



CONNECTED VEHICLE PILOT Deployment Program



NYC CV Pilot Deployment Project



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ITS Joint Program Office



TODAY'S AGENDA



- Project Overview
- Security
- Map Generation
- Operations and Management
- Pedestrian Applications

Pilot Sites



- Improve safety and mobility of travelers in New York City through connected vehicle technologies.
- Vehicle to vehicle (V2V) technology installed in up to 10,000 vehicles in Midtown Manhattan, and vehicle to infrastructure (V2I) technology installed along high-accident rate arterials in Manhattan and Central Brooklyn.



- 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.



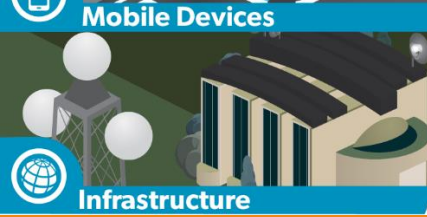
- Alleviate congestion and improve safety during morning commuting hours.
- Deploy a variety of connected vehicle technologies on and in the vicinity of reversible express lanes and three major arterials in downtown Tampa to solve the transportation challenges.



CONNECTED VEHICLE PILOT DEPLOYMENT PROGRAM

PROGRAM GOALS

Spur Early CV Tech Deployment



Wirelessly Connected Vehicles

Mobile Devices

Infrastructure

Measure Deployment Benefits



Safety

Mobility

Environment

Resolve Deployment Issues



Technical

Institutional

Financial

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



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



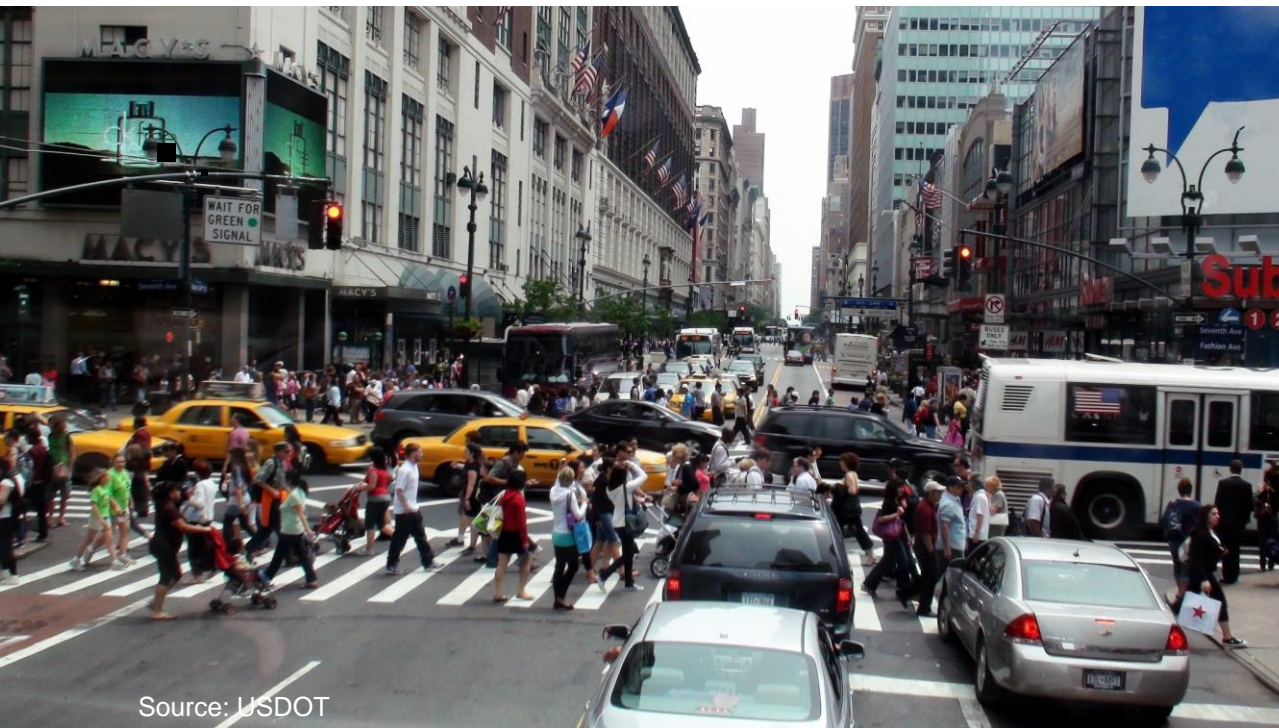
U.S. Department of Transportation

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**.

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 Stat



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

Patrol Borough: Manhattan South Precinct: All

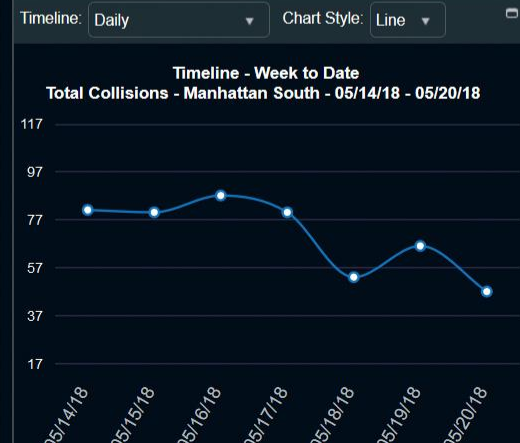
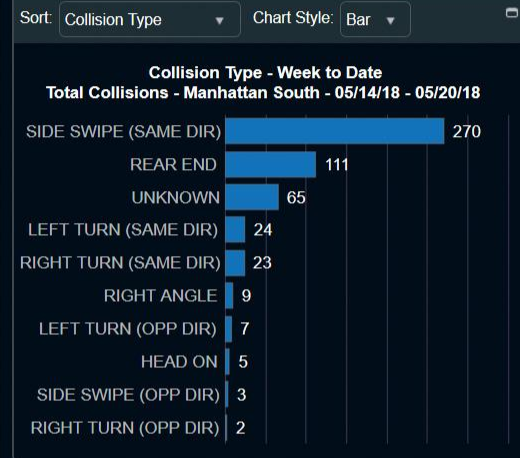
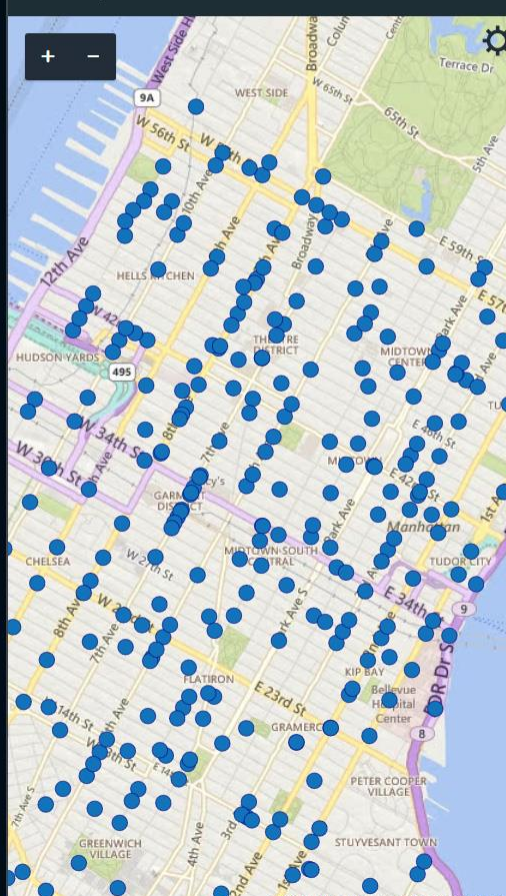


