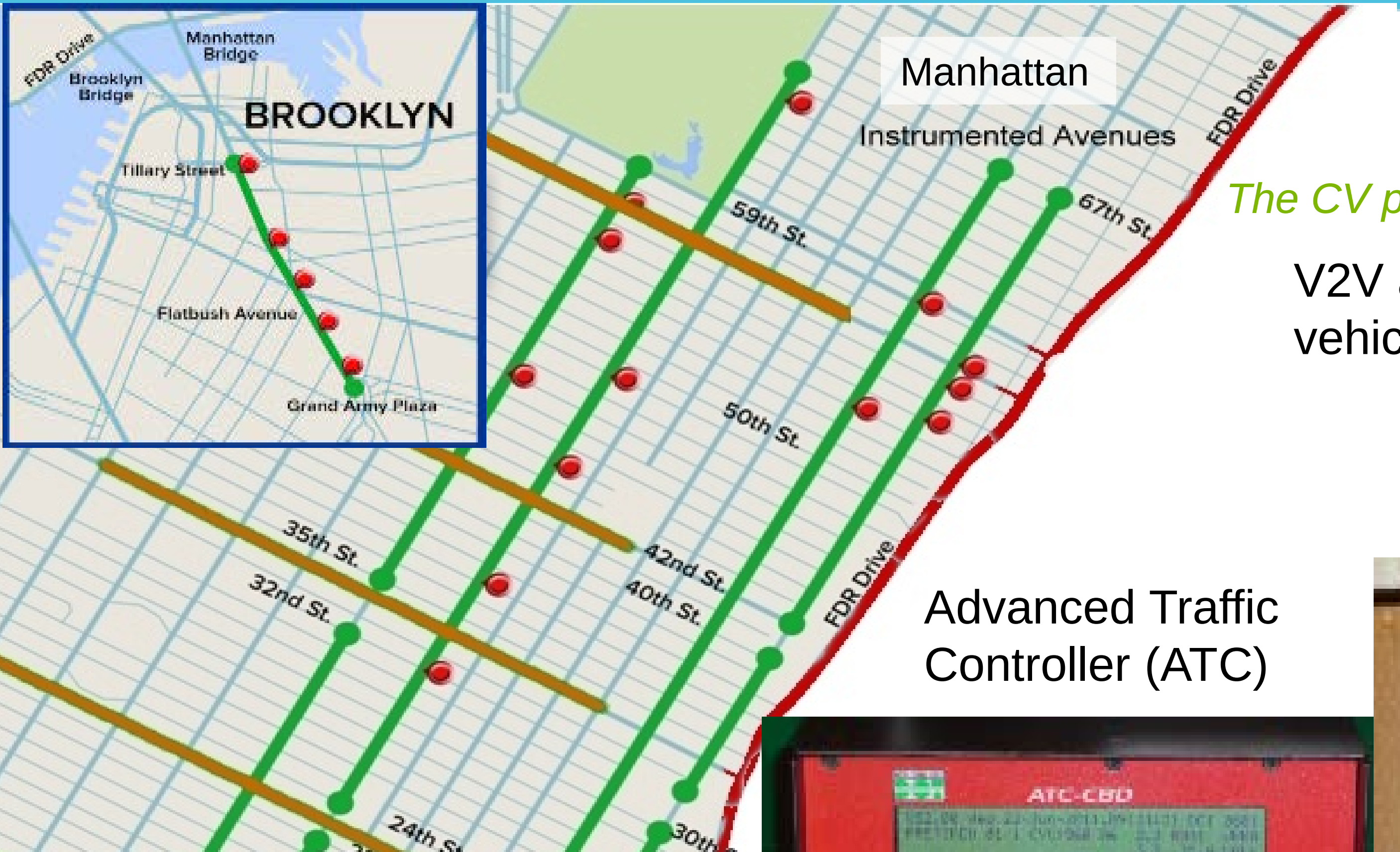
"Traffic Death and Injury on City streets is not acceptable"

Vision Zero Goal : to eliminate traffic deaths by 2024

*NYC CV Pilot will evaluate*

- ***Safety** benefits of CV technology*
- *Address CV deployment challenges*
  - *With a Large number of vehicles & types*
  - *Issues associated with the dense urban environment*

# Locations (Manhattan, Brooklyn)




V2I applications work where **infrastructure is installed** (along highlighted streets).

*The CV project leverages the City's transportation investments*

V2V applications work **wherever** equipped vehicles encounter one another.

Advanced Traffic Controller (ATC)


NYCWiN

Traffic Control System

# CV Stakeholder/User Deployment

## Vehicles

- **Up to 8,000 fleet vehicles with Aftermarket Safety Devices (ASDs):**
  - ~5,800 Taxis (Yellow Cabs)
  - ~ 700 MTA Buses
  - ~ 1,050 Sanitation & DOT vehicles
  - ~ 400 DCAS vehicles

**Operating Statistics:**
*Vehicles are in motion or active ~**14 hours per day!***
*Average taxi drives 197 miles per day*
*Fleet total Vehicle Miles Traveled:*
***>1.3 Million Miles per day***
***~40 Million Miles per month***

**Revenue Vehicles**

## Pedestrians

- Pedestrian **PIDs**
  - Visually Impaired
  - 100 Subjects – PID
- PED in Crosswalk
  - 10 Fully Instrumented Int.

