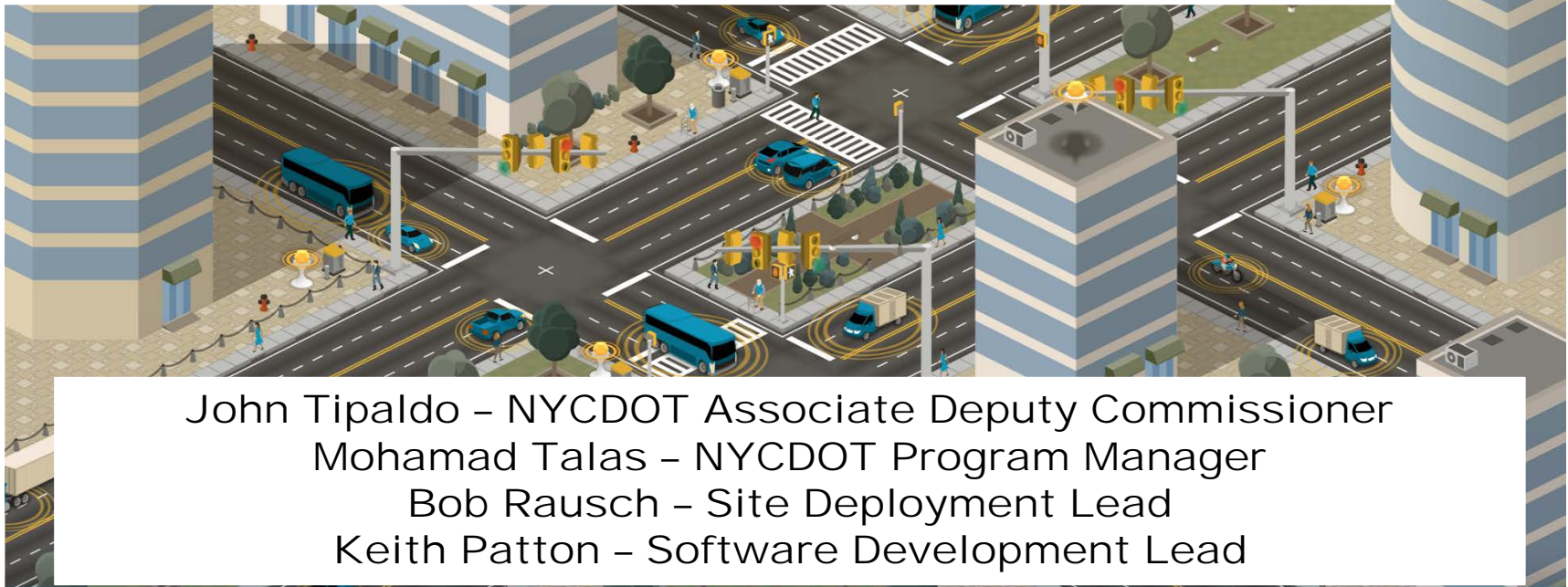




CONNECTED VEHICLE PILOT Deployment Program



New York City Pilot Update at the Application Design Stage



John Tipaldo – NYCDOT Associate Deputy Commissioner
Mohamad Talas – NYCDOT Program Manager
Bob Rausch – Site Deployment Lead
Keith Patton – Software Development Lead

ITS Joint Program Office



TODAY'S AGENDA



- Purpose of this Webinar
 - Share experiences of designing CV applications
 - Talk about how these applications are being designed/developed
 - Identify technical and other barriers and how they are being overcome
 - Discuss how these apps will eventually be tested and their performance measured

- Webinar Content
 - Connected Vehicle Pilot Deployment Program Overview
 - New York City CV Application Design Experiences
 - 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 upcoming Webinars/Conference Presentations from the three Pilot Sites (see website for exact dates and times)

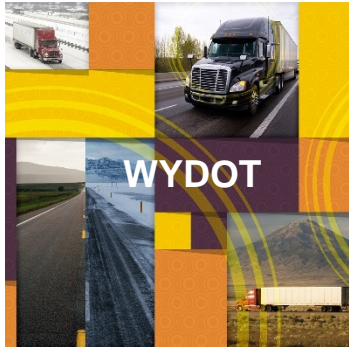
July 2018	Aug 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019
◆	◆	◆	●	◆	◆	◆
Device Acquisition and Installation			ITE Annual Meeting	Operational Readiness		TRB

◆ Public Webinars ● Conference Presentations

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



THE THREE PILOT SITES



- Reduce the number and severity of adverse weather-related incidents in the I-80 Corridor in order to improve safety and reduce incident-related delays.
- Focused on the needs of commercial vehicle operators in the State of Wyoming.



- Improve safety and mobility of travelers in New York City through connected vehicle technologies.
- Vehicle to vehicle (V2V) technology installed in up to 7,000 vehicles in Midtown Manhattan, and vehicle to infrastructure (V2I) technology installed along high-accident rate arterials in Manhattan and Central Brooklyn.



- Alleviate congestion and improve safety during morning commuting hours.
- Deploy a variety of connected vehicle technologies on and in the vicinity of reversible express lanes and three major arterials in downtown Tampa to solve the transportation challenges.





John Tipaldo - NYCDOT

- Project Overview
- Safety Applications
- Performance Measurement
- Operations and Management
- Discussion and Questions

Safety – Mobility - Environment



Today's Transportation Challenges



Safety

- 32,675 highway deaths in 2014
- 6 million crashes in 2014
- Leading cause of death for ages 11, 16-24



Mobility

- 6.9 billion hours of travel delay
- \$160 billion cost of urban congestion



Environment

- 3.1 billion gallons of wasted fuel
- 56 billion lbs of additional CO₂



Data Sources:

Quick Facts: 2014 Data, National Highway Traffic Safety Administration (January 2016); 2015 Annual Urban Mobility Report, Texas Transportation Institute (Aug 2015); Centers for Disease Control



U.S. Department of Transportation
ITS Joint Program Office



U.S. Department of Transportation

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**.

These benefits and goals cannot be achieved without the **active participation of our Partner Stakeholders!**

Source: USDOT

NYC Transportation Challenges



A 76-year-old Florida woman died Saturday after being struck by a taxi as she walked in a crosswalk in Manhattan, emergency officials said.