NYPD TrafficStat

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

Incident Map



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

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

CV Deployment Equipment



- Up to 8,000 **fleet vehicles** with Aftermarket Safety Devices (ASDs):
 - ~5,850 Taxis (Yellow Cabs)
 - ~1,250 MTA Buses
 - ~ 500 Sanitation & DOT vehicles
 - ~ 400 UPS 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:

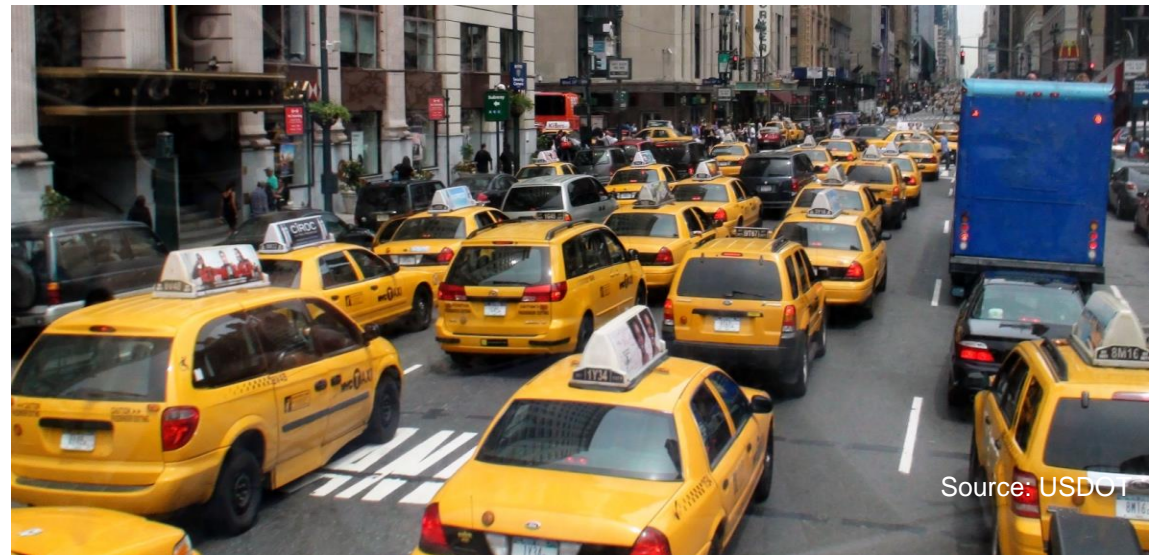
Vehicles are in motion or active ~14 hours per day!

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

CV Applications (A)



Vehicle-to-Vehicle Safety Applications

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

Vehicle-to-Infrastructure Safety Applications

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

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.

Other Applications



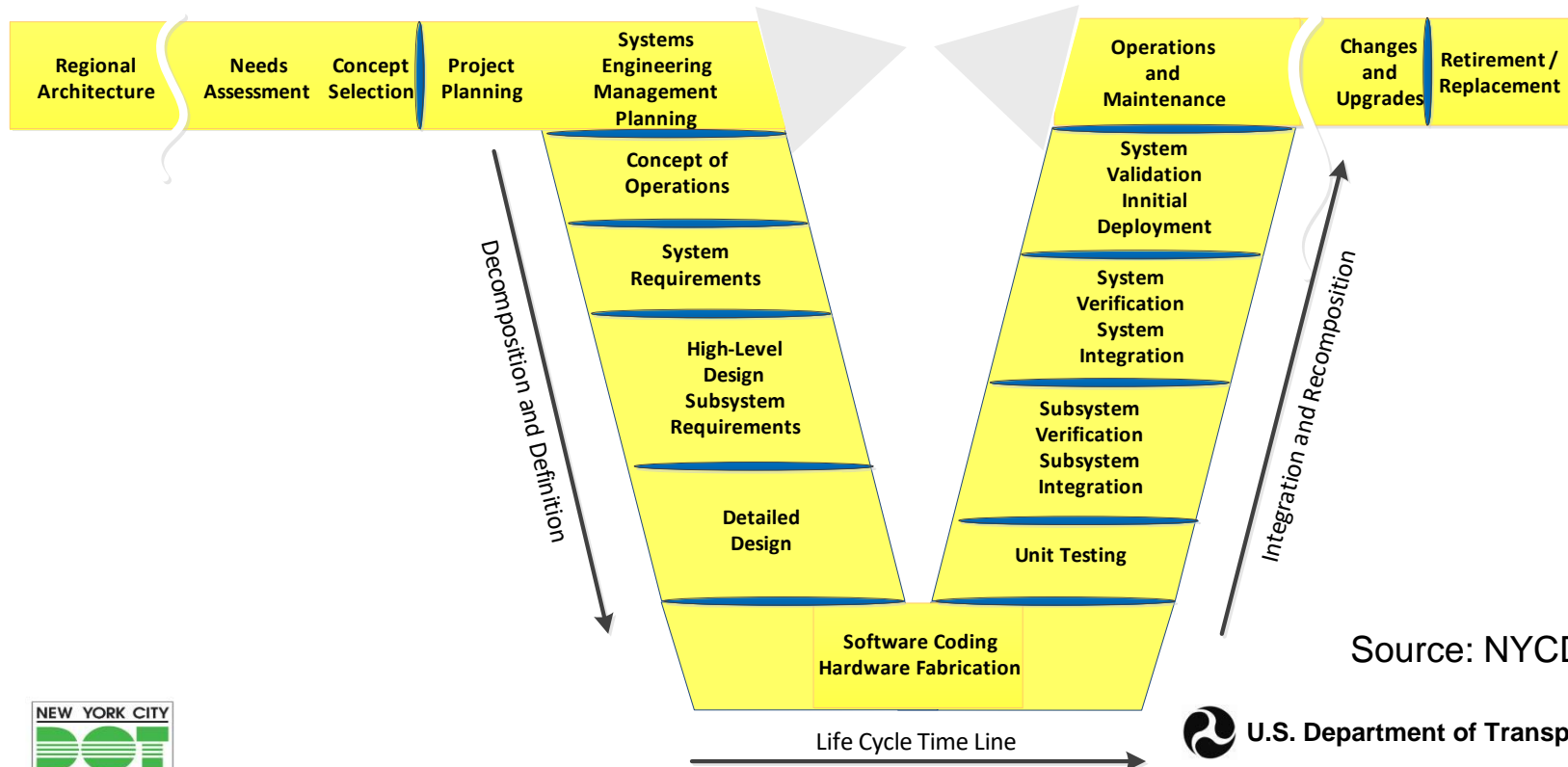
- Access Security Credential Management System (SCMS)
- TMC signing of selected messages
 - TIM
 - MAP
 - *Future RTCM*
- Security Management for NTCIP communications
 - TMC ↔ Traffic Controller
 - Traffic Controller ↔ RSU
 - TMC ↔ RSU
- TMC Collection/Export SPaT data for PED applications
- Data “Obfuscation” and aggregation – Privacy protection
- Data Export – FHWA research data
- Data analysis – safety benefits and operating statistics