# Safety Applications

**Vehicle-to-Vehicle (V2V) Safety Applications**

- Vehicle Turning Right in Front of Bus Warning
- Forward Collision Warning
- Emergency Electronic Brake Light
- Blind Spot Warning
- Lane Change Warning/Assist
- Intersection Movement Assist

**Vehicle-to-Infrastructure (V2I) Safety Applications**

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

# ADDITIONAL APPLICATIONS

## Pedestrian

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

## Traffic Management

- CV Data for Intelligent Traffic Signal System

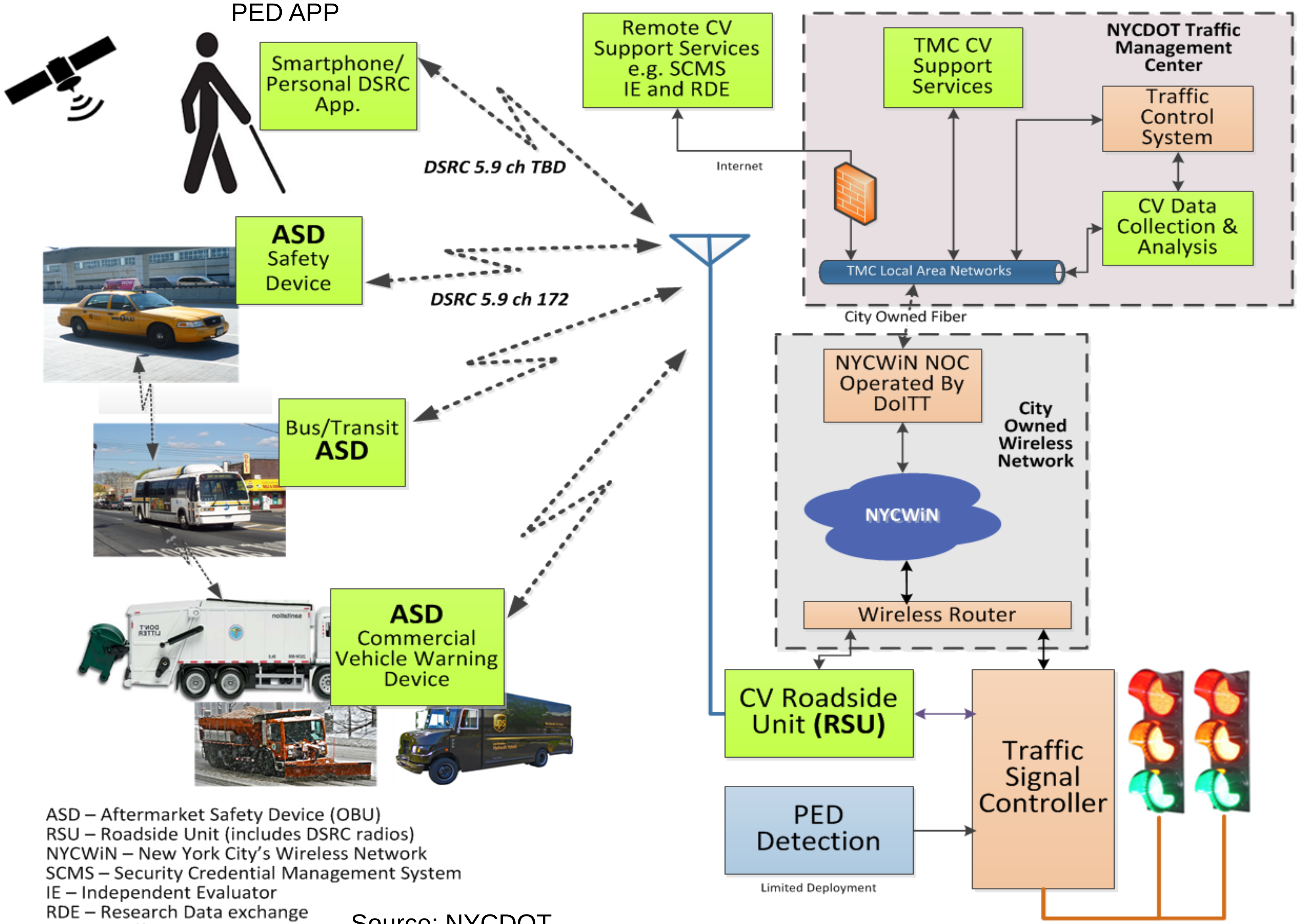
***Roadway segment travel times***

## Operations, Maintenance, and Performance Analysis

- RF Monitoring
- OTA Firmware Update
- Parameter Up/Down Loading
- Traffic data collection
- *Event History Recording*
- *Event History Up Load*

***To Evaluate the benefits***

# OVERALL PROJECT CONCEPT




ASD – Aftermarket Safety Device (OBU)
RSU – Roadside Unit (includes DSRC radios)
NYCWiN – New York City's Wireless Network
SCMS – Security Credential Management System
IE – Independent Evaluator
RDE – Research Data exchange
TMC – Traffic Management Center

Source: NYCDOT

# Where are we now ?

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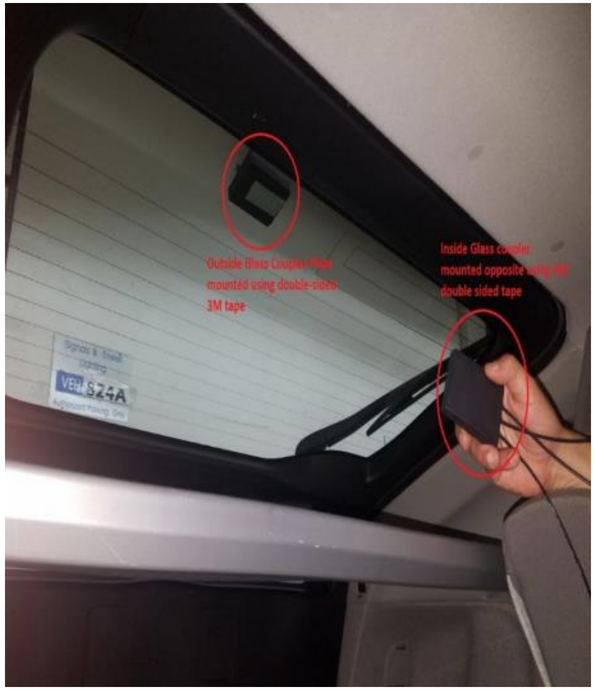
# PROTOTYPE INSTALLATION AND TESTING

