



# CONNECTED VEHICLE PILOT Deployment Program



## New York City (NYC) Pilot Update at the System Design Milestone



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*Mohamad Talas (NYCDOT, NYC CVPD Project Management Lead)*  
*Bob Rausch (TransCore, NYC CVPD Site Deployment Lead)*  
*David Benevelli (TransCore, NYC CVPD System Engineering Lead)*



# TODAY'S AGENDA



- Purpose of this Webinar
  - Present the conceptual overviews and status reports of the New York City pilot project, as well as the technical challenges and lessons learned of the system design process.
  
- Webinar Content
  - Connected Vehicle Pilot Deployment Program Overview
  - New York City Pilot Overview
  - System Design Overview
  - Challenges and Lessons Learned
  - Stakeholder Q&A
  
- 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



WYDOT



NYCDOT



Tampa (THEA)

STAY CONNECTED

- Participate in **Design/Build/Test Phase** Webinars/Conference Presentations from the three Pilot Sites (see website for exact dates and times)

Sep 2017	Oct 2017	Nov 2017	Dec 2017	Jan 2018	Feb 2018	Mar 2018	Apr 2018	May 2018
◆◆◆	●	◆ ◆ ◆		●		●	◆ ◆ ◆	
System Design	ITS World Congress	Application Deployment		TRB		SXSW	Operational Readiness	

◆ Public Webinars      ● Conference Presentations

- Visit Program Website for Updates: <http://www.its.dot.gov/pilots>
- Contact: Kate Hartman, Program Manager, [Kate.Hartman@dot.gov](mailto:Kate.Hartman@dot.gov)





# **New York City CV Pilot Deployment Concept**

Speaker

Mohamad Talas, PE, PTOE, PhD



# NYC Pilot Goal



## VISION ZERO

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



The NYC pilot will evaluate the **safety** benefits and challenges of implementing CV technology with a **significant number of vehicles** in the **dense urban environment**.

Source: USDOT



# NYC Transportation Challenges

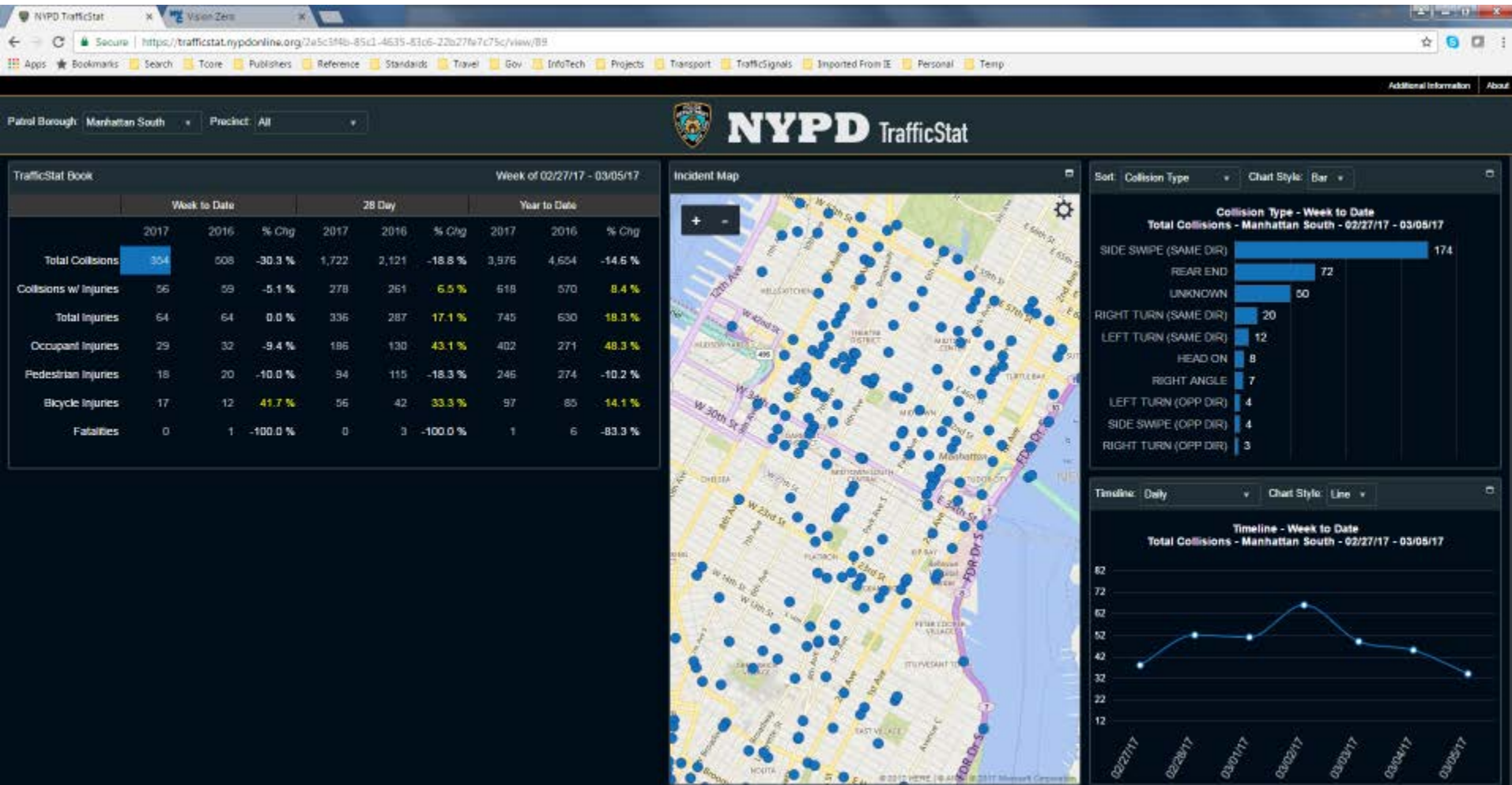


BUS HITS TEENAGE GIRL  
DIE TO CROSS STREET



# NYC Transportation Challenges

## Sample Accident Statistics



This page displays the NYCPD's Traffic statistics as recorded in the TrafficStat book. TrafficStat periods run Monday through Sunday. All figures reflect statistics from the end of the most recent TrafficStat period. The date and information on this website is for informational purposes only. Only the first 5,000 records associated with any given field will be mapped, but all of the data will be available in the analytics panels. For best mapping services, select a specific Patrol Borough or Precinct.

Source: NYCPD <https://trafficstat.nypdonline.org/>

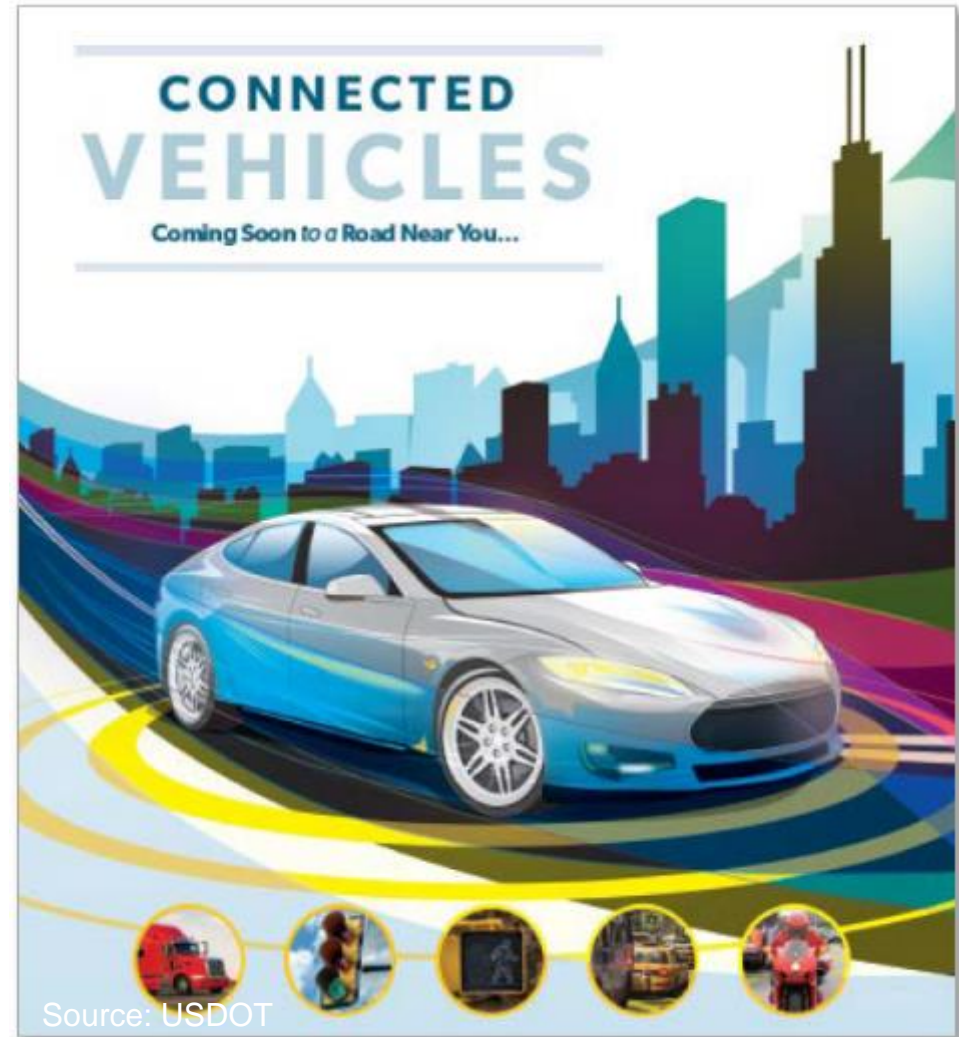


# The Time is Now!



- NHTSA proposed rulemaking that will require all new vehicles to transmit **Basic Safety Messages** is out for comment
- First new cars with connected vehicle technology available for sale/lease in 2017
- Aftermarket safety devices (ASD) will bring existing vehicles into the connected environment

NYCDOT and our Stakeholder's experience will test the standards and shape the future of CV Technology!