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
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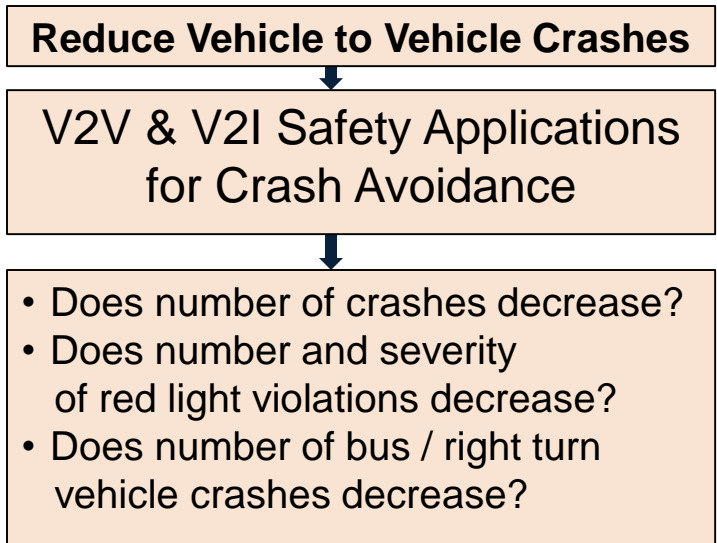
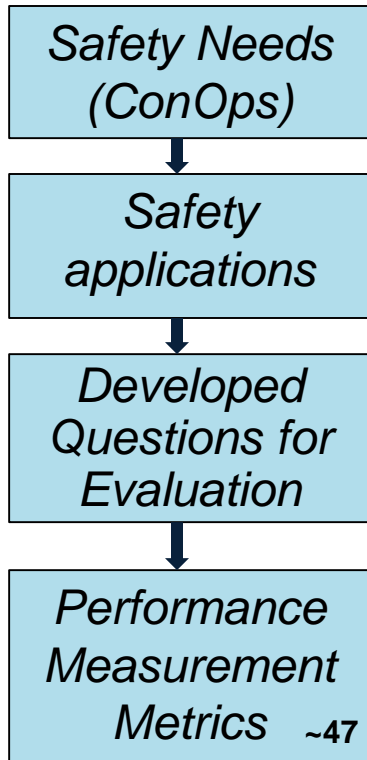
Phase -1	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Interfacing with Planning and the Regional Architecture	Concept Exploration and Benefits Analysis	Project Planning and Concept of Operations Development	System Definition and Design	System Development and Implementation	Validation, Operations and Maintenance, Changes & Upgrades	System Retirement/ Replacement



Source: NYCDOT

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

Performance Measurement



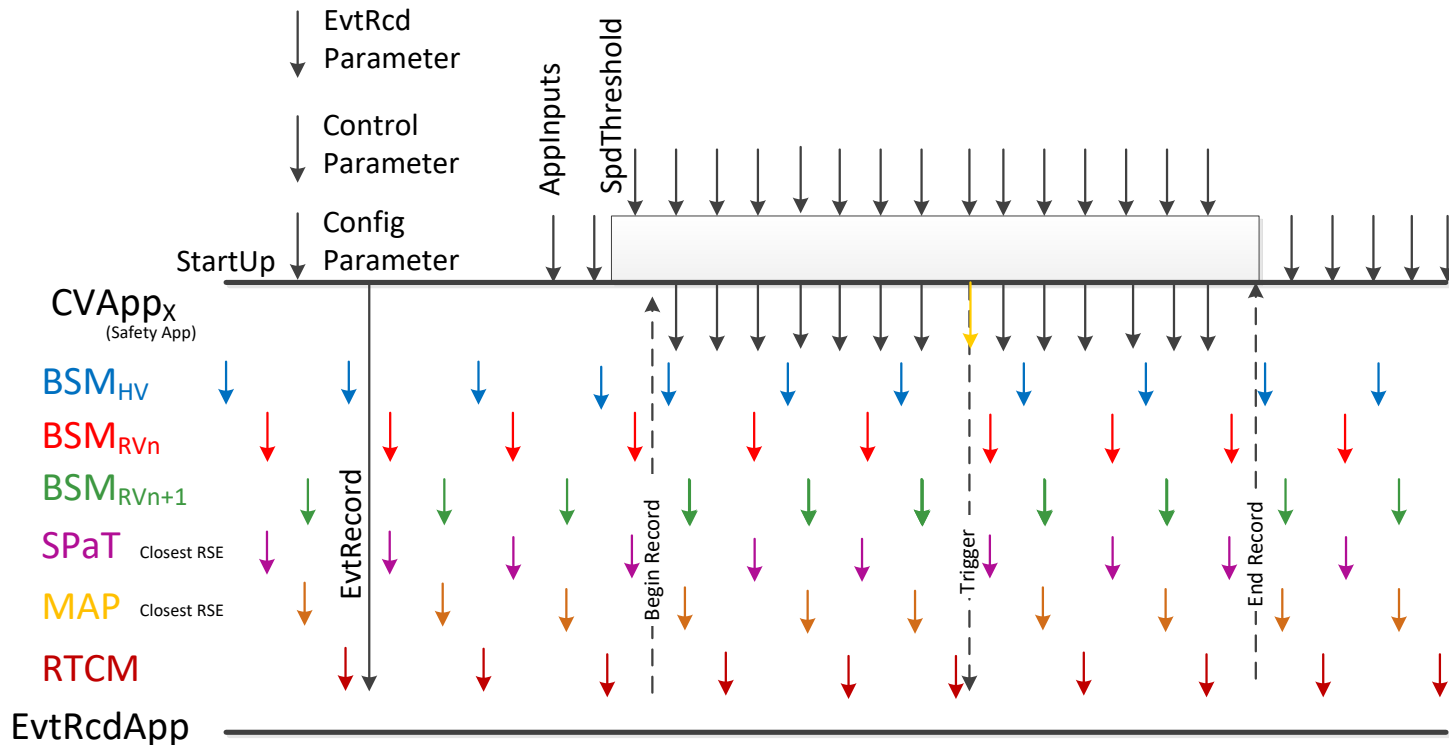
- Key Factors
 - V2V encounters can happen anywhere two equipped vehicles meet
 - Fleet vehicles regularly return to terminal facilities
 - Backhaul bandwidth is approximately half of the V2I/I2V connection
 - Privacy matters

Performance Measures

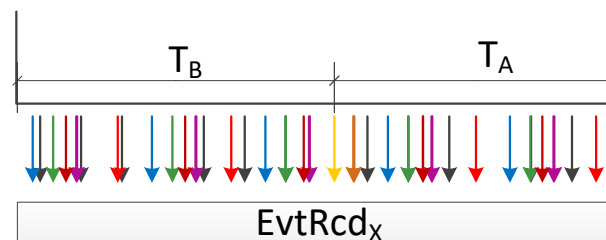


- Approach
 - Collect all relevant raw data for each individual event
 - Provide for customization of event data collection
 - Store event data securely on ASD at time of collection
 - Encrypt
 - Limit life-time of data
 - Over-The-Air collection of raw data from ASD to RSU (support sites)
 - Obfuscate raw data and then aggregate into bins to obscure any individual event

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.