- Developing MAP message Content (USDOT tool)
- RSU - Planning installation sites
  - Establishing Installation “partners”
  - Optimizing for triangulation and location accuracy testing
- ASD - Developing vehicle installation kit designs
  - Working with vendors – NY Specific Software
  - Working with Fleet owners – Establish installation procedures
  - Running samples – awaiting prototypes – checking coverage and interference

**~360 Roadside Units**
**36 Units at key locations**

# Vehicle Installation



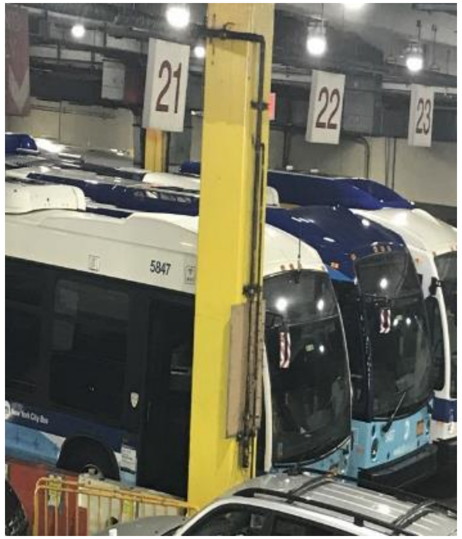
- 80 Samples installed in fleet vehicle
- Testing through the glass and drilled mountings
- Working with various different vehicle types
- Verifying calibration and RF radiation patterns

# NYC DOT INSTALLATIONS

- NYC DOT Installation
  - Various Makes/Models/Year NYC DOT vehicles are being equipped with prototype ASDs in order to fine tune and optimize installation methods and approaches
  - NYC DOT Vehicles 770
    - Toyota
      – Prius, RAV4
    - Ford
      – Fusion
      – F-150 – F-550
    - Chevrolet
      – Silverado
      – HD3500
      – Economy

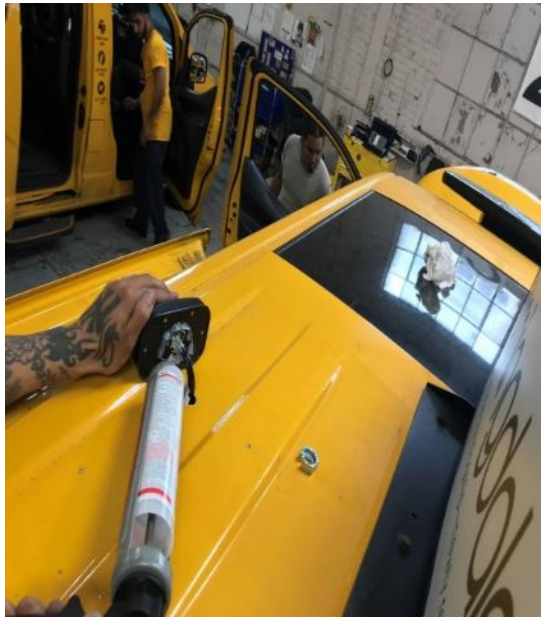
# MTA Installation

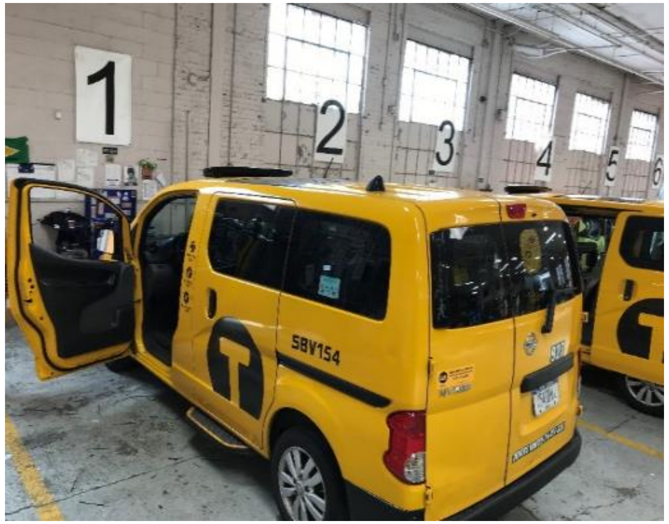
- The buses were installed to test RF DSRC communication with light vehicles, and to develop an installation template
- Key element for MTA – **Through the glass Antenna**


# Taxi Installation

- Taxi Installations are estimated at 5000 vehicles between the participating fleet owners
- 2 authorized technology installers
- Taxi fleet is expected to include:
  - Toyota
  - Prius
  - Sienna
  - RAV4
  - Nissan NV 200



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# Some Lessons Learned and Challenges

NEW YORK CITY DOT NYC Connected Vehicle Project For Safer Transportation

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# Pilot vs. Deployment

- Ambiguities within the standards
  - Need for “how to use” in many cases!
  - Complexity of deploying the security (1609.2) is significant
  - Protocols & Data elements must be the same for interoperability
  - Three pilots worked together
    - Review of all standards
      - insure same “objects” for the same purpose and meaning
    - Requirements for messages all the same
      - Optional vs. Mandatory
- Product certification (US DOT Requirement) – OmniAir and their program
  - Trusted devices - - protect the integrity of the trusted environment
  - Fundamentals – messages, channel usage, security usage, timing, etc.