# Project Participants



## Stakeholders Fleet Owners and Users



## Project Team



University  
Transportation  
Research Center



# Needs Considered



## ■ Safety

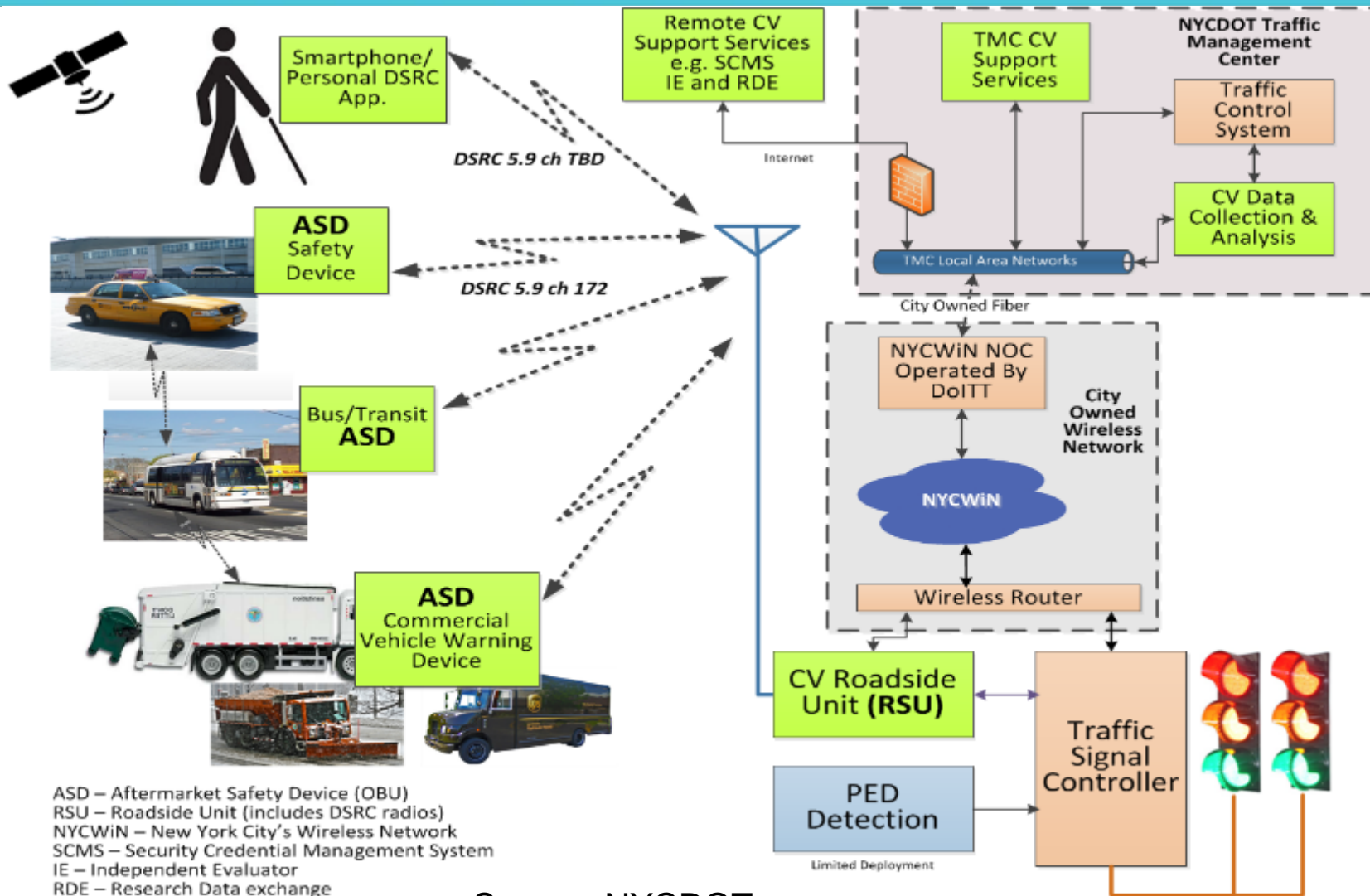
- Need to “manage” speed (25 MPH city-wide except Fwy)
- Need to reduce crashes
  - vehicle-to-vehicle crashes
  - pedestrian injuries
  - crashes & injuries at intersections
  - crashes involving buses
  - crashes of vehicles with infrastructure
- Need to inform drivers of serious travel restrictions

## ■ Management

- Collect performance metrics (safety benefits, traffic conditions)
- Protect privacy
- Manage apps in the urban environment (traffic and geometries)
- Manage and monitor overall operational integrity of the system
- Data needs for the independent evaluator
- Support OTA software and parameter updates



# 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

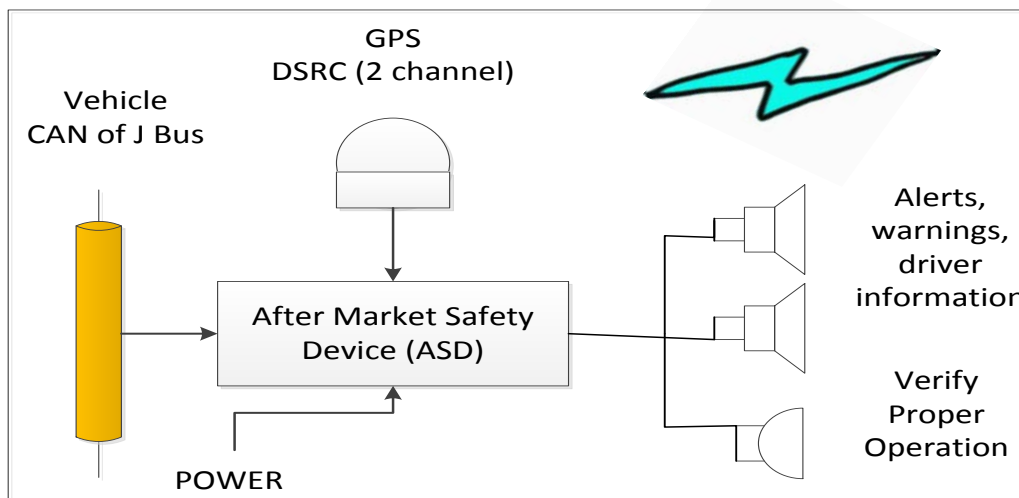
Source: NYCDOT



# Field Infrastructure Concept



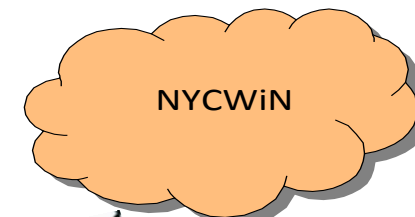
## Typical Vehicle



GPS DSRC (2 channel)



## Typical Roadside



City Owned Network (Fiber or citynet)



Optional Traffic Controller



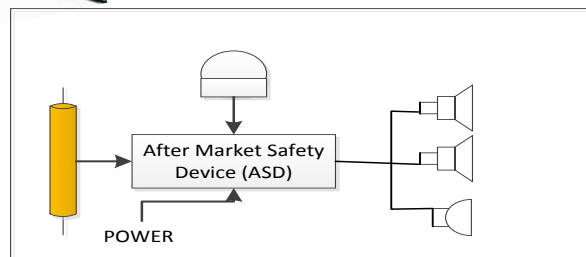
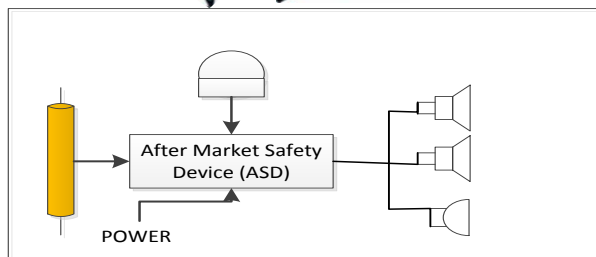
Option Required