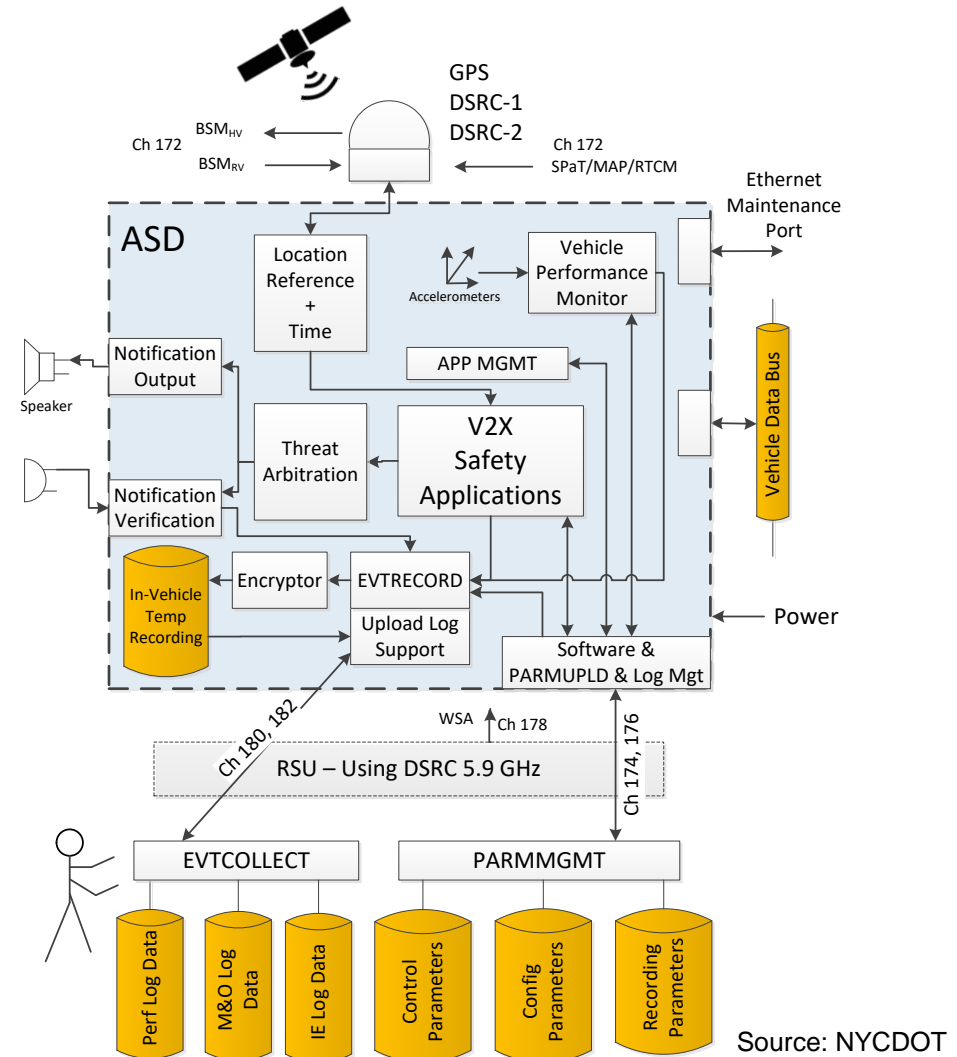


Source: NYCDOT

ASD Event Recording / Uploading



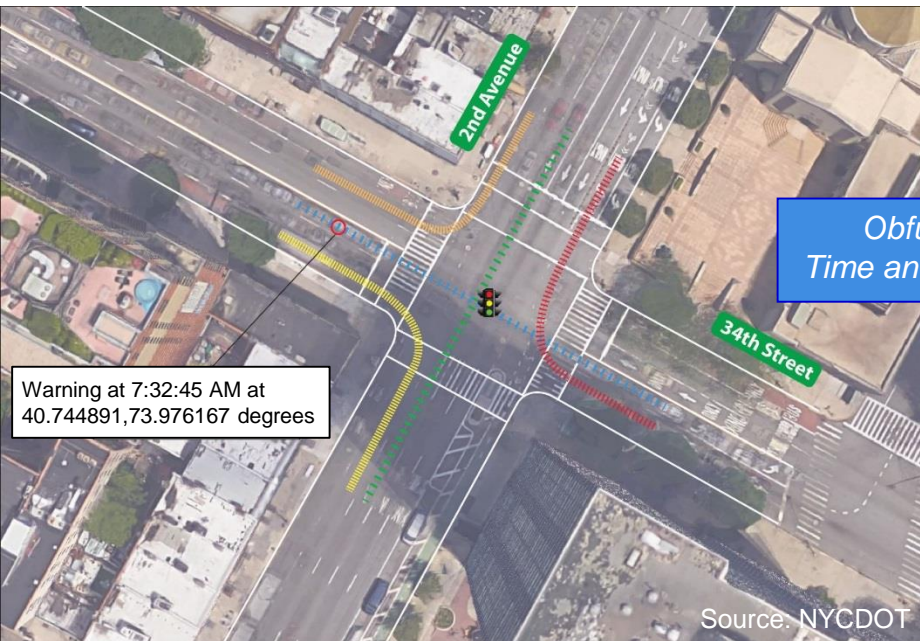
- Generic ASD context for event data lifecycle
 - CV application parameter configuration
 - Event identification
 - Event info collection
 - Store securely on ASD
 - Move stored events to the back-office (upload)
 - TMC event data obfuscation and aggregation



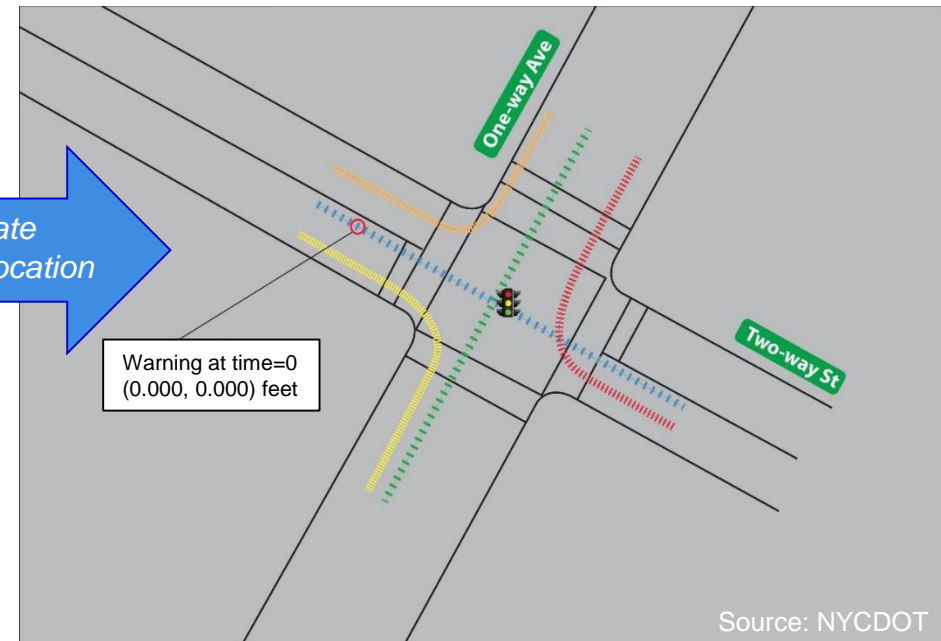
System Design: Privacy Protection



Raw ASD Event Log Data



Obfuscated ASD Event Log Data



Obfuscate
Time and Location

- 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

Our Experience



I'm not crazy about reality, but it's still the only place to get a decent meal.