Interoperable
Incremental
Deployment

# Need Standards for the Applications

- "Demonstrations" by 6 vendors
  - Fundamental operation ~same
  - **BUT** – Differences
    - Configuration management
    - Operating parameter management
      – "Intensity" of application
  - "Need for ability to test applications
      – Controlled environment
      – Need "testable" requirements for applications – Precision!

  - **Need more extensive "<u>certification</u>" that applications meet some minimum?**

# Cybersecurity Is Fundamental to CV Deployment

***CV depends on a "trusted" environment - vehicles & infrastructure***

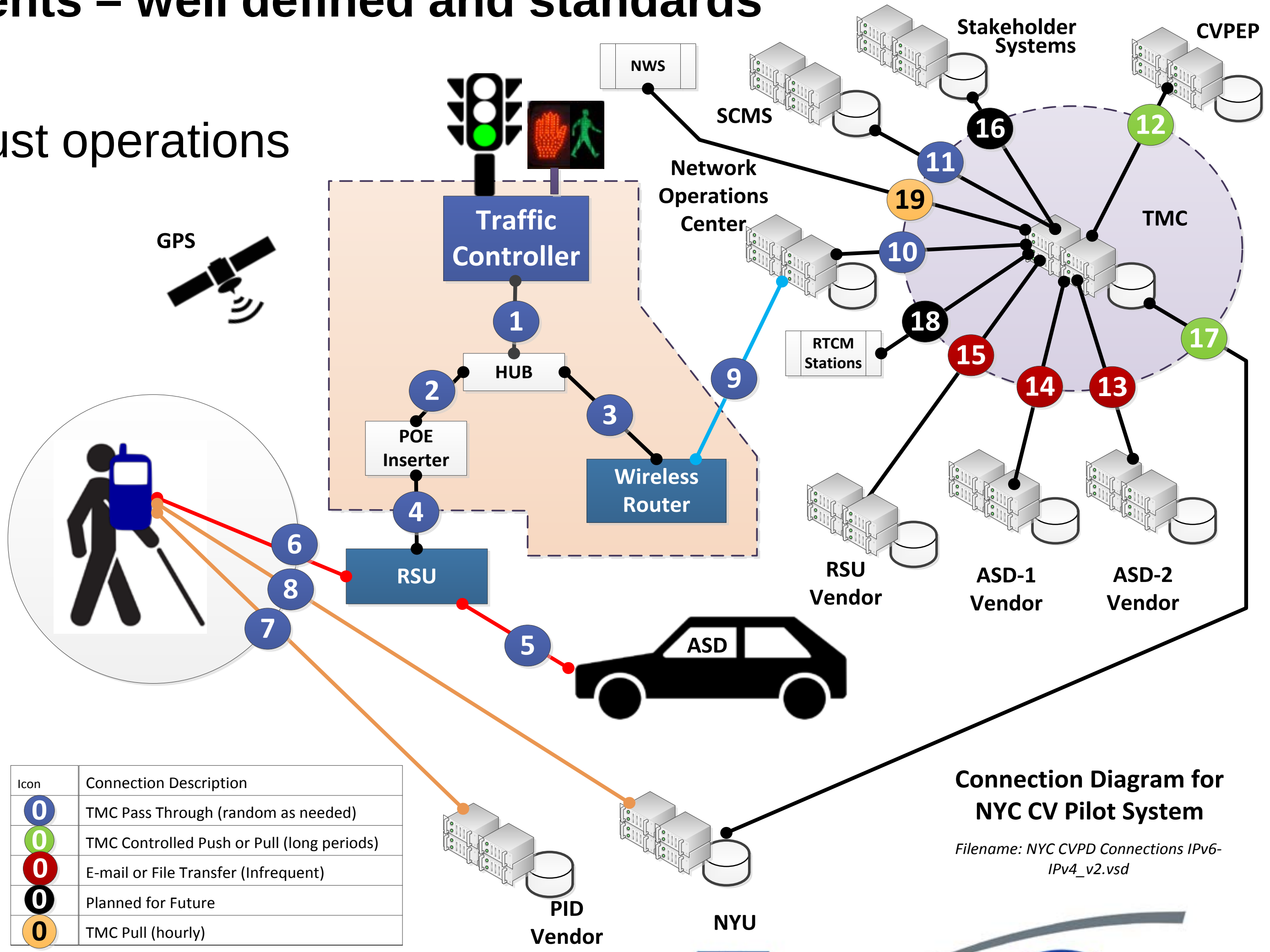
- Message authentication (BSM, SPaT, MAP, TIM, etc.…)
- Data encryption of (To preserve privacy)

- Requires Equipment Certification
- Organizational IT security
  - Physical security of the TMC systems
  - Agency login and security practices
- **Protection for all connections and data exchanges – need to Secure**
  - **TMC-ATC, ATC-RSU, TMC-RSU - - DTLS with X.509 Certificates**
- CV Hardware Impact
  - Hardware Security Module (HSM) for the TMC system
  - HSM inside the ASD/OBU and RSU

# Security Issues – Extend Everywhere

**Connected Vehicle has security requirements – well defined and standards**

- Issue
  - All of the ITS and IT systems need to adjust operations
  - Classic ITS – adopted security measures
  - Certificate management
  - Certificate Revocation Lists
  - Need for real time access to SCMS
  - Secure Boot of all field devices
    - OBU, RSU - - Traffic Controller?
  - Physical security re-visited (cabinet keys)
  - Password policies
  - Firewall rules - - etc.
  - Misbehavior detection coming soon!