DSRC V2V

DSRC V2I

DSRC V2V

DSRC V2I



Source: NYCDOT



# Locations (Manhattan, Brooklyn)



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

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

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



Source: NYCDOT



# Equipment



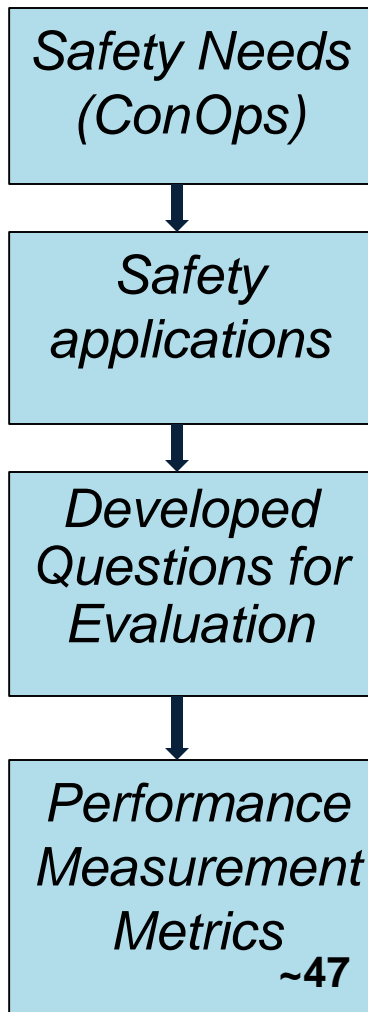
- Deployment of CV Technology in a Dense Urban Environment
  - Up to 8,000 **fleet vehicles** with After Market Safety Devices (ASDs):
    - a ~5,850 Taxis (Yellow Cabs)
    - a ~ 700 MTA Buses
    - a ~1,050 Sanitation & DOT vehicles
    - a ~ 400 UPS vehicles
  - Pedestrian **PIDs** ~100 units
  - Roadside Units (**RSU**) at
    - a ~353 Locations
    - a ~ 8 on FDR
    - a ~ 28 on Flatbush Ave
    - a ~202 Manhattan Ave
    - a ~ 79 Manhattan Cross
    - a ~ 36 Support locations (airports, river crossings, terminal facilities)

**Revenue Producing Vehicles**  
➔ **Cost to Access Vehicles**



# Performance Metrics & Evaluation Methods

## While preserving privacy **47 Metrics**



### Reduce Veh-Veh Crashes

V2V & V2I Safety Applications for Crash Avoidance

- Does number of crashes decrease?
- Does number and severity of red light violations decrease?
- Does number of bus / right turn vehicle crashes decrease?

- Fatality crash counts
- Injury crash counts
- Property damage only crash counts
- Time to Collision
- Red light violation counts
- Red light violation crash counts
- Driver actions and/or impact of actions when they receive alerts
- Bus & right turn related crash counts
- Number of warnings generated
- Right-turning related conflicts

### Data collection:

*Everything that “occurred” immediately before and after the alert*





# System Design Overview

Speakers

Bob Rausch, PE

David Benevelli, PE





## V2V Safety Applications

- |   |      |
|---|------|
| ▪ Vehicle Turning Right in Front of Bus Warning | VTRW |
| ▪ Forward Collision Warning                     | FCW  |
| ▪ Emergency Electronic Brake Light              | EEBL |
| ▪ Blind Spot Warning                            | BSW  |
| ▪ Lane Change Warning/Assist                    | LCA  |
| ▪ Intersection Movement Assist                  | IMA  |

*V2V applications based on existing demonstrations and prior developments and documentation*



## V2I Safety Applications

- Red Light Violation Warning RLVW
- Speed **Compliance** SPD-COMP
- Curve Speed **Compliance** CSPD-COM
- Speed **Compliance**/Work Zone SPDCOMPWZ
- Oversize Vehicle **Compliance** OVC
  - Prohibited Vehicle (Parkways)
  - Overheight
- Emergency Communications and Evacuation Information (*Using the traveler information features*) EVACINFO
- Mobile [**Visually Impaired**] Ped Signal System PED-SIG
- Pedestrian in Signalized Intersection Warning PEDINXWALK
- CV Data for Intelligent Traffic Signal System I-SIGCVDAT

# CV Applications - 3



## Operations, Maintenance, and Performance Analysis

- RF Monitoring RFMON
- OTA Firmware Update FRMWUPD
- Parameter Up/Down Loading PARMLD
- Traffic data collection TDC
- *Event History Recording* *EVTRECORD*
- *Event History Up Load* *EVTCOLLECT*



# Where Did We End in Phase 1?



- Phase 1

Task	Task Name
1	Program Management
2	Concept of Operations (ConOps)
3	Security Management Operating Concept (SMOC)
4	Safety Management Plan
5	Performance Management Plan
6	System Requirements Specification (SyRS)
7	Application Deployment Plan
8	Human Use Approval
9	Participant Training and Stakeholder Education Plan
10	Partnership Coordination and Finalization
11	Deployment Outreach Plan
12	Comprehensive Deployment Plan
13	Deployment Readiness Summary

- Documents Located: [https://www.its.dot.gov/pilots/cv\\_pubs.htm](https://www.its.dot.gov/pilots/cv_pubs.htm)

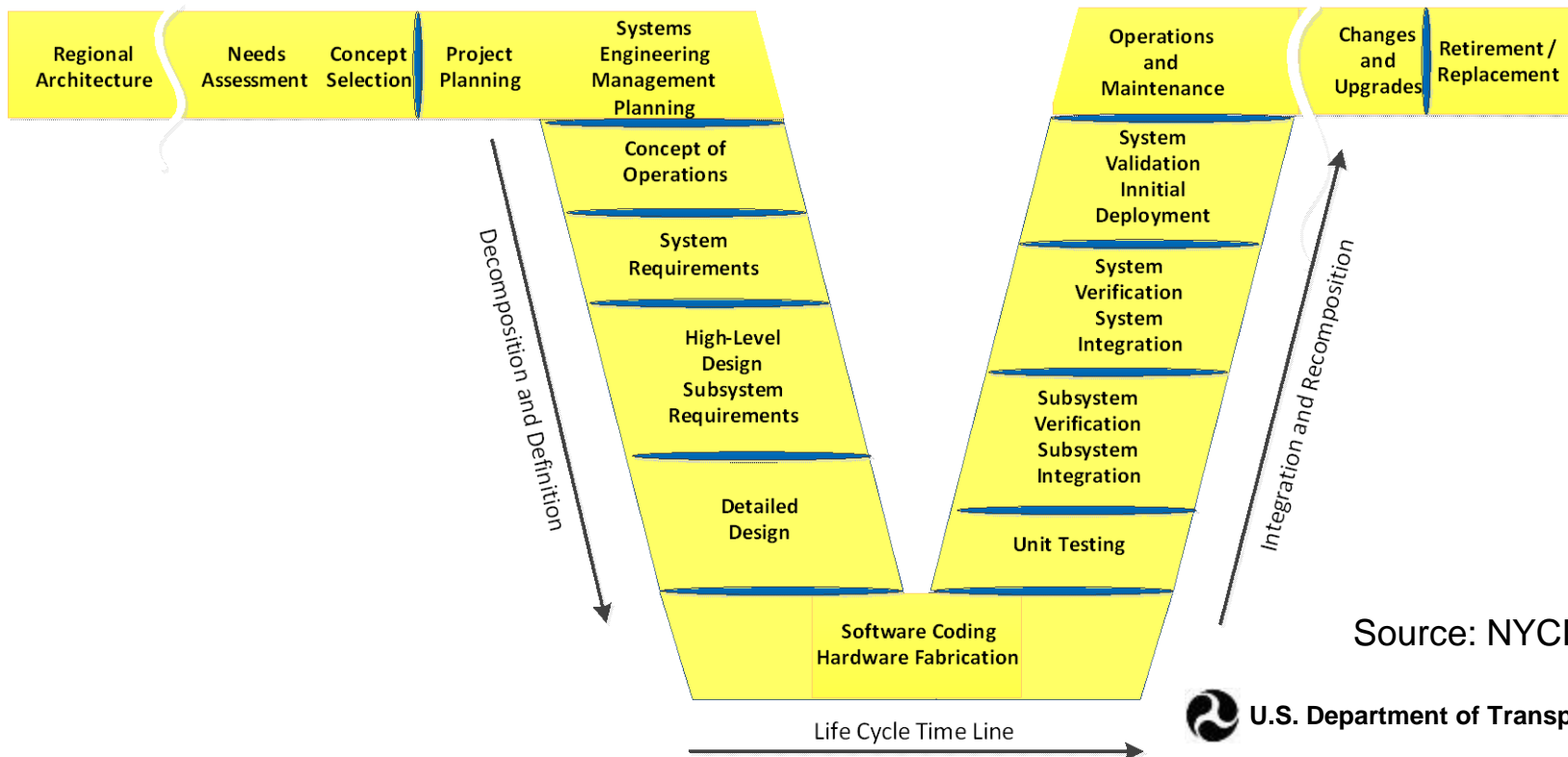




# Where Did We End in Phase 1?

Project Phase I: ConOps, Requirements, Deployment Plan	Project Phase II: Procurement Specifications Development	Project Phase II: Application Design, Procurement Development, Integration	Project Phase II: Requirements, Verification, and Acceptance Testing	Project Phase III: Operations, Data Collection, and Assessment
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Phase -1	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Interfacing with Planning and the Regional Architecture	Concept Exploration and Benefits Analysis	Project Planning and Concept of Operations Development	System Definition and Design	System Development and Implementation	Validation, Operations and Maintenance, Changes & Upgrades	System Retirement/ Replacement