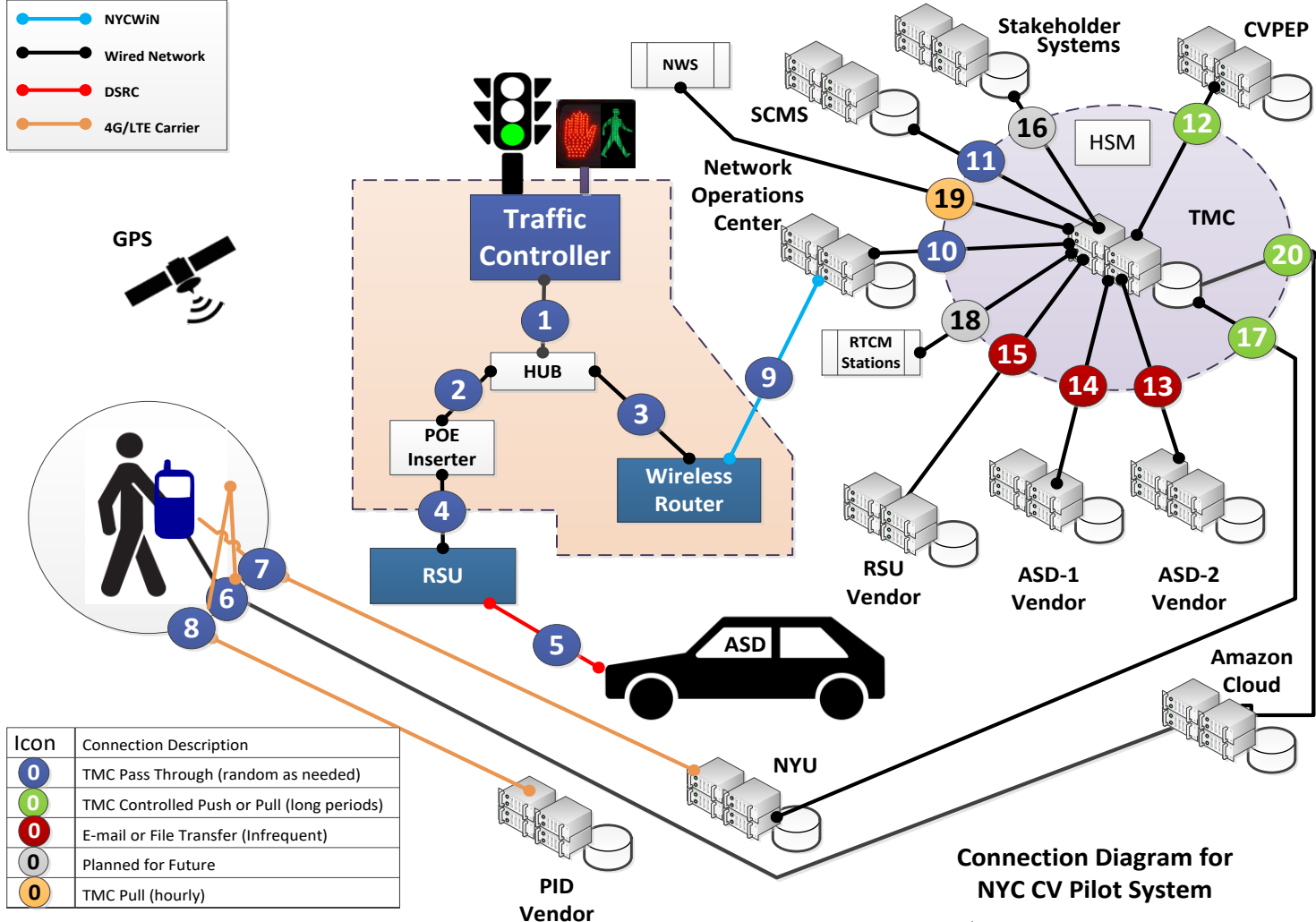
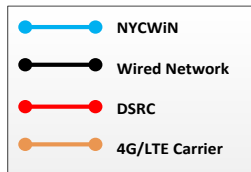
-- Groucho Marx --





- Securing 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
 - 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