NYPD Manhattan South Traffic Statistics



NYPD TrafficStat <https://trafficstat.nypdonline.org/2e5c3f4b-85c1-4635-83c6-22b27fe7c75c/view/89> 120%

Most Visited Getting Started Search Weather TransCore Travel References CvTools Gov Local

Additional Information About

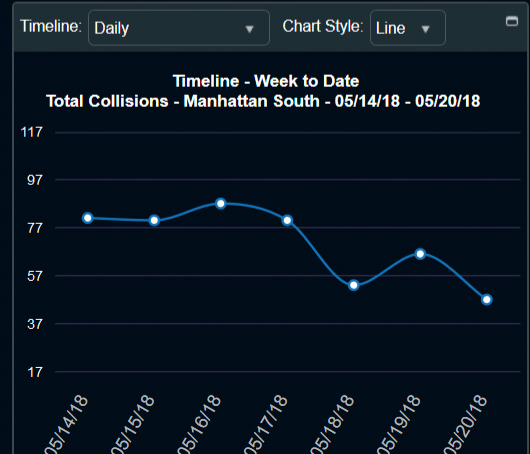
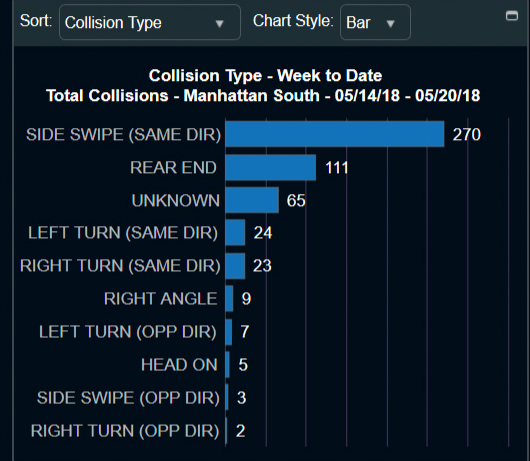
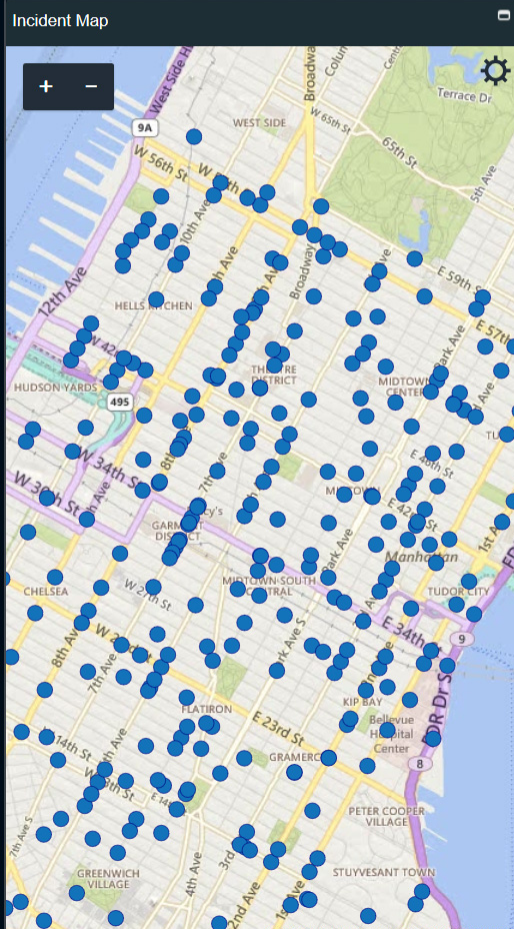
Patrol Borough: Manhattan South Precinct: All



NYPD TrafficStat

TrafficStat Book Week of 05/14/18 - 05/20/18

	Week to Date			28 Day			Year 1
	2018	2017	% Chg	2018	2017	% Chg	2018
Total Collisions	519	639	-18.8 %	2,037	2,327	-12.5 %	9,573
Collisions w/ Injuries	73	77	-5.2 %	271	309	-12.3 %	1,361
Total Injuries	99	119	-16.8 %	338	390	-13.3 %	1,607
Occupant Injuries	67	49	36.7 %	185	197	-6.1 %	802
Pedestrian Injuries	17	51	-66.7 %	89	124	-28.2 %	544
Bicycle Injuries	15	19	-21.1 %	64	69	-7.2 %	261
Fatalities	0	1	-100.0 %	0	3	-100.0 %	3



Project Goals



- Assess the application of CV technology in a dense urban environment.
- Focus on equipping fleets to enable a significant number of vehicle interactions in a concentrated area.
- Develop strategies to address daily operations of CV technologies.
- Assess the benefits of the CV applications with respect to safety and mobility

CV Deployment Equipment



- Up to 7,000 **fleet vehicles** with Aftermarket Safety Devices (ASDs):
 - Taxis (Yellow Cabs)
 - MTA Buses
 - Sanitation & DOT vehicles
 - DCAS vehicles
- Pedestrian **PIDs** ~100 units for visually impaired
- Roadside Units (**RSU**)
at ~353 Locations
 - ~202 Manhattan Ave
 - ~ 79 Manhattan Cross
 - ~ 28 on Flatbush Ave
 - ~ 8 on FDR
 - ~ 36 Support locations (airports, river crossings, terminal facilities)

Interesting 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



Source: USDOT

Locations (Manhattan, Brooklyn)



Vehicle to Vehicle (V2V) applications work **wherever** equipped vehicles encounter one another.