Source: NYCDOT



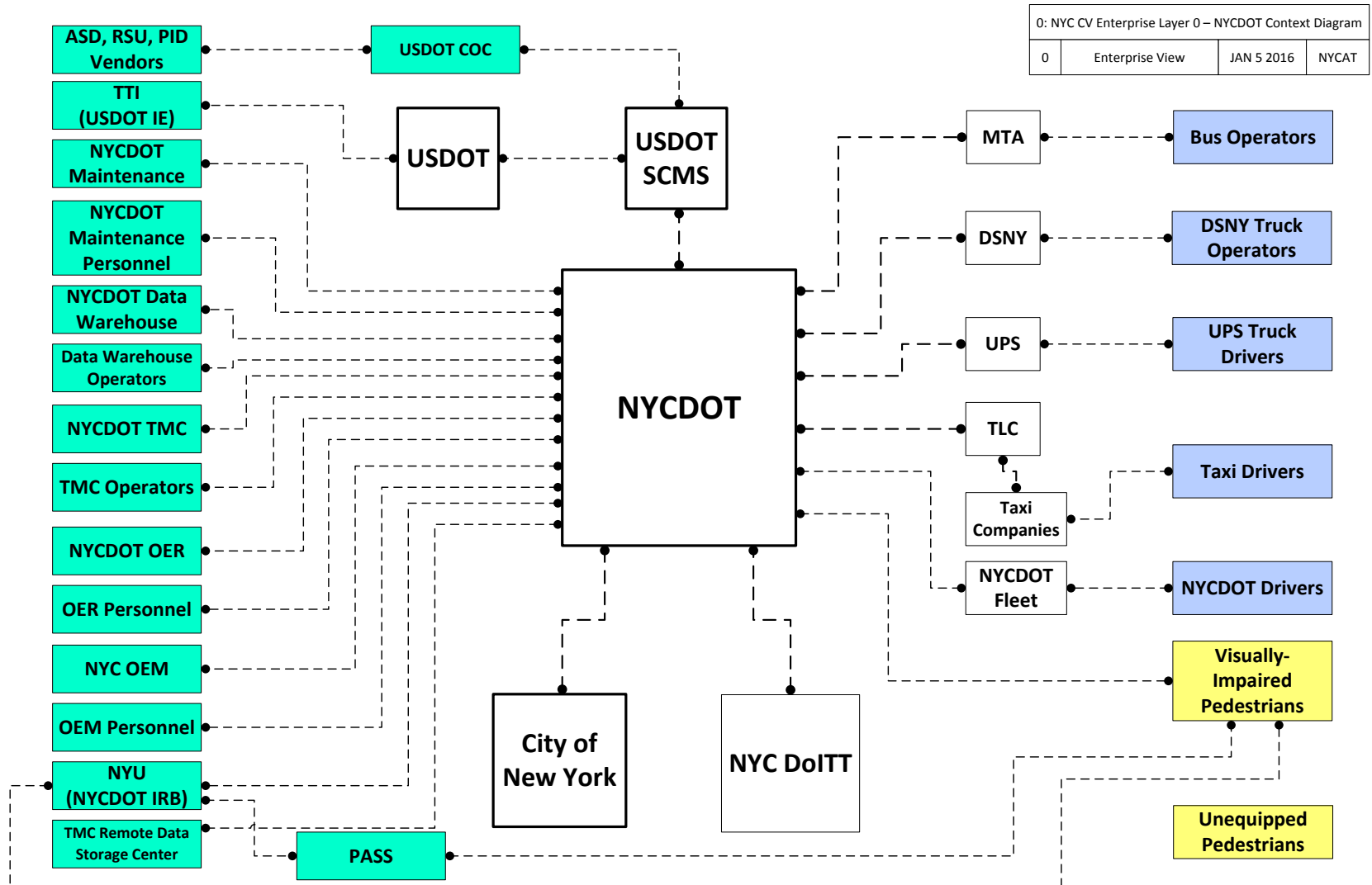
# System Architecture



- Architecture Views
  - Enterprise: roles and relationships between organizations
  - Physical: physical objects (systems and devices), their application objects, and high-level interfaces between physical objects (information flow triple)
  - Communication: communication protocols between application objects
  - Functional: abstract functional elements (processes) and their logical interactions or data flows that satisfy the requirements
- Standard message sets for interoperability
  - BSM
  - MAP
  - SPaT
  - TIM
  - RTCM
- Merged information flow triples (data flow name, source, destination)
- Coordination with all three CV Pilots



# System Architecture: Enterprise

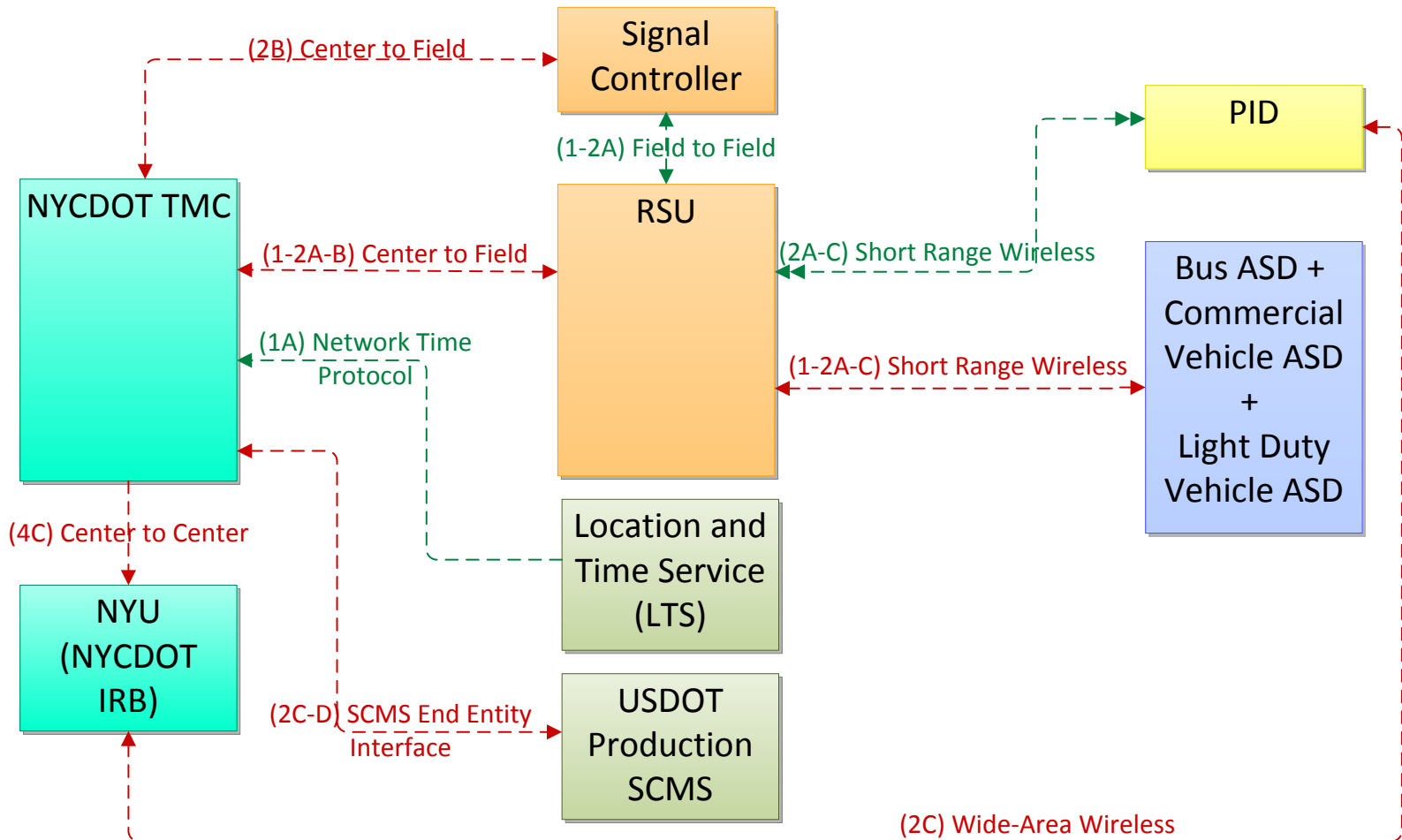


# System Architecture: Physical



## Layer 0 (Simplified)

0: NYC CV Physical Layer 0 - Summary (Simplified)			
2	Physical View	Nov 22 2016	NYCAT