Connection Diagram for NYC CV Pilot System

*Filename: NYC CVPD Connections IPv6-IPv4_v2.vsd*

# Scaleable and Reliable Deployment

- 100 vehicles – no problem
- 8,000 revenue generating vehicles
  - Cannot physically access - $$$ per minute/hour etc.
  - Project specifications stressed reliability and un-manned recovery
  - Work with the "experts" for installation
- Applications subject to changes
  - Schedule cannot wait until everything is "perfect"
    - 23 weeks to deploy
  - Needed reliable means to update and add applications
  - Needed reliable means to "tune" the applications
  - Likely future changes in communications media and standards

# CHALLENGE – SCALABLE OTA DATA EXCHANGES

- Push (20 MB+) software updates to 8,000 vehicles efficiently over **DSRC**
  - **No WiFi and No LTE/4G**

- Developed Scheme to support broadcast updates
  - ASD’s read WSA from Control Channel
  - Directed to Service Channel if RSU supports Updates
  - RSU **broadcasts** available updates
    - Some updates broadcast (continuous) some available by unicast
    - Vehicles initiate update using unicast or monitor broadcast streams
    - Using licensed software to manage the efficient breakdown and assembly
    - Efficient Channel Use
    - Privacy is maintained

# Challenge – Location Accuracy

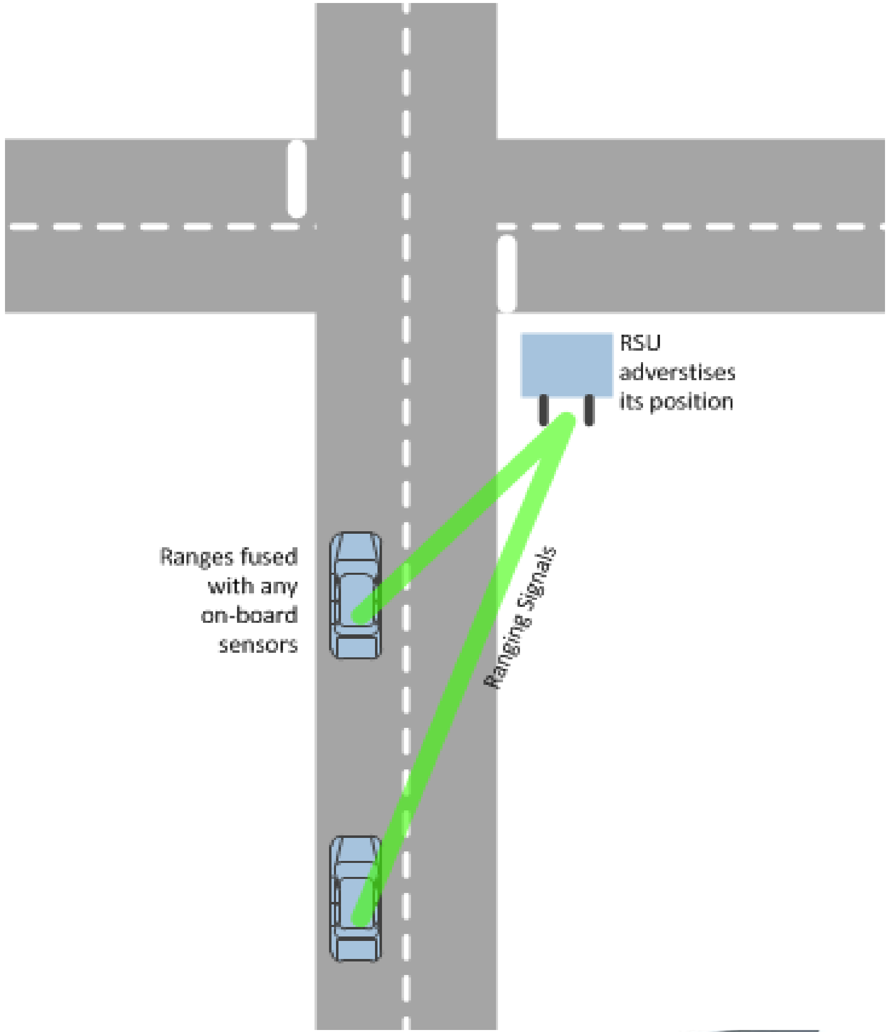
- **Location Accuracy** –
  - Urban Canyons pose issues *(both relative V2V and absolute V2I)*
    - Dropout at underpasses
    - Loss of GPS lock
  - **ASD vendor demonstrated RSU triangulation**
  - Established Compound ASD requirements:
    - Dead reckoning,
    - Triangulation with static DSRC locations,
    - Map matching,
    - Tethered to the vehicle - vehicle interface
- **Testing is ongoing 10 RSU's worst locations**

# RSU TRIANGULATION

V2X Locate uses
- standard RSUs and OBUs
- standard V2X over the air messages to determine position of vehicle by ranging

RSU location known _ Requires High Accuracy!
thanks to standard
advertisements

Fuses vehicle sensors and GNSS
when available.






* Based on recommended deployment set-up

# Other Technical Challenges

- Adjusting the applications for 25 MPH and Freeway speeds

- CAN/J (vehicle) Bus Interface –
  - **Vendor (OEM) resistance to providing necessary information**
  - Purchasing a gateway device

- Many different vehicle types and model years
  - Varied installation kits
  - Fortunately – they are fleets – we drill holes! – and - - -
    - Agency can establish terms and conditions of support!