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

The CV project leverages the City's transportation investments



Source: NYCDOT



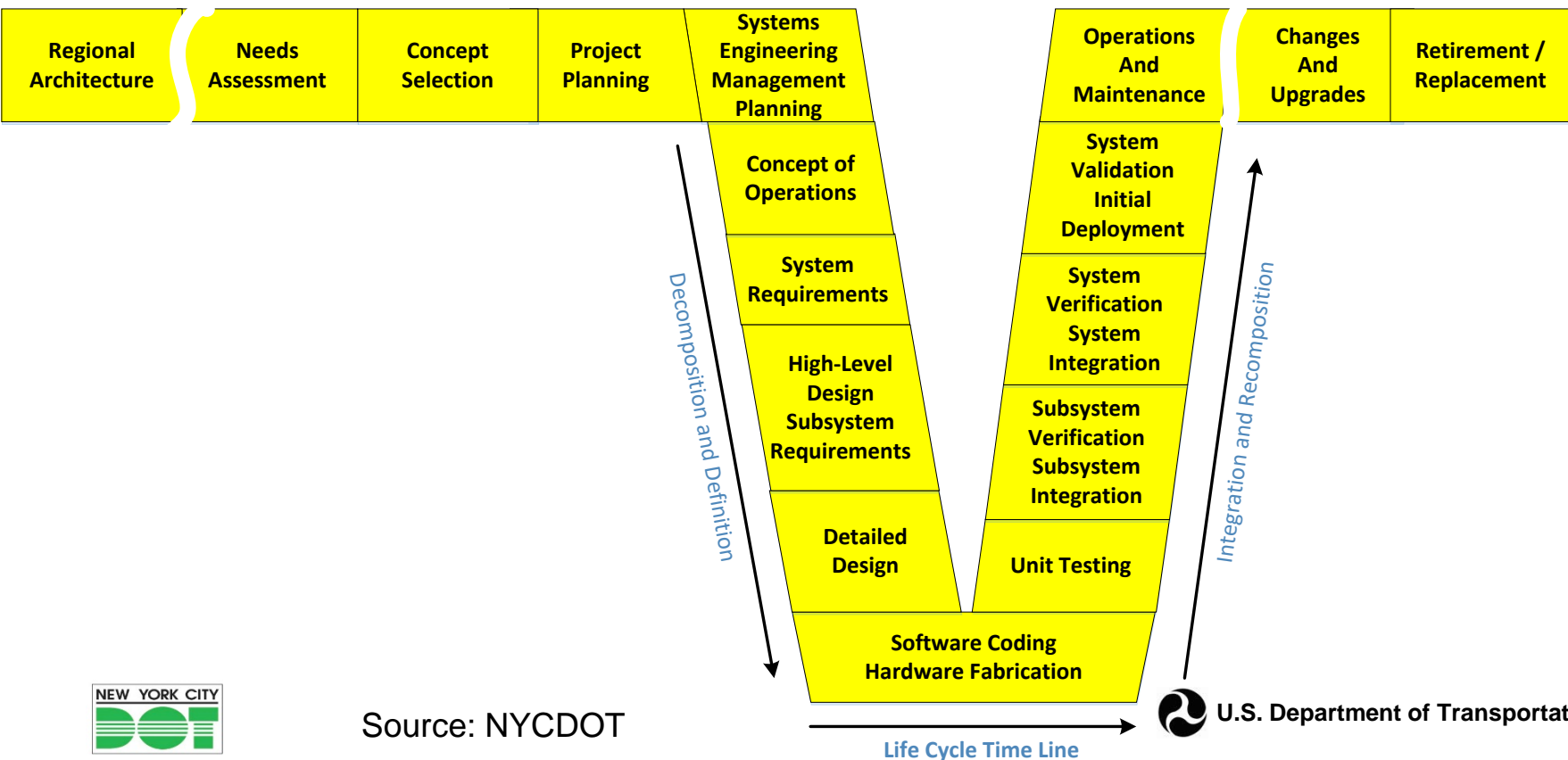
Applications Development Overview

Bob Rausch

System Engineering Process



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	
Phase -1	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5			
Interface 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			





Vehicle-to-Vehicle

- 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

Pedestrian Applications

- Pedestrian in Crosswalk
- PED-SIG

Vehicle-to-Infrastructure

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

Safety Applications Approach



- Build vs **Buy**: Leverage apparent marketplace experience
- Evaluation Needs:
 - State of the Applications
 - ^a Demonstration Evaluations
 - ^a Supplier Submittals
 - ^a Review of other demonstrations (CAMP)
- Final Decision: Buy with additional system requirements
 - ^a Application may not be appropriate at all times - enable/disable
 - ^a Applications not initially developed for the low speeds
 - Configurable parameters (Active >35? Speed limit 25)

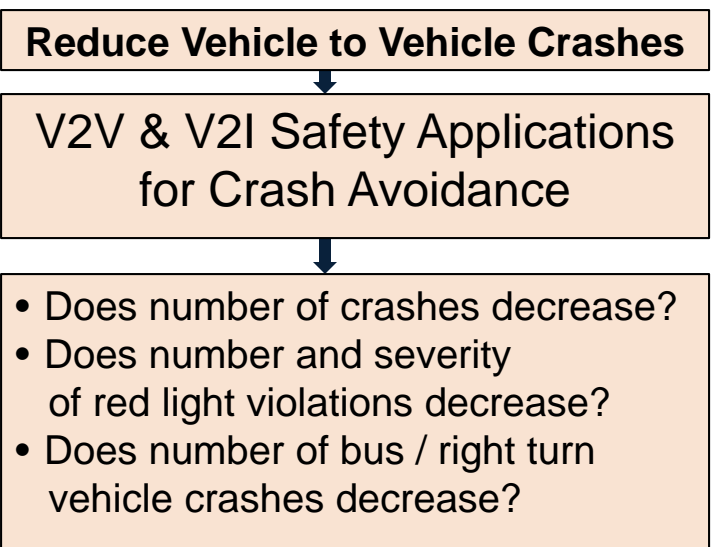
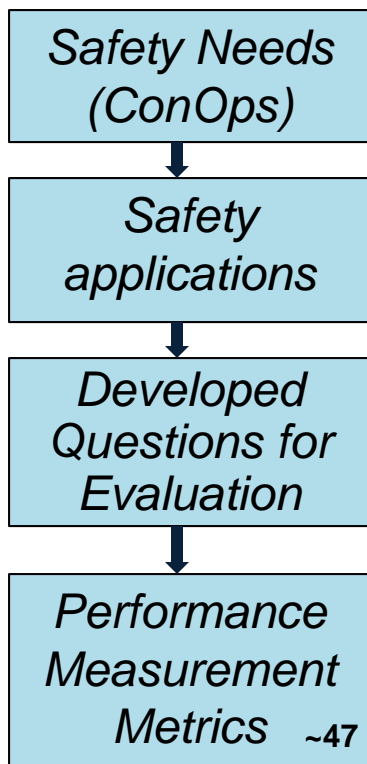
Application Enhancements



- Selected multiple vendors
- Interactive application design sessions & reviews and adjustments to parameters to tailor performance
- Modifications for City requirements
 - Adjust for slower traffic conditions (Activation speed)
 - Speed compliance thresholds
 - Audio alerts – Tuning & Testing
 - Power management of applications and system
 - Encryption of data
 - Common/interoperable approaches to Over-The-Air updates

Performance Metrics & Evaluation Methods

While preserving privacy



- 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

Application dependent data collection requirements developed



- Approach
 - Collect relevant raw data for each individual event
 - Provide for customization of event data recording
 - Store event data securely on ASD at time of collection
 - ^a Encrypt
 - ^a Limit life-time of data
 - Push Over-The-Air collection of raw data from ASD to RSU (support sites)
 - ^a RSU can perform store and forward functions
 - Obfuscate data and aggregate in bins to obscure any individual event

CV “Support” Applications (B)



- Event Logging (what happened immediately before and immediately after an alarm or alert was issued).
- Encounter Logging (Who have I seen)
- RF Data Collection (First/Last to verify radio operation)
- System logs for device management (system actions)
- Over-The-Air (OTA) uploading from ASD devices of log information (above) to the TMC systems for analysis
- Over-The-Air (OTA) downloading to ASD devices including software or firmware as well as configuration parameters.