Source: NYCDOT





# System Architecture: Communication



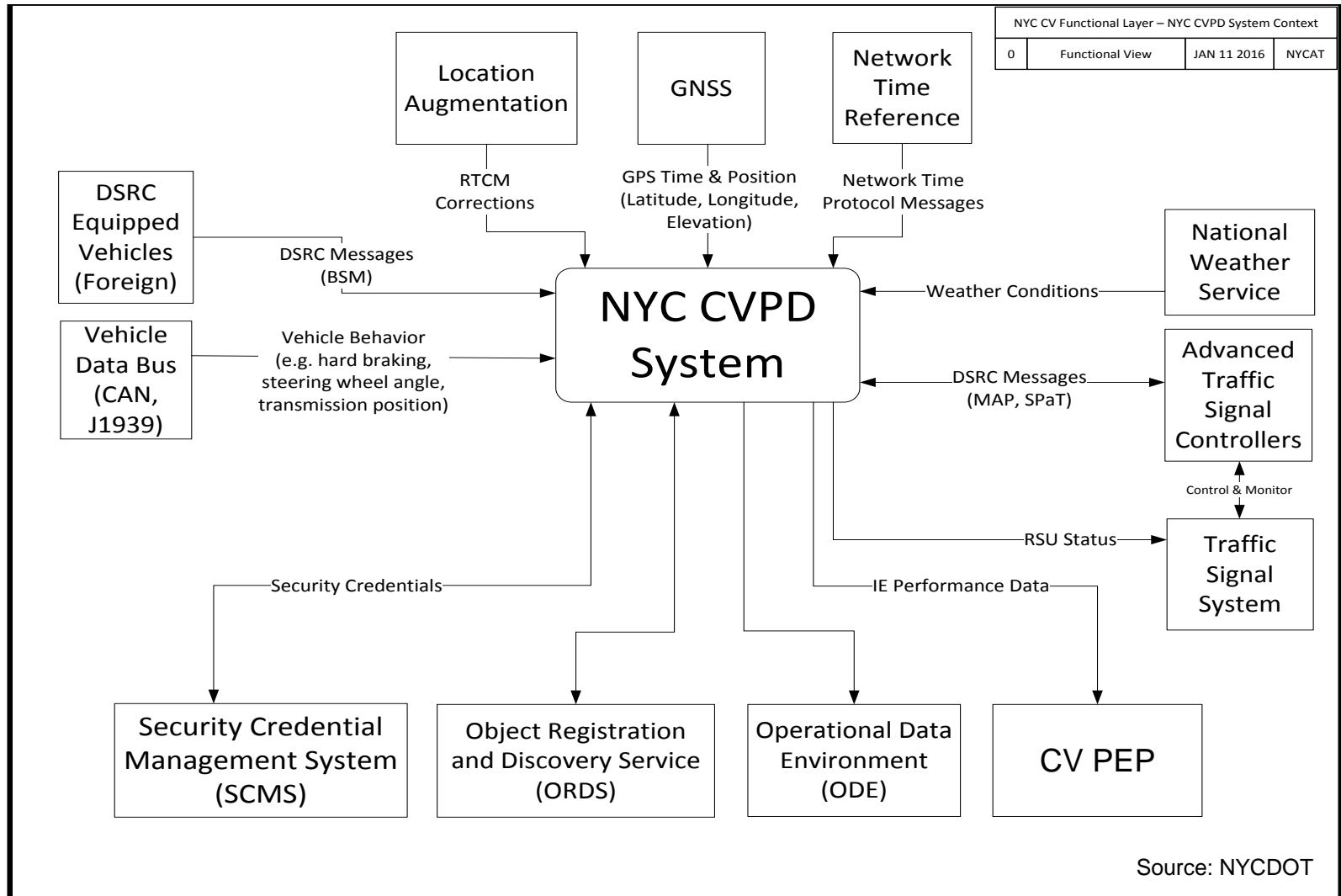
- Defined the protocol stack covering the ‘triples’ throughout the system
- One example protocol diagram for communication view in the NYC CVPD project for the Dedicated Short Range Communication WAVE Short Message Protocol from the SET-IT (ARC-IT) tool
- Identification of the standards

DSRC-WSMP		
FLOWS-SOURCE-DEST		
P-OBJECT-SOURCE		P-OBJECT-DEST
ITS Application Information Layer INFORMATION-LAYER-STANDARD	Security Plane IEEE 1609.2	ITS Application Information Layer INFORMATION-LAYER-STANDARD
Application Layer Undefined		Application Layer Undefined
Presentation Layer ISO ASN.1 DER	Security Plane Undefined	Presentation Layer ISO ASN.1 DER
Session Layer Undefined		Session Layer Undefined
Transport Layer IEEE 1609.3 WSMP		Transport Layer IEEE 1609.3 WSMP
Network Layer IEEE 1609.3 WSMP		Network Layer IEEE 1609.3 WSMP
Data Link Layer IEEE 1609.4, IEEE 802 MAC, IEEE 802.11p		Data Link Layer IEEE 1609.4, IEEE 802 MAC, IEEE 802.11p
Physical Layer IEEE 802.11p		Physical Layer IEEE 802.11p

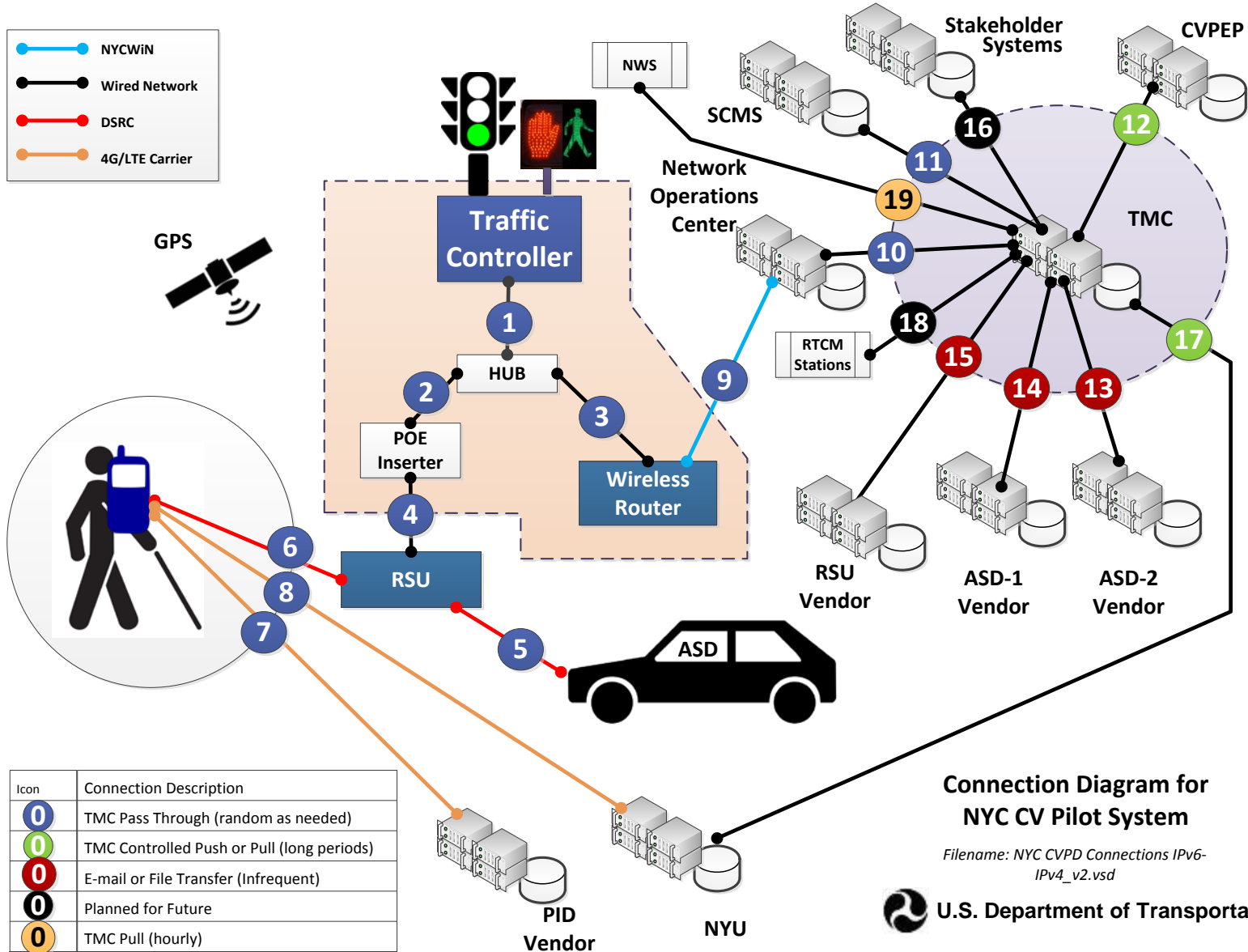
Source: NYCDOT



# System Architecture: Functional



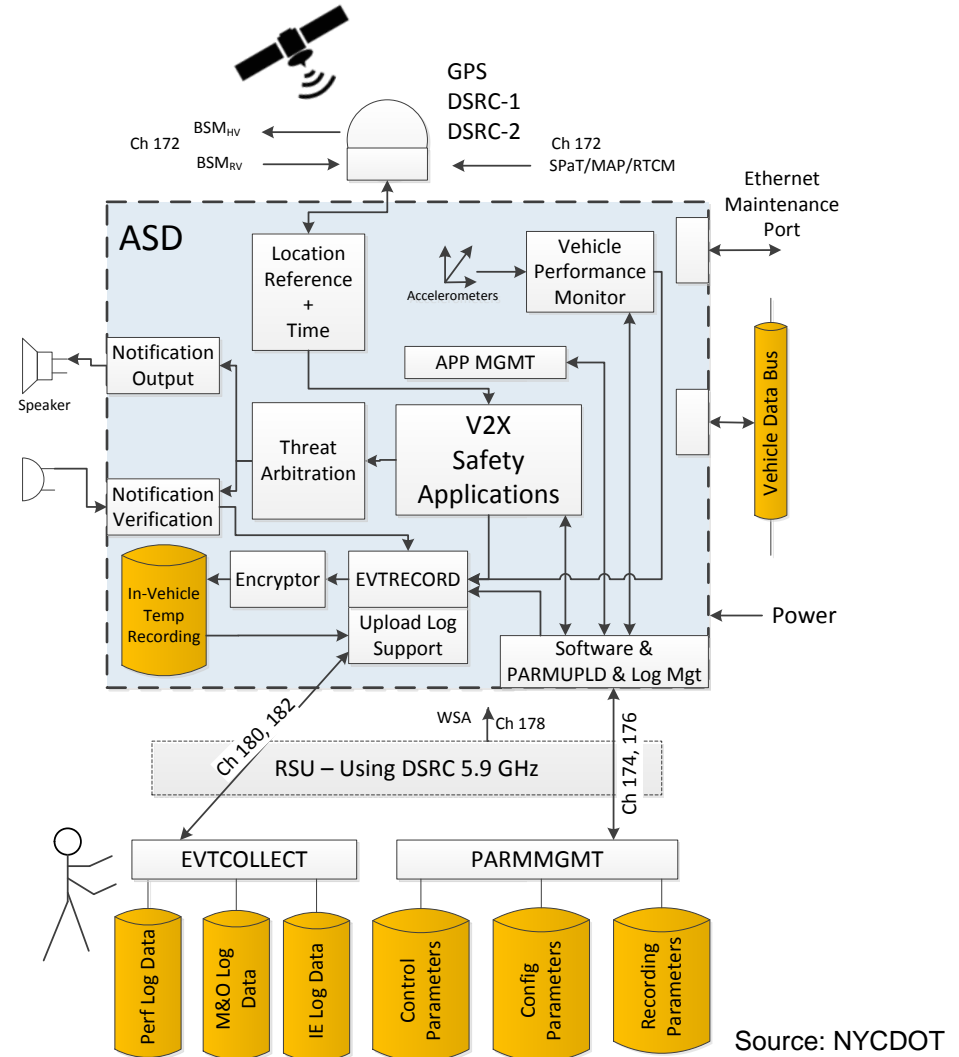
# System Architecture: Connections



# System Architecture: Functional



- Generic ASD context for event data lifecycle
  - Event Recording
  - Event Collection
  - Event Upload and Data Obfuscation