# FLEETS VS. OEMS

- There is a need for standard [secure] vehicle interface
  - Steering Wheel Angle, Yaw Rates, “hard breaking”
  - Speed, roadway friction, etc.
- Aftermarket devices NEED access to the vehicle data bus
  - Speed, directional, minimum – location enhancement
  - Transitional period to embedder safety systems
- Instead – OEMs reacting to “security” scares – making it harder!
- Future: CV can augment AV –
  - Regulations, Intersection operation, Map Dynamics (lane changes, construction, crash/incident/special event mitigation
- NYC – vehicle manufacturer cooperation (data interface and design sharing) – non existent!
- 2 Vendors – 2 different approaches – headache for everyone!

# Data Recording Issues

**NYC was not an R&D project!**

## *What to collect*

- What could I collect?
  - What is the raw data available
- What Do I need?
  - What is the intended use of the data?
- What should I collect?
  - To Justify the costs!

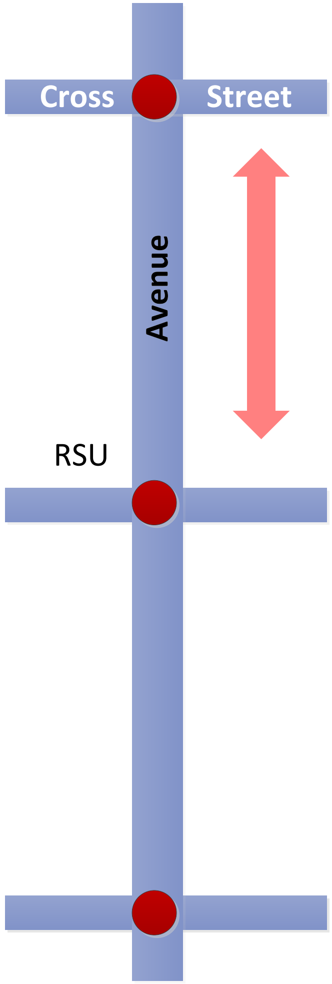
## *What are the costs*

- Backhaul communications
- Storage
- Processing
- FOIA requests
- Subpoena

## *Privacy Issues*

- Prohibition of keeping PII
- Combination with other sources.
- Data Ownership

# EXAMPLE – TRAVEL TIME



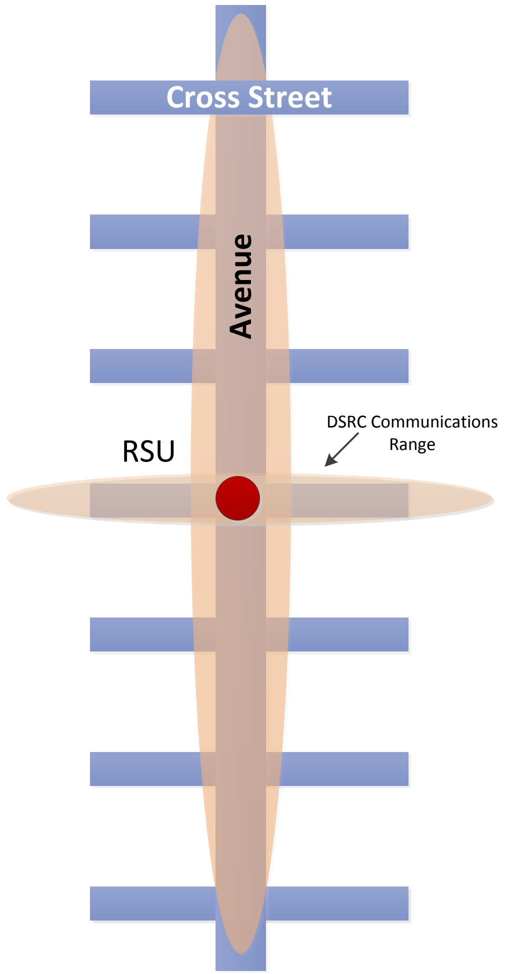

- Block Spacing ~70M Feet (230’)
- 20 MPH – 30 feet per second
- DSRC Range ~300M  (1000’)
- BSMs Xmit @ 10 Hz
- Time between blocks ~8 seconds
- BSMs transmitted 80
- BSMs needed 2  - 3%  **a 97% reduction**
- **Edge computing @ RSU**
  - RSU looks for vehicle entry to Intersection
  - Transmits one BSM to TMC per vehicle
  - TMC matches BSM – Vehicle ID
  - TMC computes travel time
  - Or TMC data times out - -

# Optimized Intersection Control

- Edge computing @ traffic controller
  - Queue length  - Stopped Vehicles
  - Vehicle speeds – Reported in local BSM
  - Priority and preemption – With local communications
  - Incident detection – deviation around obstacle
  - Pedestrian presence

- Send to TMC only what needs to be used
  - Platoon management (Freight priority)
  - Alternate route management/diversion
  - Incident detection
  - Travel Times (average link speed)
  - EVP progress (if not provided directly by the vehicle)