CV “Support” Applications (C)



- Access Security Credential Management System (SCMS)
- TMC signing of selected messages
 - TIM
 - MAP
 - *Future RTCM - not currently supported*
- Security Management for NTCIP communications
 - TMC ” Traffic Controller
 - Traffic Controller ” RSU
 - TMC ” RSU
- TMC Collection/Export SPaT data for PED applications
- Data “Obfuscation” and aggregation – Privacy protection
- Data Export – FHWA research data
- Data analysis – safety benefits and operating statistics



Support Applications Development

Keith Patton

Operations and Management



Operations and Management



- Key factors (scale):
 - Dense operational area
 - Multiple equipment operators
 - Multiple equipment suppliers
 - Quantity of field equipment (7,000 vehicles, 350 RSUs)
 - Anticipated quantity of data
 - Bandwidth resources
- Approach
 - Automate where possible
 - Use edge computing concepts



■ Operational Data collected

- Received RF signal strength
 - a ASD <-> RSU
 - a ASD <-> ASD
 - a Impact of urban canyons on V2V and V2I communications
 - Generate RF heat maps
- RSU Status
 - a Current communication status
 - a Track number of messages received / sent
- ASD Status – Who's on the road?
 - a Record last sighting
- Travel Time
 - a Calculate travel time along CV corridor

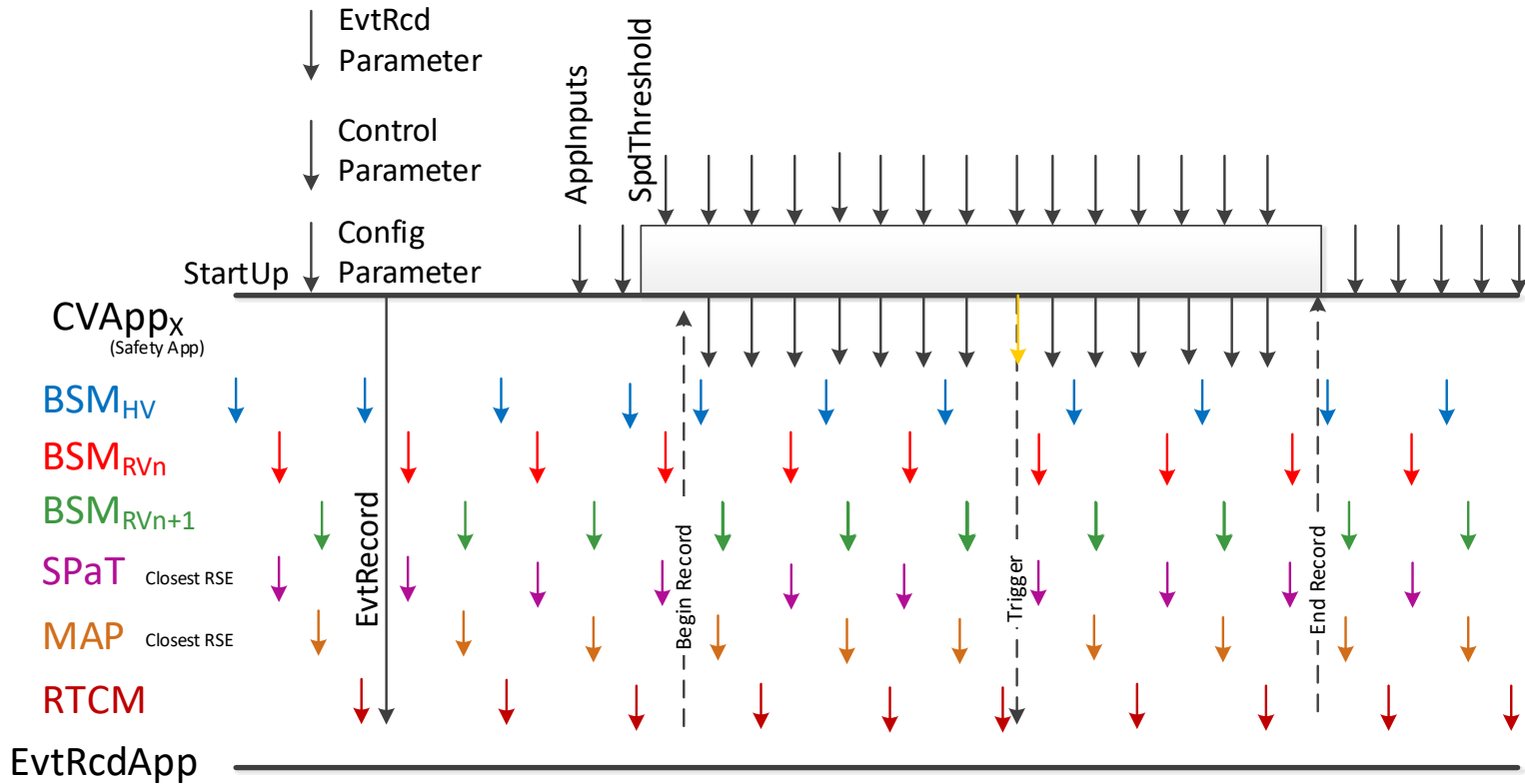
Edge computing: Adds to the computation requirements for ASD and RSU

Operations and Maintenance

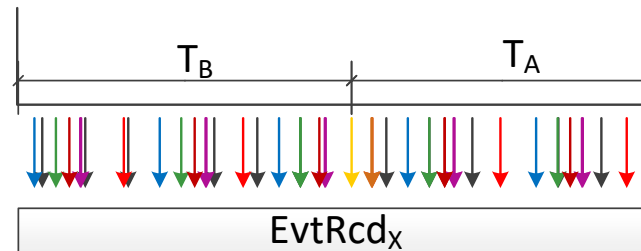


- Data Collection: ASD Event Data
 - ASD collects data for each “event” and this data is buffered on the ASD for transmission to an RSU
 - The RSU then collects the data over the DSRC link, and the back office retrieves it from the RSU
- Back office processing
 - Report number and types of events
 - Obfuscate the event data
 - Send obfuscated event data for performance evaluation

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.