# System Architecture to System Design



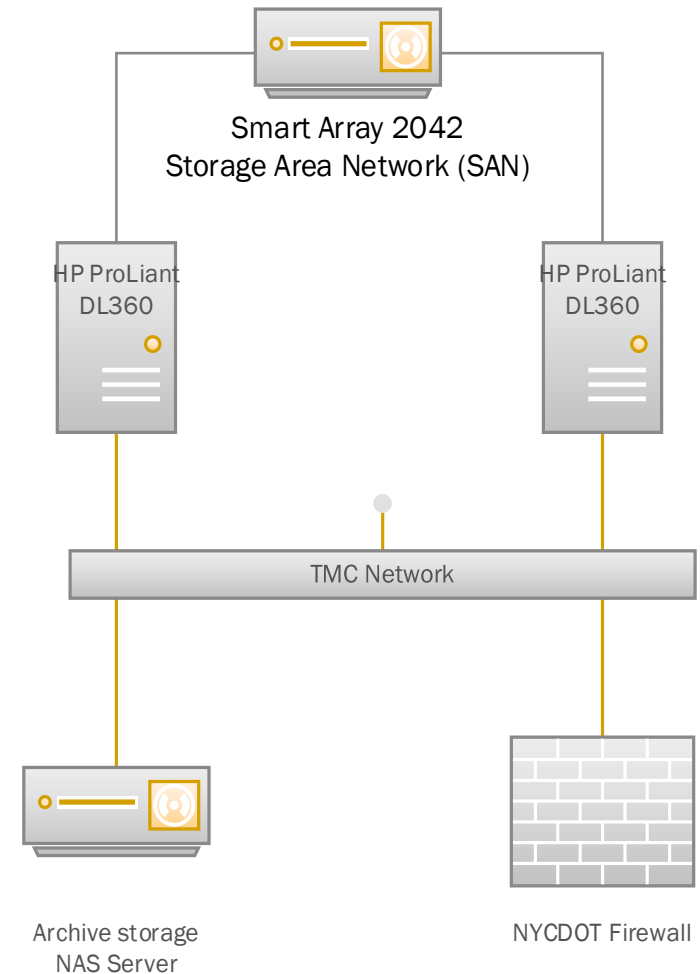
- Device Procurement Specifications
  - ASD
  - RSU
  - PID
  - TMC HSM
- Vendor solicitation, demonstration, and request for expression of interest and proposal (RFEIP)
  - RF Test Equipment
  - Ped Detection Equipment
  - Controller Firmware
- Interface Control Document (ICD) and Standards Plan
- Standard message sets for interoperability
- Development of management applications for operations, maintenance, and performance analysis at NYCDOT TMC
- Refinement of system, design, and interface requirements
- Stakeholder engagement: development installation procedures and standard operating procedures (SOP) with the vendors



# TMC / CV System Hardware / Platform



- NYCDOT Traffic Management Center (TMC)
  - Hardware
    - <sup>a</sup> Redundancy and data protection through storage area network (SAN) Smart Array 2042
      - Share data
      - Balance processing tasks
    - <sup>a</sup> Base software configuration
      - Windows Server 2016
      - Microsoft SQL Server 2016 – Standard Edition
      - A virtualized server environment established with Microsoft's Hyper-V technology



Source: NYCDOT



# TMC / CV System Software



- ASD Management
  - Processes: parameter update, monitoring, maintenance, software updates
  - Reports: malfunction, RF, status (sighting, warnings)
- RSU Management
  - Processes: editor, communication manager (ASD), communication control (TMC), mobile RSU, software updates
- RSU Status
  - Processes: monitor, communication manager (ASD), TransSuite ATMS Map, System Logger, Alarm System, NYC DoITT
  - RF propagation status
- MAP and TIM management – Includes Security Signing
- Security (HSM, Aerolink, SCMS support)



# TMC / CV System Software (Cont.)



- Performance Evaluation
  - Crash data from existing NYC PD records
  - Event data from safety applications
  - Fleet operator data from anonymous vehicle operators
  - Number of events (by event type) during Before and After periods
- Event Data Obfuscation
- Travel Time calculations
  - Feed Adaptive control system – Midtown-in-Motion
- Operations monitoring



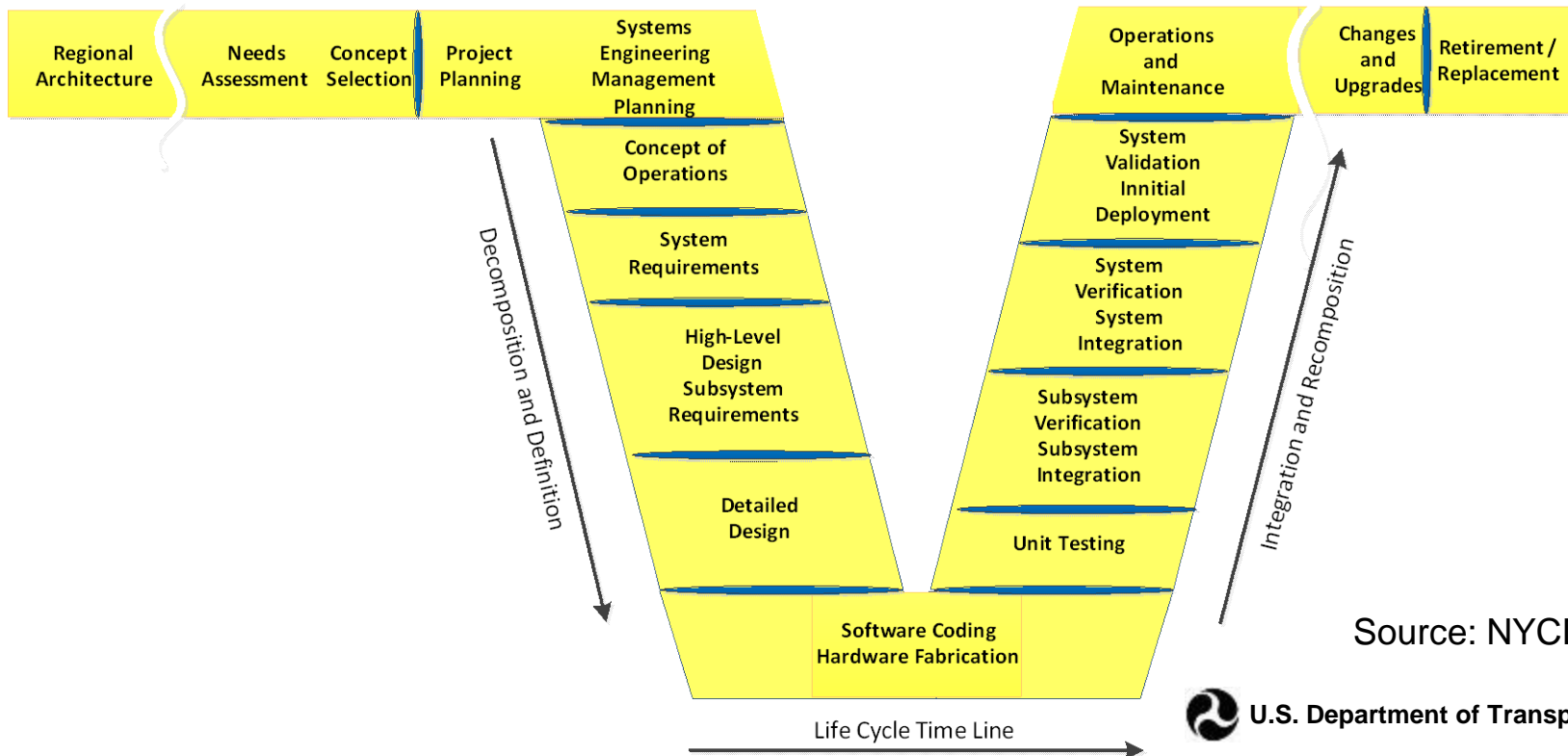


# Next Steps



Project Phase I: ConOps, Requirements, Deployment Plan	Project Phase II: Procurement Specifications Development	Project Phase II: Application Design, Procurement Development, Integration	Project Phase II: Requirements, Verification, and Acceptance Testing	Project Phase III: Operations, Data Collection, and Assessment
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Interfacing with Planning and the Regional Architecture	Concept Exploration and Benefits Analysis	Project Planning and Concept of Operations Development	System Definition and Design	System Development and Implementation	Validation, Operations and Maintenance, Changes & Upgrades	System Retirement/ Replacement