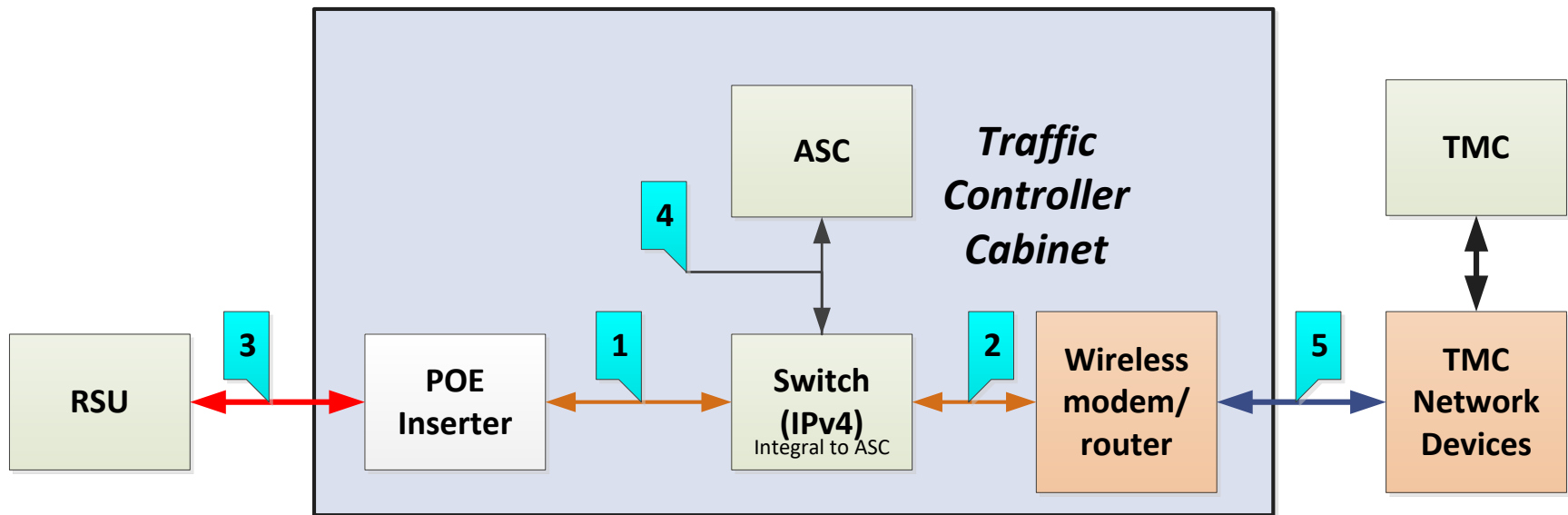


Connection Diagram for NYC CV Pilot System

Filename: NYC CVPD Connections IPv6-IPv4V3.vsd



Securing physically



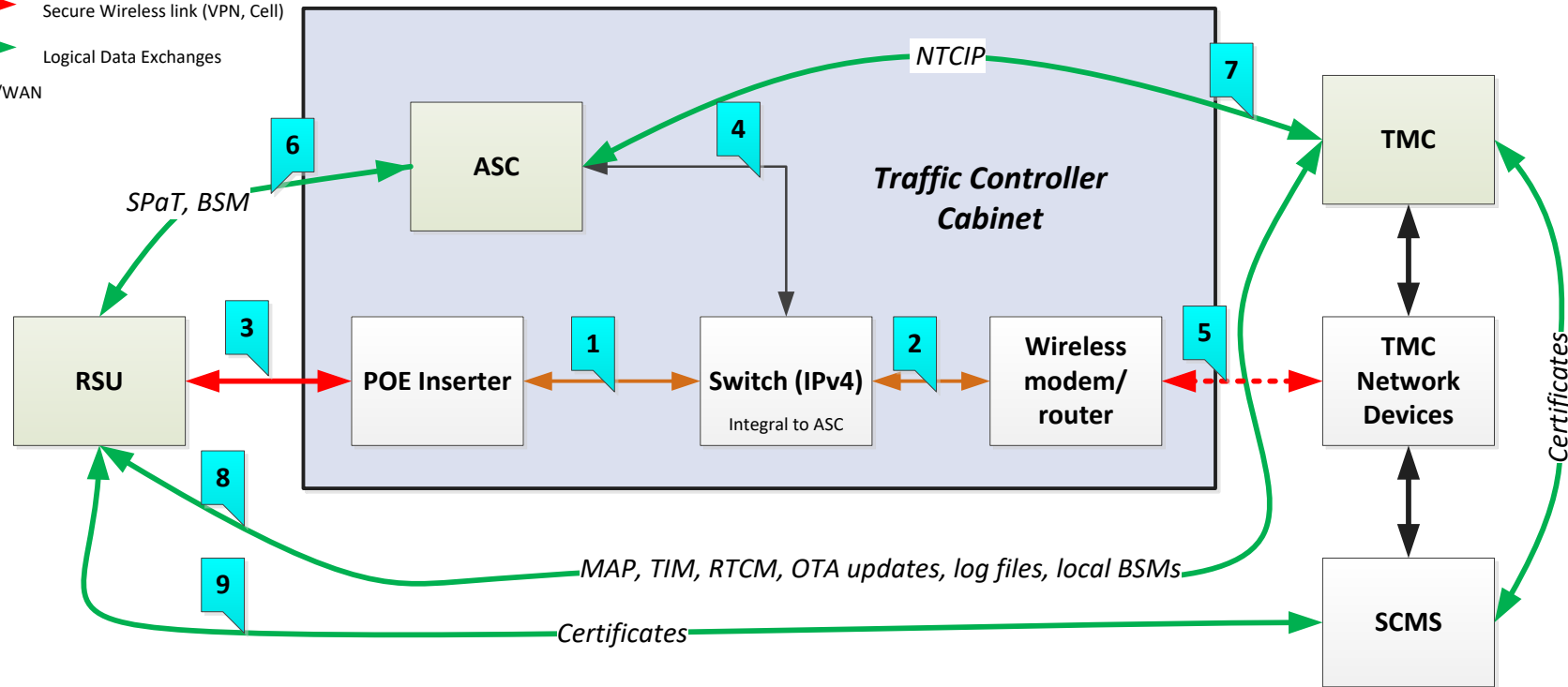
Context for ASTC/RSU/TMC Infrastructure

Securing the data flows



- Exposed Ethernet Cable outside the cabinet
- Exposed Ethernet Cable inside locked controller cabinet
- Secure Wireless link (VPN, Cell)
- Logical Data Exchanges
- LAN/WAN

Security Context for Traffic Controller Infrastructure



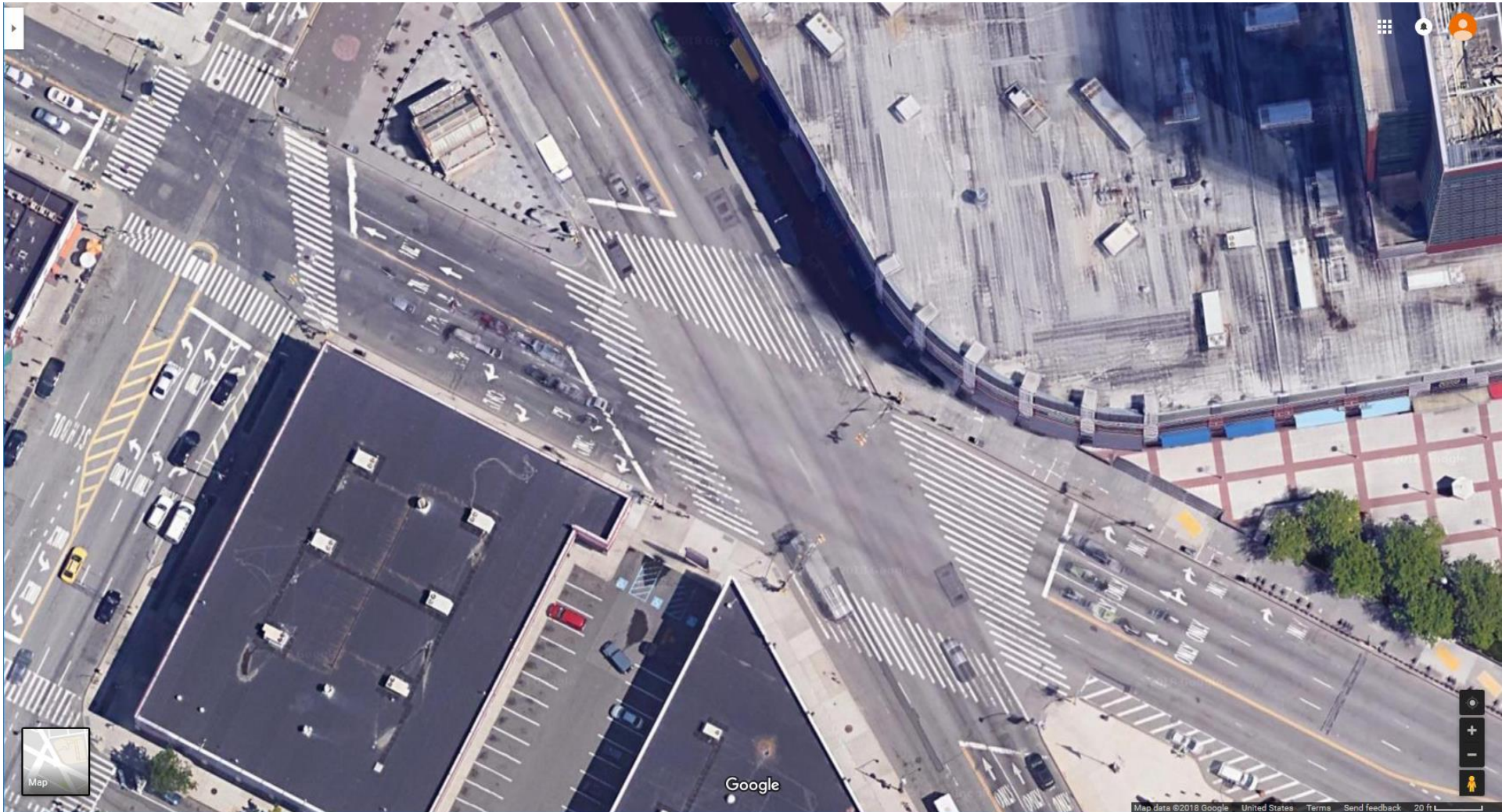
NYC MAP Generation Approach



- Use Stand-alone instead of interlaced (egress lanes from adjacent intersection)
- Model all lanes
- Use Standard 32-bit offsets for all encoding
- Minimize field review
- Find cost effective determination of verification points

- Why
 - Provides application developer flexibility for switching
 - Questions on signal propagation at building corners