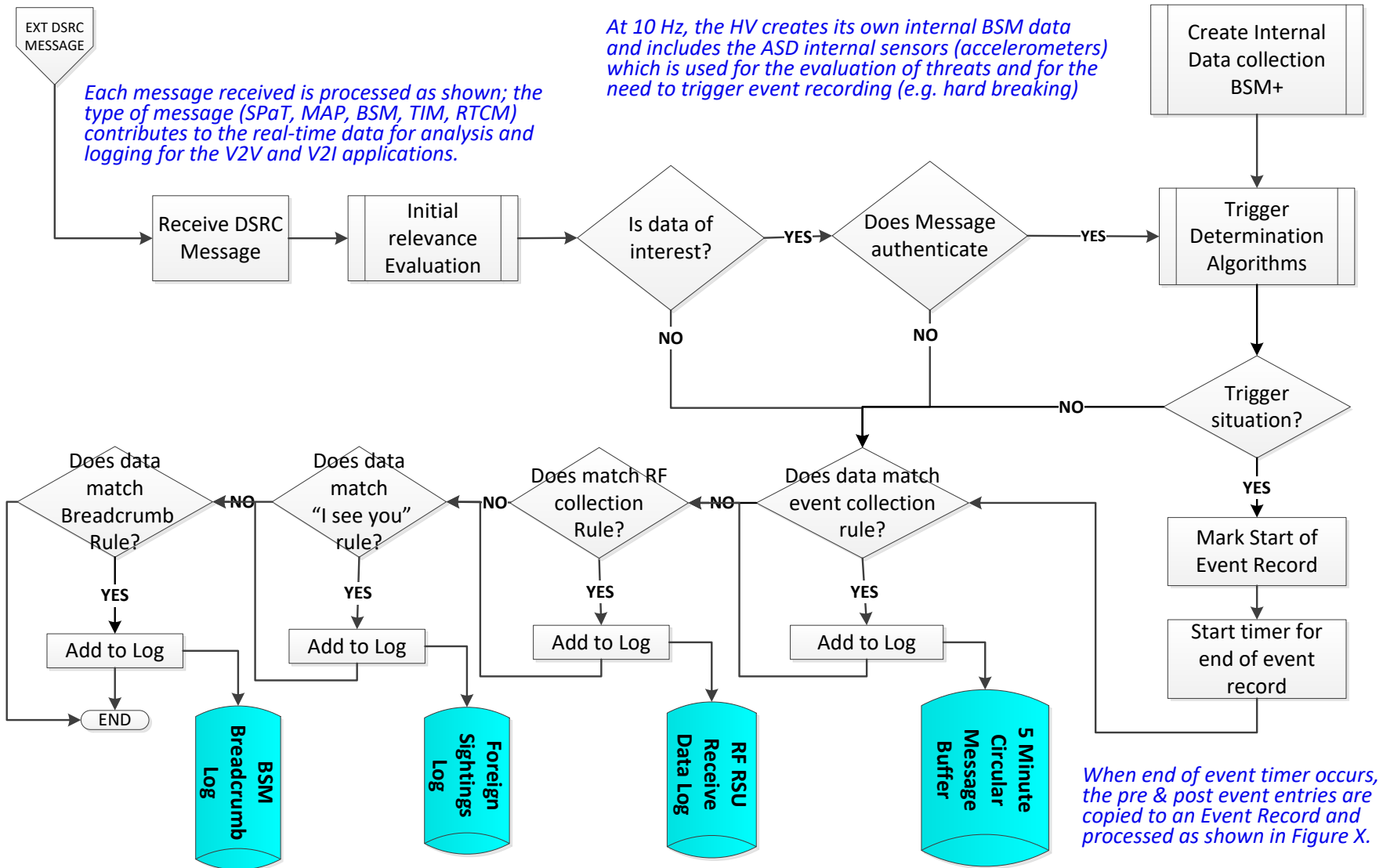


Source: NYCDOT

Concept Flow Chart for "Event" Data Collection

At 10 Hz, the HV creates its own internal BSM data and includes the ASD internal sensors (accelerometers) which is used for the evaluation of threats and for the need to trigger event recording (e.g. hard breaking)

Each message received is processed as shown; the type of message (SPaT, MAP, BSM, TIM, RTCM) contributes to the real-time data for analysis and logging for the V2V and V2I applications.



When end of event timer occurs, the pre & post event entries are copied to an Event Record and processed as shown in Figure X.