Source: NYCDOT





# Challenges and Lessons Learned

Speakers

Bob Rausch, PE

David Benevelli, PE



# Challenges Resolved



- Privacy
- Security
- ASD Procurement
- Location
- CV Application Tuning
- Traffic Signal Controller Interface





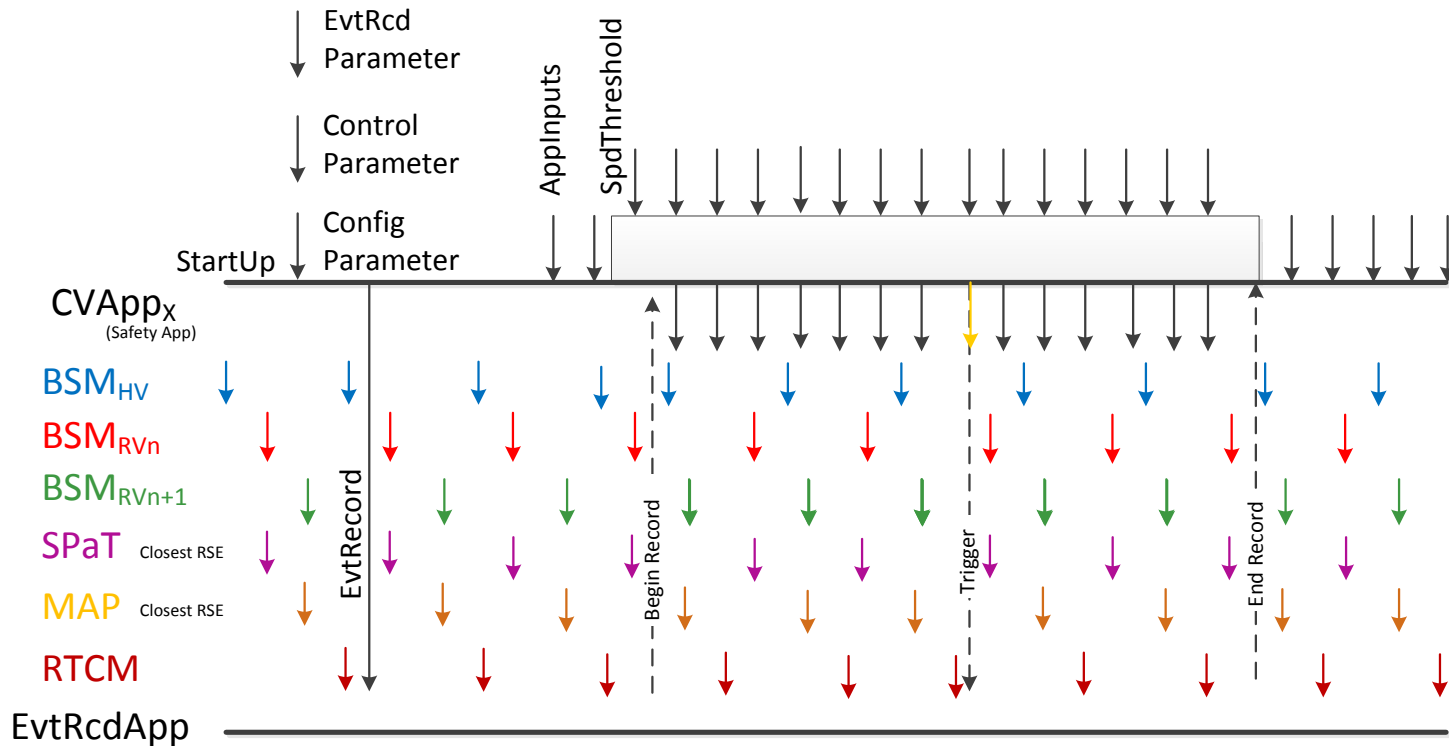
# Lesson 1: Privacy

- Privacy is a critical issue for our stakeholders.
- It is more complex than NYCDOT and USDOT previously imagined.
- Plan additional time for understanding the issues, formulating workable solutions, and negotiating agreements with the many stakeholders.
- Data collection schemes need to be tempered by the privacy issues.
- Deployment of a “production CV system” is different from an R&D platform !
- For every step, evaluate the impact on privacy
  - Focus: ***privacy by design***
  - Stakeholders needed reassurance on protection of privacy

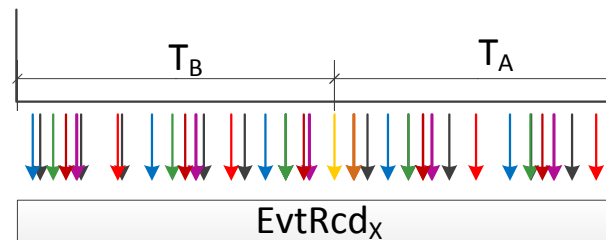
- ✓ Address privacy of safety/operational data using multiple tools
  - ✓ MOUs
  - ✓ Onboard data encryption
  - ✓ Collection time limits
  - ✓ Data obfuscation, sanitization, normalization



# System Design: Data Collection



All of the data collected during  $T_B$  is transferred to the event record, and after the trigger the data is collected and added to the record until  $T_A$  expires.



Source: NYCDOT



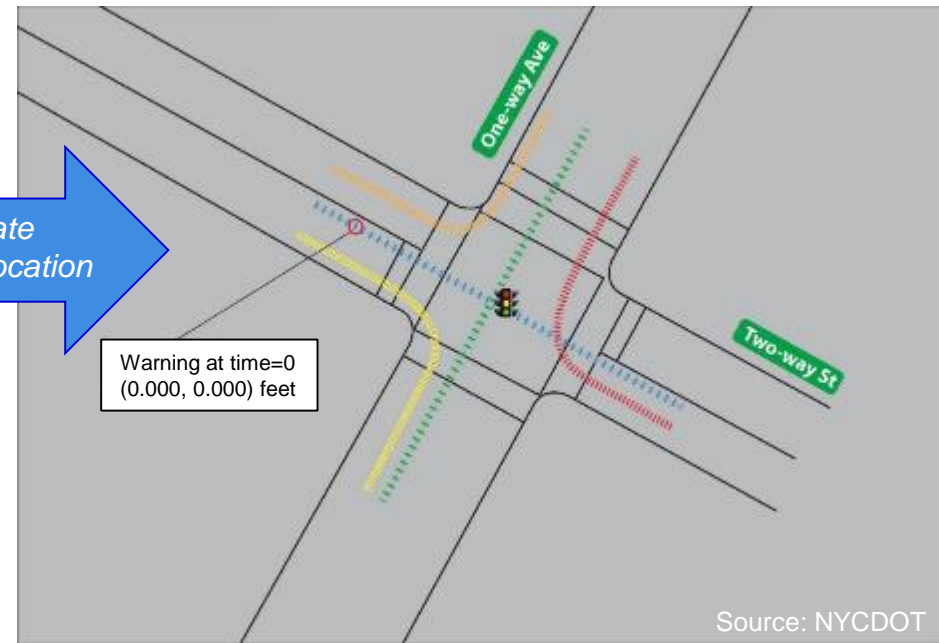
# System Design: Privacy Protection



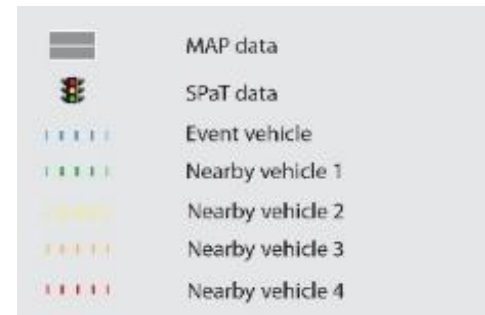
Raw ASD Action Log Data



Obfuscated ASD Action Log Data



- Obfuscation process to scrub precise time and location data from the ASD action logs for privacy
  - Relative details retained
- Non-obfuscated data will be destroyed following the obfuscation process



# Lesson 2: Security –

## Maintaining a Trusted Environment



- Integration with USDOT SCMS
  - SCMS development in parallel with project
  - SCMS Proof-of-Concept (POC) End Entity (EE) requirements continue to be refined
  - SCMS POC is to be released for production shortly
  - SCMS PlugFest sessions
  - Signing TMC content generates new requirements
  - Protecting SCMS investment (FIPS-140-2 Level, HSM)
  - Policies for certificate life-cycles
  - IPv4 and IPv6 access

- ✓ Address security in all aspects of the CV and DOT system
  - ✓ TMC security (physical, system access needs)
  - ✓ Devices & networks (operating firewalls, NATs, management)
  - ✓ Complexity and troubleshooting
  - ✓ Security monitoring



# Lesson 3: ASD Procurement

- NYC fleets are a special case
- Data collection needs for performance measures
- Application maturity lower than expected
  - No industry application performance requirements **available**
- Transportation agency's to consider user's equipment
  - Fleets vs private vehicles

- ✓ Tools, tools, tools, ...
  - ✓ System Engineering Process (needs, requirements, specifications, traceability)
  - ✓ Leverage existing device vendor experience
  - ✓ Request for Expression of Interest and Proposal Process
  - ✓ RF tools (interference detection, protocol analyzers, GPS repeaters, ...)
  - ✓ Security monitoring







# Lesson 4: Location

- GPS accuracy in the urban canyon is challenging
  - Limited sky views limit satellite connections
  - Bridges, roadway decks, and short tunnels limit sky views
  - Relative V2V and absolute V2I accuracy needs

- ✓ Require supporting techniques to improve location accuracy
  - ✓ Dead reckoning
  - ✓ CAN bus integration for speed information
  - ✓ Inertial Management Unit (IMU) integration
  - ✓ RSU triangulation



# Lesson 5: CV Application Tuning



- One application, three different experiences
  - 1) Your Grandmother would be comfortable
  - 2) It does its job as you gasped that it felt close
  - 3) Its aggressive and all passengers looking for their virtual brake pedal

- ✓ Key is tuning for urban density and speeds to balance alerts versus false alarms
  - ✓ Consistent expectations
  - ✓ Performance tradeoffs
  - ✓ Stage open sky testing and urban canyon testing



# Lesson 6: Controller Interface



- Controller interface required for SPaT data source



- ✓ Employ DRAFT NTCIP 1202-v3
  - ✓ First implementation
  - ✓ Standards based
  - ✓ Single vendor
  - ✓ Active owner participation
  - ✓ Future interoperability?