# PRACTICAL DATA COLLECTION - INCIDENTS

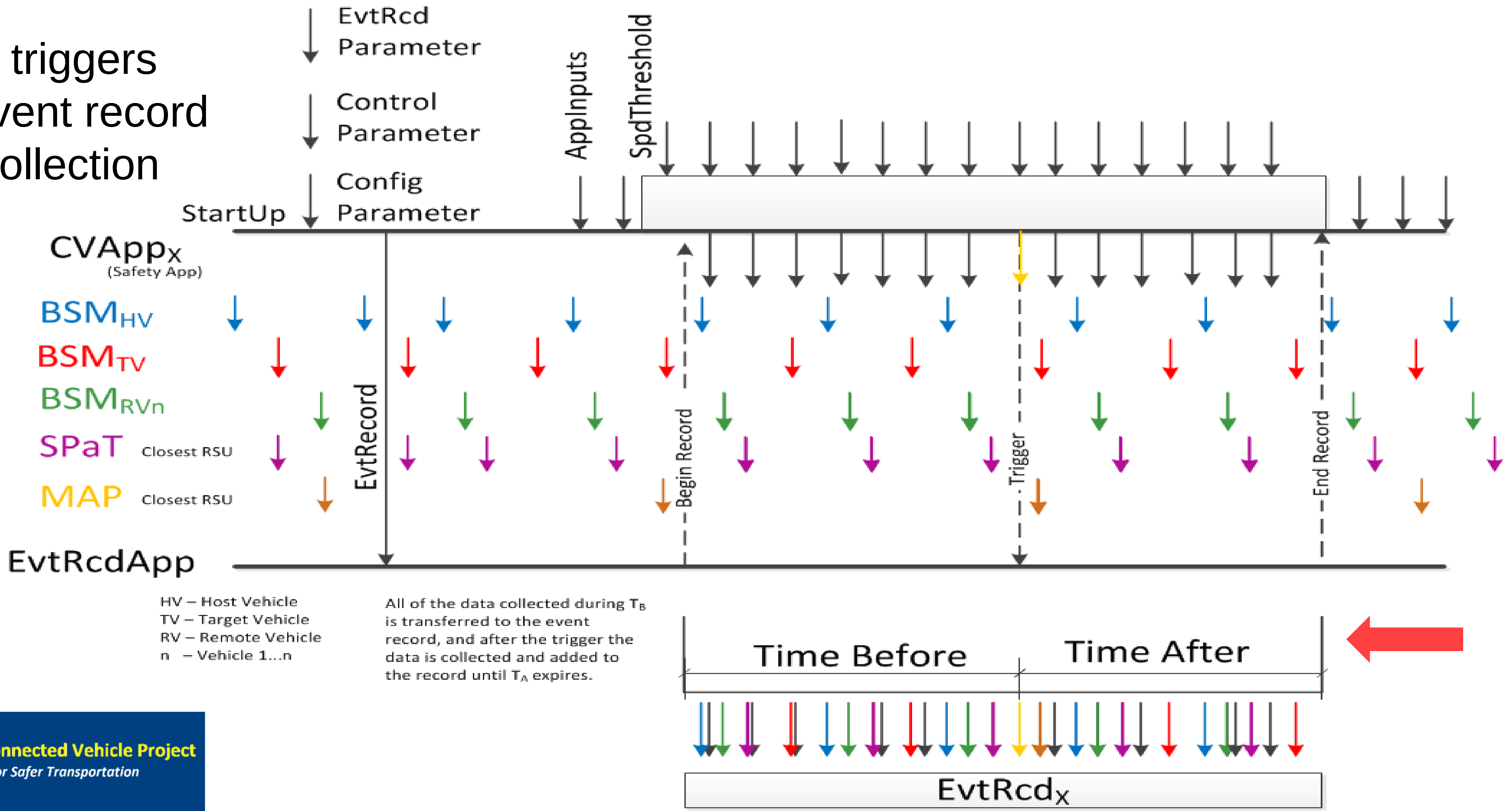



- 1.2 M vehicles in NYC broadcast **83 TB/day**
- 13,000 NYC intersections broadcast **3 TB/Day SPaT & Map**
- 8,000 vehicles collect ***2 TB BSM data/day***
- Data ***needed*** for benefits analysis:
  - How many crashes per day did we prevent
  - How many crashes per day did we mitigate
- Edge computing – Onboard Unit (OBU)
  - OBU monitors vehicle operation (S, Yaw, etc.)
  - OBU monitors surrounding vehicles' operation
  - OBU assesses threats
  - OBU alerts driver to mitigate threat
  - OBU records what the caused alert and driver actions

# SOLUTION "INCIDENT DATA"

## INTERMITTENT LOGGING

"Alert" triggers and event record data collection



# Data Reduction and Privacy Protection

**Magnitude of Data**

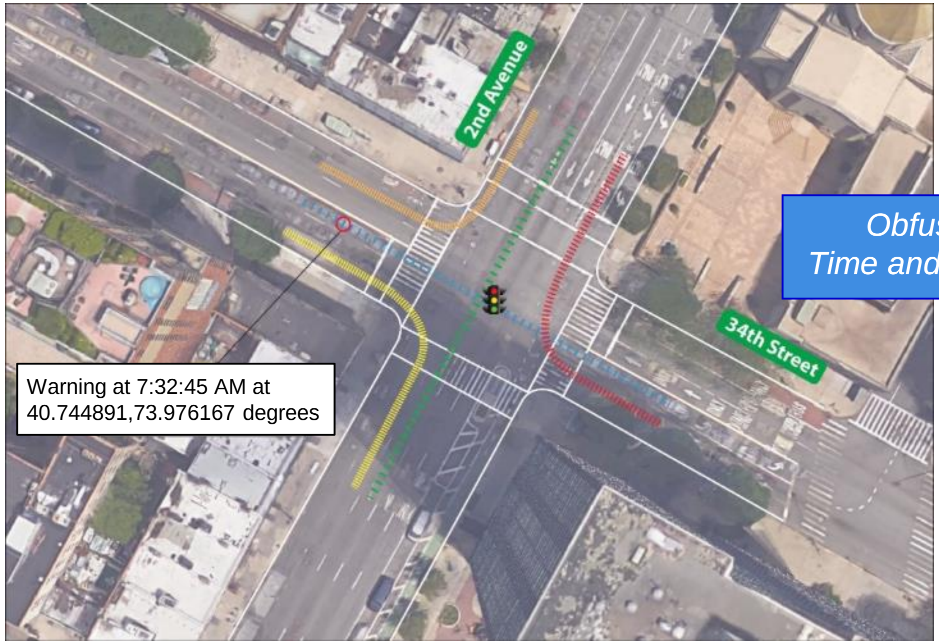
- Instead of 2 TB – only 116 GB per day
  - 17 times less – and more useful detail (@4 events/hour)
  - Includes SPaT and MAP information
  - @1 event / hour /vehicle = 29 GB/day or 67x reduction!