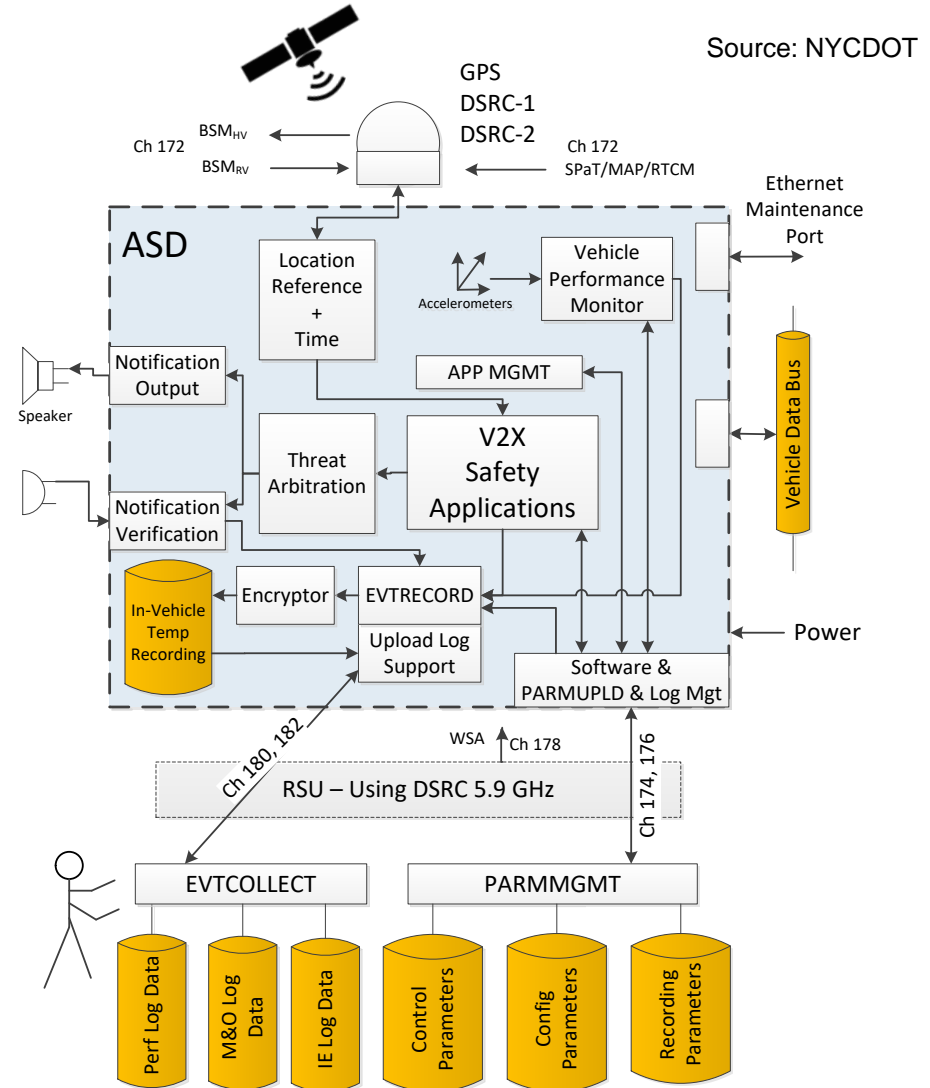
Entries indicate the message type and whether they are for the HV and whether the content was authenticated

Logs are uploaded and purged when the appropriate WSA is received and the data has been transferred to the TMC; only the event log entries are encrypted when added to the event log.

ASD Event Recording / Uploading



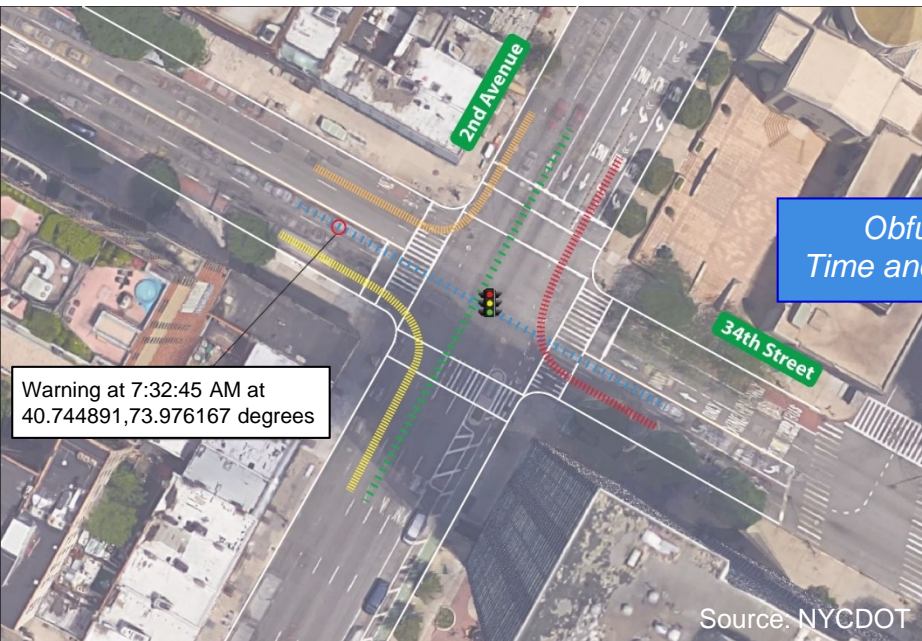
- Generic ASD context for event data lifecycle
 - CV application parameter configuration
 - Event identification
 - Event recording
 - Event collection/upload
 - TMC event data obfuscation and aggregation