# Challenges Outstanding

- SCMS POC Protection
  - FIPS-140-2 Level
  - Integration of Hardware Security Modules (HSM)
  - TIM/MAP signing at data generation source - TMC
  - Policies for certificate life-times
  - Certificate capture and storage for potential CRL use
- Interoperability
  - Messages
  - Channel allocation
  - Applications
- CAN bus integration
- Location Referencing
  - RTCM need?



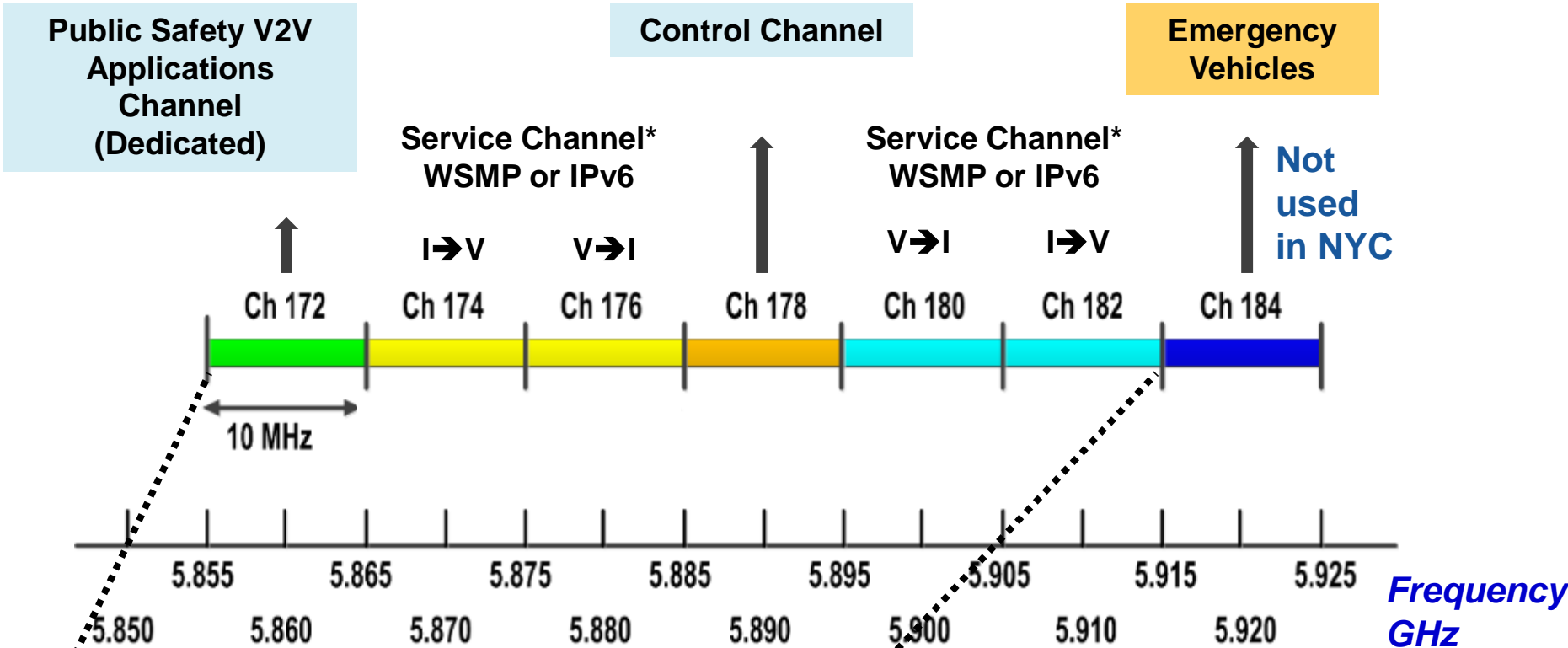
# Interoperability



- Interoperability with interfaces, applications, channel allocation
- Standard message sets (Adding SSPs to messages, security profiles)
  - BSM
    - <sup>a</sup> BSM Part II content required for trucks & fleet operations
    - <sup>a</sup> Multi-unit vehicle length
    - <sup>a</sup> Over-height application
  - MAP
    - <sup>a</sup> Mapping crosswalks
  - SPaT
  - TIM
  - PSID usage for SSM and SRM
  - WSA assignment
- Agreed to conventions for using standards in compatible manner
- SCMS certificate requests
- *OTA software updates and application tuning*



# Challenge Only DSRC Communications



DSRC only communications

Plan on using 6 channels – Dual Radios

*\*Service Channel: uploading log files; downloading firmware & application parameters and security certificates*





# Challenges Forthcoming

- Vender intellectual property (IP) vs. parameter tuning
- Bandwidth for OTA updates (time required)
- Devices from multiple vendors
- Installation in a wide variety of vehicles, antenna location and cable routing paths, CAN bus integration
- Intersection deployment planning
  - Mast arm visibility
  - Controller cabinet location
- Standards evolution and stability
- Misbehavior reporting/detection, CRL
- Performance evaluation, simulation modeling
- Pedestrian recruitment
- DSRC on PIDs





# Infrastructure Experience

- DSRC Licensing (FCC)
  - Class C devices required three applications per site to license the full channel range (~1000 total)
  - A long process (+16 months)
  - 75 Km airport range (LGA, JFK, ENW, TEB)
    - <sup>a</sup> Heliports / Seaplane (Four in Manhattan)
  - Requires Interdepartment Radio Advisory Committee (IRAC) coordination (NTIA, FAA, ...)
  - Waiver requests to expedite the process
    - <sup>a</sup> IRAC geographic coordination
    - <sup>a</sup> Antenna EIS
  - Working with USDOT/FCC to improve the process with a goal of bulk data exchange







# Infrastructure Experience

- MAP generation
  - Manage costs (utilize existing tools, survey needs)
  - Adopt conventions
    - <sup>a</sup> Intersection approach (standalone, interlaced, mid-point)
    - <sup>a</sup> Crosswalk approach (link, end-points, combination)
  - Assumptions
    - <sup>a</sup> Each intersection map must stand-alone for CV app use
    - <sup>a</sup> Maps don't link together (interlaced)
  - Tool Improvement Examples

• Photo dating	• Zoom levels
• Lane identification	• Connections
• Encoding size	• Error messages
  - Working with USDOT tool to improve the next generation



# Current Activities



- Working with stakeholders & vendors
  - Developing installation procedures and installation verification environment
    - <sup>a</sup> Have outfitted a number of vehicles
  - Interface to CAN and J bus
  - Working with sample and prototype units
- Procurement
  - Final negotiations with 2 vendors for ASD and installation kits
  - Working with vendors on design and deployment “issues”
- Developing Software for Back Office CV support
  - Have connected to sample RSUs
  - Developing performance measures analysis and obfuscation software
- Final execution of MOUs with stakeholders – details have been worked out
- Did sample Initial RF interference study of critical locations – awaiting RF test Eqpt.
- Moving forward on the integration of a Level 3 HSM at TMC to sign TIM, MAP, [RTCM]
- Working with standards organizations – SPaT, MAP, BSM, TIM, ISO (19091) for conformance to standards and updating standards to meet NYC requirements
- Cooperating with our Sister Sites for interoperability testing



# 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



## 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

## Visit the Pilot Site Websites for more Information:

- NYCDOT Pilot:  
<https://www.cvp.nyc/>
- Tampa (THEA):  
<https://www.tampacvpilot.com/>
- Wyoming DOT:  
<https://wydotcvp.wyoroad.info/>

## Contact for CV Pilots Program:

Kate Hartman, Program Manager

[Kate.hartman@dot.gov](mailto:Kate.hartman@dot.gov)

## Contact for Pilot Sites:

- Kate Hartman, WYDOT Site AOR  
[Kate.Hartman@dot.gov](mailto:Kate.Hartman@dot.gov)
- Jonathan Walker, NYCDOT Site AOR  
[Jonathan.b.Walker@dot.gov](mailto:Jonathan.b.Walker@dot.gov)
- Govind Vadakpat, THEA Site AOR  
[G.Vadakpat@dot.gov](mailto:G.Vadakpat@dot.gov)