NYC: Flatbush Ave @ Atlantic Ave



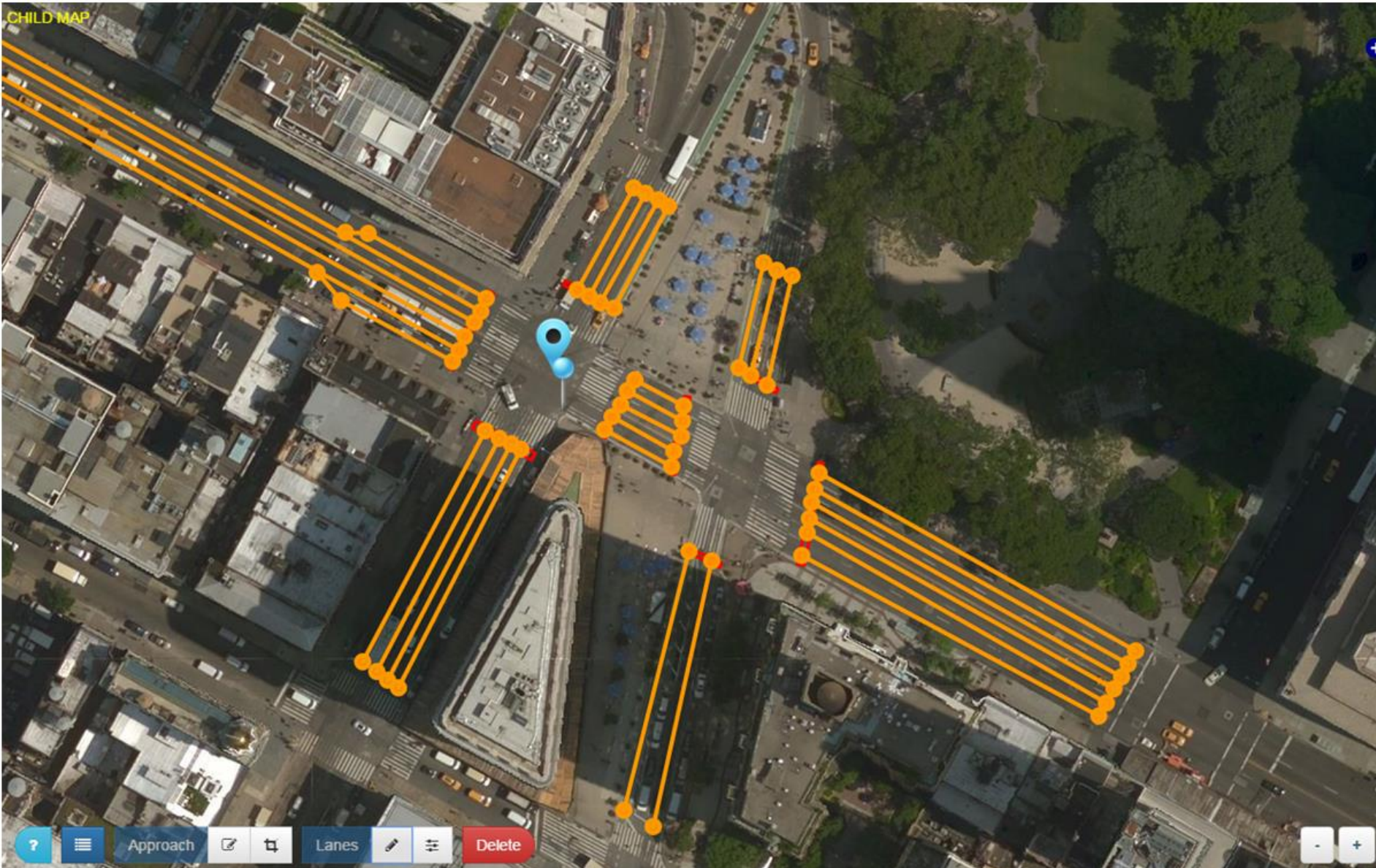
Seoul



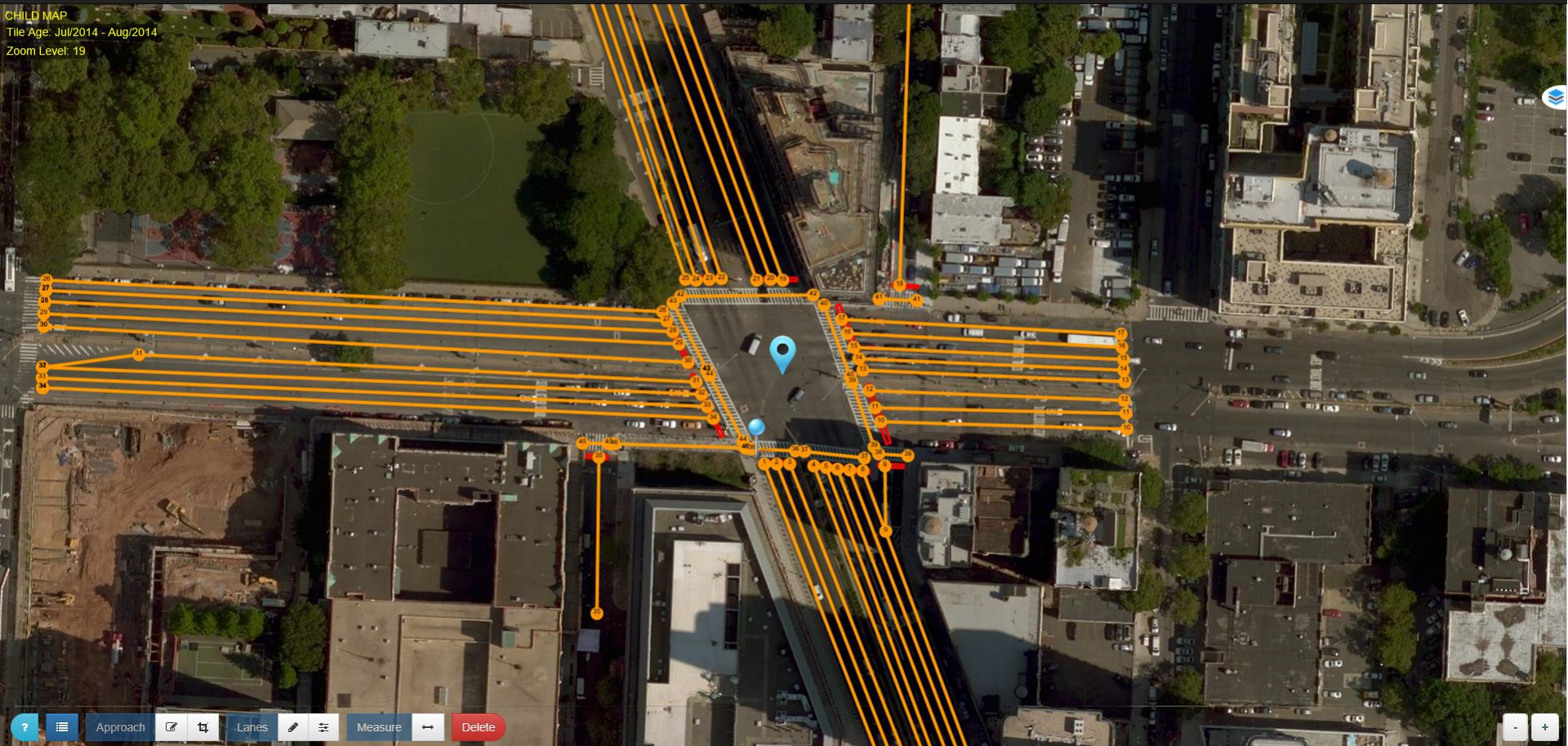
NYC: 5th Ave @ 23rd St



CHILD MAP



Flatbush Ave @ Tillary St

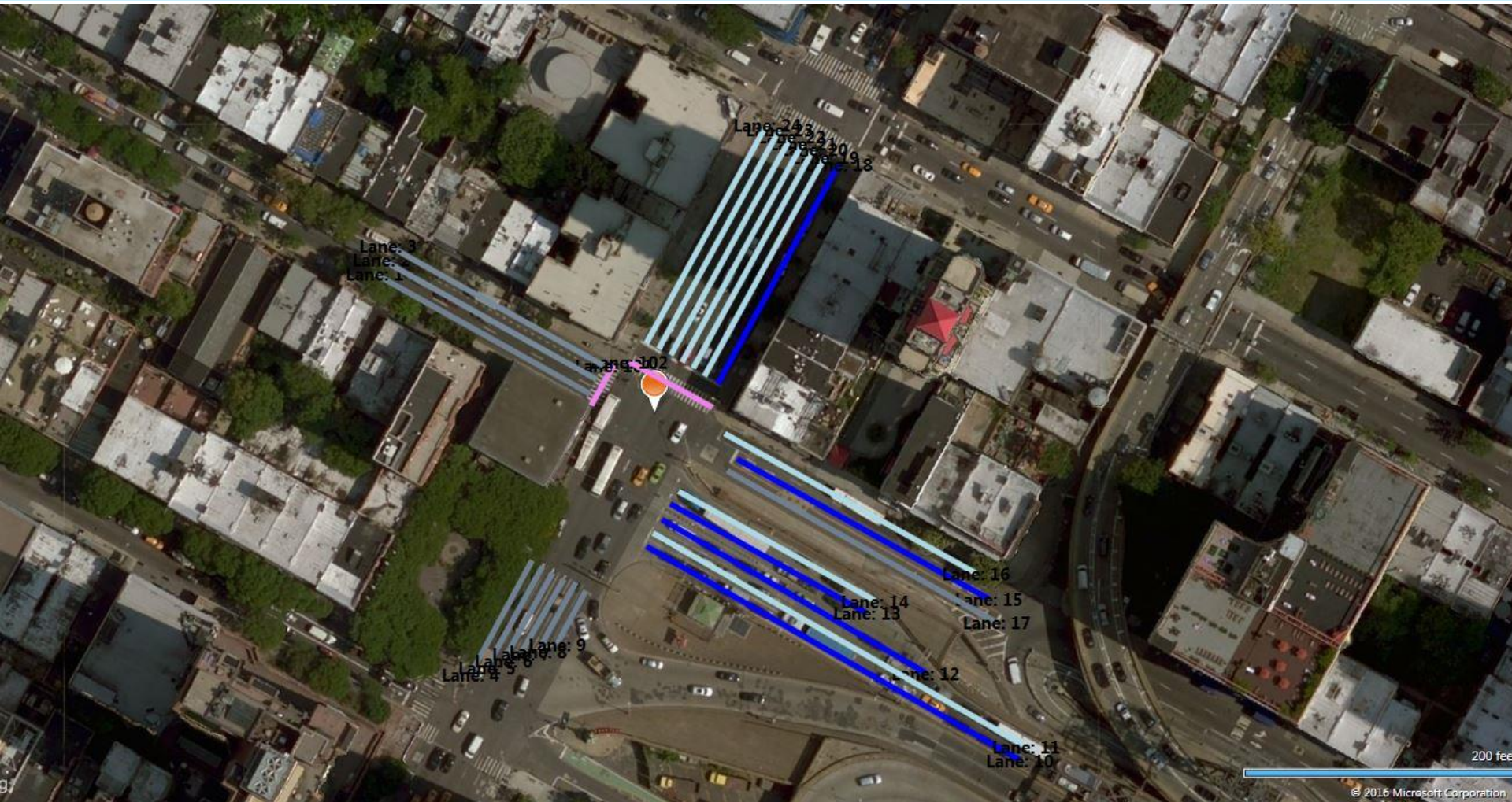


Flatbush Ave @ Tillary St



MAP Message Contents	Construction	LLH Point Description	UPER Size (Bytes)
Vehicle Lanes + Ped Crosswalk Lanes	Frame+MAP	Explicit 64-bit full location	1610
Vehicle Lanes + Ped Crosswalk Lanes	Frame+MAP	Standard 32-bit offsets	1184
Vehicle Lanes + Ped Crosswalk Lanes	Frame+MAP	Compact	1184
Vehicle Lanes + Ped Crosswalk Lanes	Frame+MAP	Tight (smallest)	1104

NYC: 2nd Ave @ E 60th St



Map Generation



- Tool capabilities
 - ✓ Image age
 - ✓ Verification point management
 - ✓ Node offset encoding (Explicit, Standard, Compact, Tight)
 - ✓ Lane widths
 - ✓ Revocable lanes for multiple purposes
 - ✓ Reversible
 - ✓ Exclusive vehicle vs mixed vehicle traffic
 - Computed lanes
 - Curb lane attributes
- Standards issues
 - Crosswalks
 - Bike boxes
 - Internal storage lanes

MAP Optimization Strategies



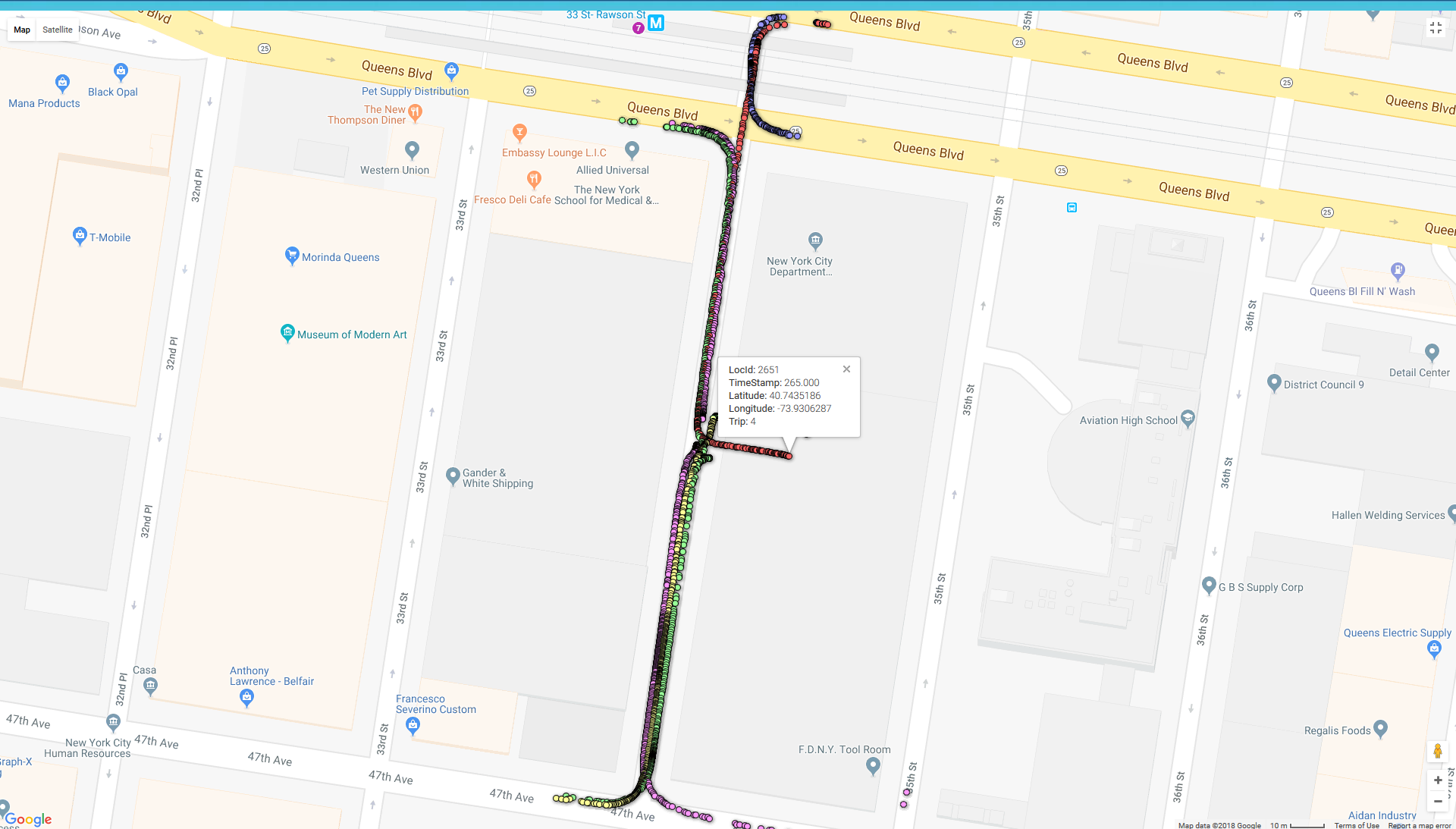
- Tight encoding
- Computed lanes (under development)
- Stub egress lanes - shorten (modified interlacing)
- Consolidate egress lanes – merge together

Operations and Management



- RF Monitoring
 - Encounter Logs (Who have I seen)
 - RF Collection (First/Last to verify radio operation)
- ASD Monitoring
 - OTA Log uploading
- Over-The-Air (OTA) updates of ASD devices:
 - software or firmware
 - configuration parameters
 - system status log

DSRC RF Test



DSRC RF Test Sky View





Pedestrian Issues

- Stakeholders are the visually impaired
 - Assistance crossing the street
 - Information about vehicles: All or nothing
 - Potential for cost reductions
- Positioning accuracy
 - Location augmentation
 - Working on external positioning system
- Pedestrian detection
 - Video/Infra-red detection
 - May restrict time-of-day operation to limit distractions

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
 - Inventory Vehicle types
 - Finalize installation and test procedures
 - Finalize calibration procedures
- Complete Procurement of ASDs, RSUs and Ped Devices
- Ready, Set, ...



Thanks You

For more information contact:

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NYCDOT Pilot: <https://www.cvp.nyc/>