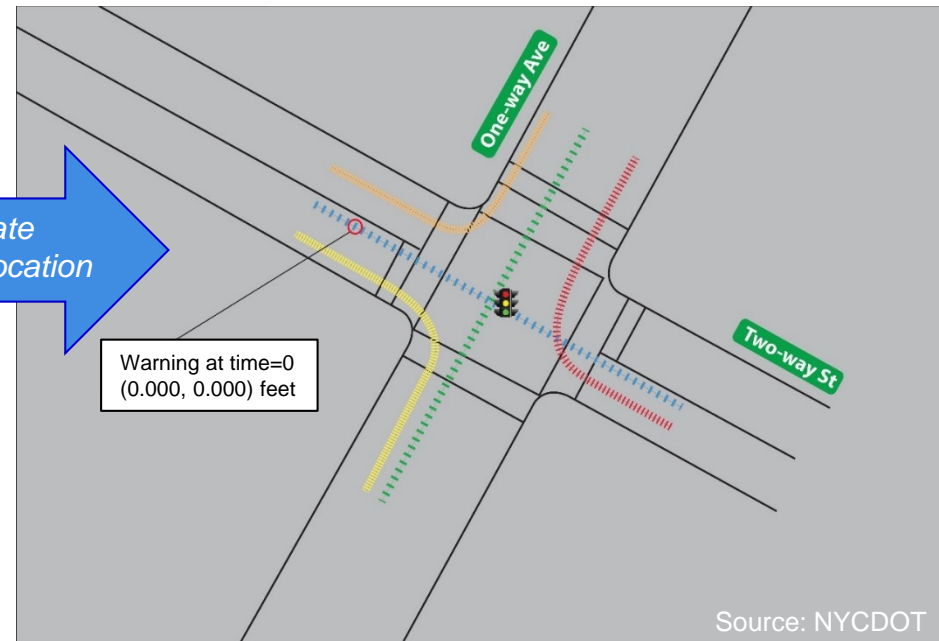
System Design: Privacy Protection



Raw ASD Action Log Data



Obfuscated ASD Action Log Data



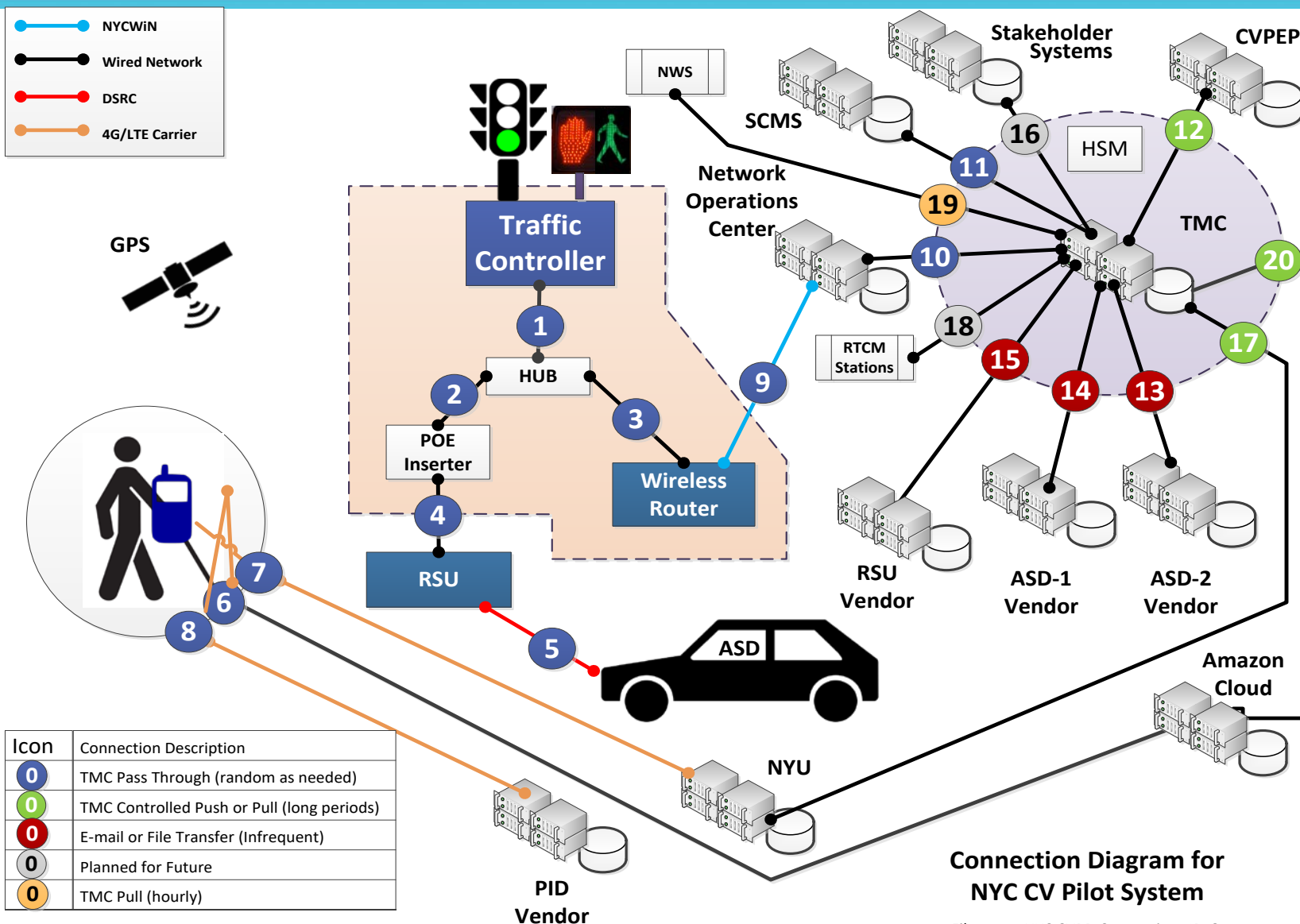
- Obfuscation process to scrub precise time and location data from the ASD action logs for privacy
 - Relative details retained
- Non-obfuscated data will be destroyed following the obfuscation process

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



- Securing for connection with the security system
 - Misbehavior detection and CRL distribution are non-existent or immature: pseudonym certificates limited to life-span of a week
 - Goal: sign data at its origin: MAP, TIM, *RTCM-[future]*
 - Lease Hardware Security Module to protect the cryptographic materials for signing
 - MAP & SPaT security needs differ: separate PSIDs
 - Service Specific Permissions applications
- Improving system and field infrastructure security
 - External interfaces
 - Inside the controller cabinet