**Privacy Concern**

- If BSM data were to be collected - -
  - Provides vehicle locations at 0.1 second intervals
  - Time-of-day Stamped to 0.1 second accuracy
  - Police Records indicate "final position" of vehicles and time of day
  - CV data could be used to recreate the accident scene
- Even though CV vehicle ID is randomly changed – the raw data can be tracked to an individual vehicle

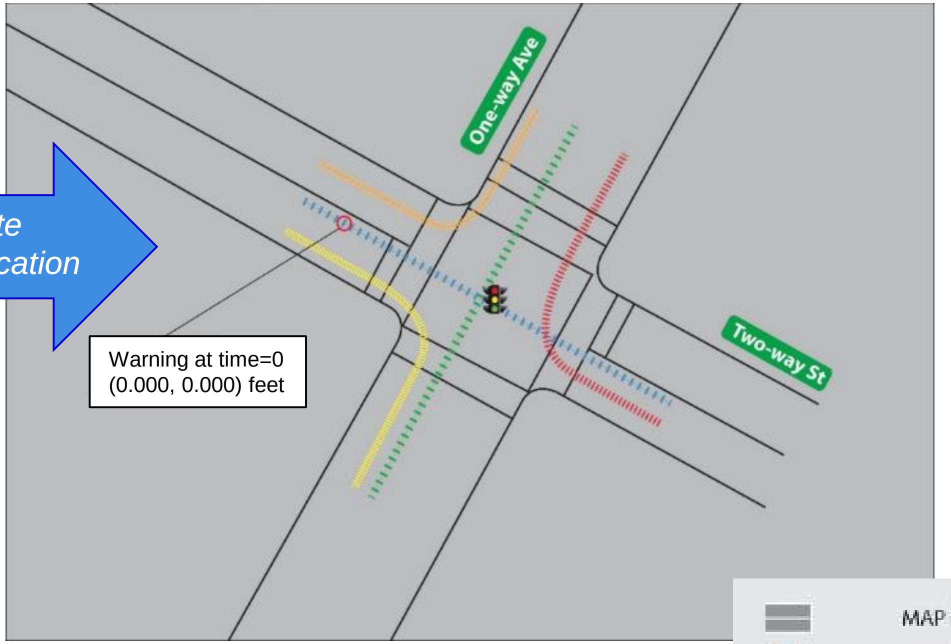
# OBFUSCATION OF OBU ACTION LOGS

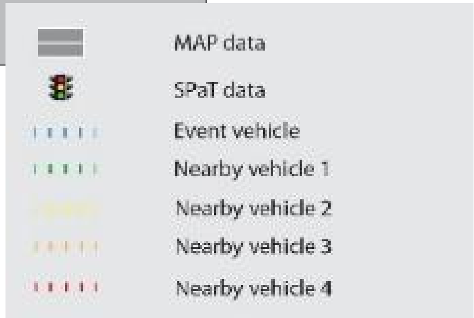
Raw ASD Action Log Data




*Obfuscate*
*Time and Location*

Obfuscated ASD Action Log Data




- Obfuscation process to scrub precise time and location data
  - Relative details retained
- Non-obfuscated data will be destroyed following the obfuscation process

# OTHER EXAMPLES – OPERATIONS DATA

- RF Data – Proactive Analysis
  - Records first and Last BSM heard from each OBU
  - Time-out to find dropouts
  - At 1000 ft. vehicle “hears” RSU for 50 seconds
  - Actual BSMs from that vehicle – 500
  - Assuming 4 dropouts – actual BSMs needed – 8  or 2%
  - Edge computing RSU – monitor OBU keep first/last
  - Same for OBU – 98% bandwidth reduction!
  - Only 8 BSMs actually captured
- Guess who I saw today
  - Track other OBUs seen throughout the City
  - Approximately 2 bytes per encounter

# DATA COLLECTION - SUMMARY

- The CV technology *could* make “mountains of data” available – but there is a cost
  - DSRC Channel time
  - Cellular media monthly limitations
  - Processing and  storage
  - Retrieval (FOIA) & Subpoena
- NYC pilot deployment project
  - Tailored data collection to meet needs
  - Concept is to distribute processing to the edge
  - Added RSU locations to collect data

**NYC System – DSRC only V2I**

# THANK YOU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# STAY CONNECTED

## Contacts for CV Pilots Program/Site AORs:

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- Govind Vadakpat, Tampa (THEA) Site AOR; G.Vadakpat@dot.gov
- Walter During, Evaluation COR, Walter.During@dot.gov

## Visit CV Pilot and Pilot Site Websites for More Information:

- CV Pilots Program: http://www.its.dot.gov/pilots
- NYCDOT Pilot: https://www.cvp.nyc/
- Tampa (THEA): https://www.tampacvpilot.com/
- Wyoming DOT: https://wydotcvp.wyoroad.info/