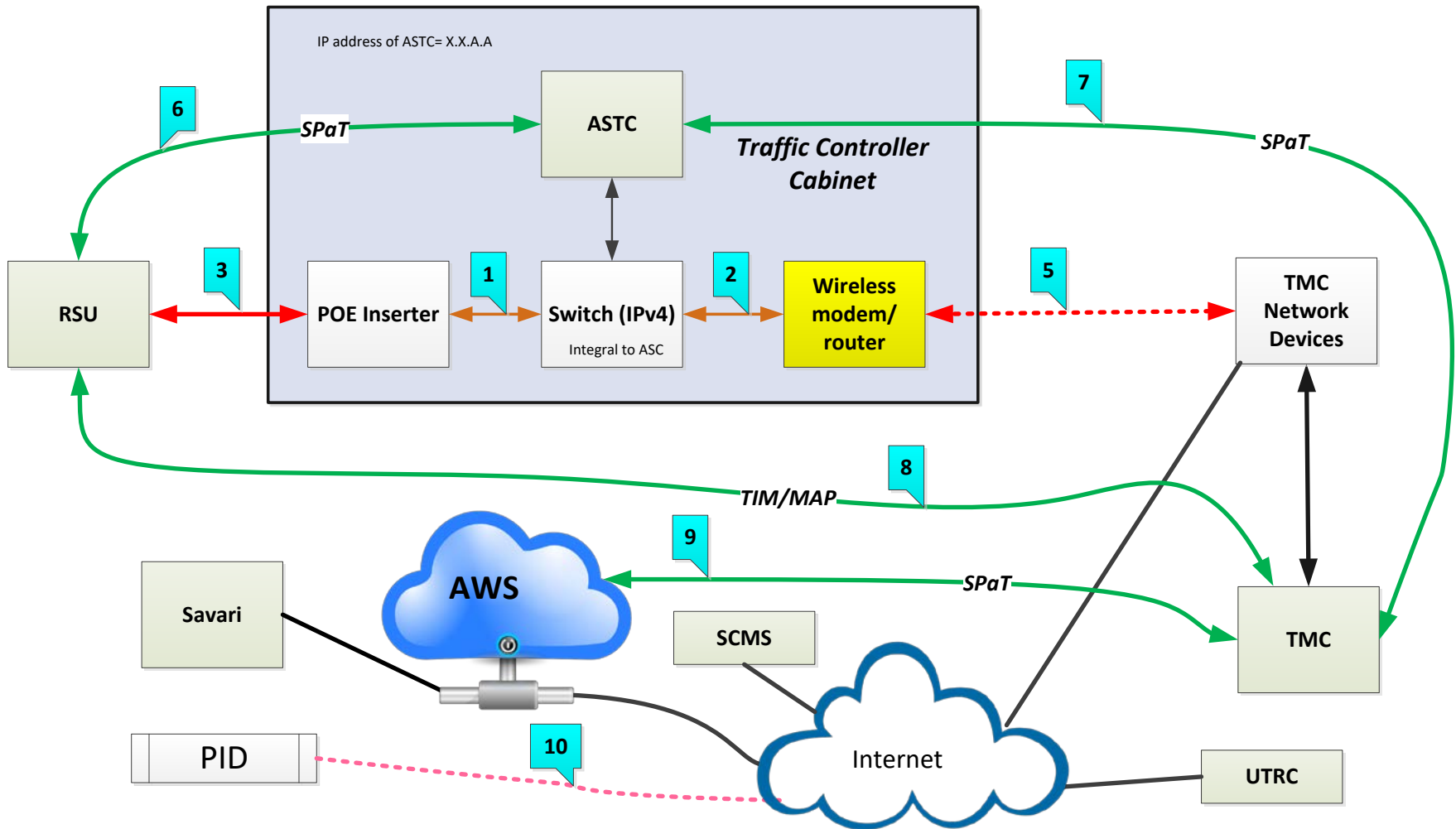
Security Considerations



TYPICAL OF THE SECURITY RISKS



Inter Device Communications Context Diagram



Security Affects All Systems!



- Protect the exposed links from “man in the middle” attack;
 - Added the HSM to the TMC – Sign TIM, MAP, [RTCM]
- NTCIP is not secure (SNMPv1)
 - DTLS 1.2 per RFC 6347
 - TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA
- Developed Security Profiles for all of our messages
 - SPaT, MAP, TIM, SSM, SRM
- Modifying Maintenance Procedures – to mitigate security threats by limiting physical access and monitoring for stolen equipment
- Established short-term security requirements for NYC devices
 - 60 Certificates per week – 14 hour vehicle use per day
 - Certificates only good for 1 week – 7 day advance (TBD)
- Using IEEE 1609.2 and Aerolink for all DSRC message security
- Logging for authentication failures



- RSU Management
 - Update MAP files
 - Update TIM files
 - Retrieve RSU Operational logs
 - Manage ASD firmware files on RSU for OTA distribution
 - Provide RSU firmware updates
 - Provide real-time status to City TMC
- ASD Management
 - Report ASDs not seen for specific periods
 - Verify ASD firmware versions
 - Retrieve and process ASD Event logs
 - Retrieve and process ASD operational logs
 - Update encryption keys for ASD events
 - Update application configuration settings in ASDs

Automating the Back office functions

Operations and Management



■ ASTC Management

- Updates traffic control system security
- Configure for communications with RSU
- Retrieve signal data to generate SPaT message for PID
 - ^a Supports Aggregation of SPaT information
 - ^a Relays SPaT information to Amazon Cloud for PID applications
 - ^a Tracks reliability of PID operation
- Updated ASTC firmware and Central TCS to support
 - ^a PED in crosswalk detection
- Provide real-time status to City TMC

Operations and Management



- Over the Air (OTA) updates
 - Problem: updating firmware and configuration for 7,000+ Vehicles
 - Solution: use a common OTA **broadcast** mechanism
 - ^a Based on a commercial software package: *CodeOn*
 - ^a Uses Random Linear Network Coding (RLNC) techniques
 - RLNC deals with lost packets without requiring a retransmit
 - Firmware delivered using multicast vs unicast
 - More efficient use of DSRC bandwidth
 - Reduces firmware download time to <1 minute
 - ^a Each RSU has the firmware/configuration update
 - ^a ASDs pick up pieces of the firmware/configuration update as they pass multiple RSUs
 - ^a ASDs recombine the pieces for the full firmware update
- ***Vendor is responsible for verifying integrity of updates***

Operations and Management



- ASD Activity Monitoring
- RF Monitoring
 - Encounter Logs (Who have I seen)
 - RF Collection (First/Last to verify radio operation)
 - Developing scatter graphs of each RSU and ASD for human review – can monitor changes.
- Over-The-Air (OTA) updates of ASD devices:
 - software or firmware
 - configuration parameters
 - OTA Log uploading – includes System log and all activity logs

Where Are We Now & Next Steps



- Purchased and installed prototypes and samples (~35)
- Working with the vendors to develop OTA
 - For incremental tuning and “updates”
 - ASTC updated: exports SPaT and accepts PED detection
- Developing installation procedures with installers & vendors
 - Finalize installation agreements/contracts
- Finalize deployment preparation
 - a Inventory Vehicle types
 - a Finalize installation and test procedures
 - a Finalize calibration procedures
- Complete Procurement of ASDs, RSUs and Ped Devices
- Ready, Set, ...

Questions and Answers



Thank You

For more information contact:

John Tipaldo, P.E.

[**jtipaldo@dot.nyc.gov**](mailto:jtipaldo@dot.nyc.gov)

Mohamad Talas, P.E., PTOE, PhD

[**mtalas@nyc.dot.gov**](mailto:mtalas@nyc.dot.gov)

Bob Rausch, P.E.

[**bob.rausch@transcore.com**](mailto:bob.rausch@transcore.com)

Keith Patton

[**keith.patton@transcore.com**](mailto:keith.patton@transcore.com)

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

FREE CONNECTED VEHICLE PILOT DATA AVAILABLE

Wyoming data is now streaming and available to the public—with others coming soon.

Explore the data at ITS Public Data Hub

www.its.dot.gov/data

Questions? Contact us via email at data.itsjpo@dot.gov

Intelligent Transportation Systems Joint Program Office



U.S. Department of Transportation

STAY CONNECTED



Join us for the *Ready to Design, Build, and Test Operational Systems 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

Contact for Pilot Sites:

- Kate Hartman, WYDOT Site AOR
Kate.Hartman@dot.gov
- Jonathan Walker, NYCDOT Site AOR
Jonathan.b.Walker@dot.gov
- Govind Vadakpat, THEA Site AOR
G.Vadakpat@dot.gov

