
DC
ITS AMERICA
JUNE 2019
INTELLIGENT MOBILITY:
SAFER. GREENER. SMARTER.

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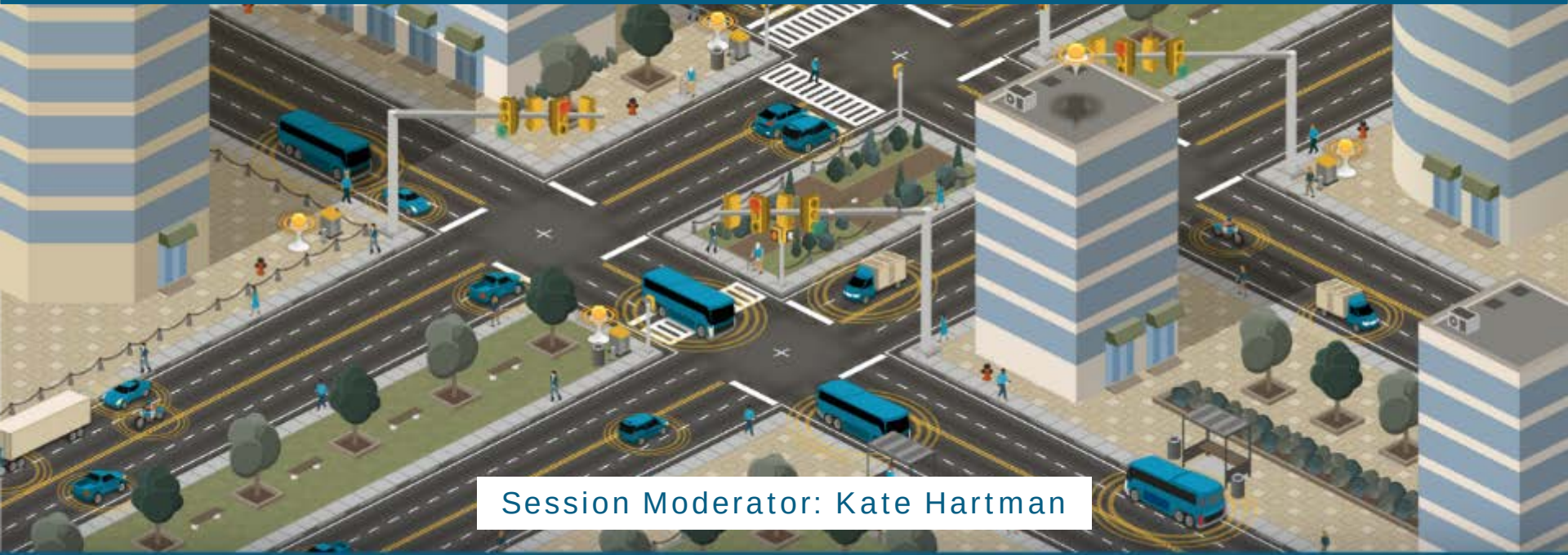
CONNECTED VEHICLE PILOT
Deployment Program

Managing and Operating at Scale



Session Moderator: Kate Hartman

What to Expect in this Session

- Connected Vehicle Pilot Deployment Program Overview
  - Summarize progress-to-date in the Connected Vehicle Pilot Deployment Program.
  - Describe the deployment status of each of the three pilot sites.
- Managing and Operating at Scale
  - The view of success in terms of the deployment up until now.
  - Lessons learned, success stories, challenges and suggestions to share with other potential deployers.

NYCDOT

Tampa (THEA)

WYDOT

USDOT

U.S. Department of Transportation

Session Agenda

- 2:00 – 2:10 PM Introduction and CV Pilots Overview

  Kate Hartman, Chief, Research, Evaluation, & Management, ITS JPO, USDOT

- 2:10 – 2:30 PM Wyoming DOT Pilot Deployment

  Deepak Gopalakrishna, Principal, ICF

- 2:30 – 2:50 PM Tampa (THEA) Pilot Deployment

  Bob Frey, Planning Director, Tampa Hillsborough Expressway Authority (THEA)

- 2:50 – 3:10 PM NYCDOT Pilot Deployment

  Mohamad Talas, Deputy Director of Systems Engineering, New York City Department of Transportation

- 3:10 – 3:15 PM Q&A

CV Pilot Deployment Program Goals

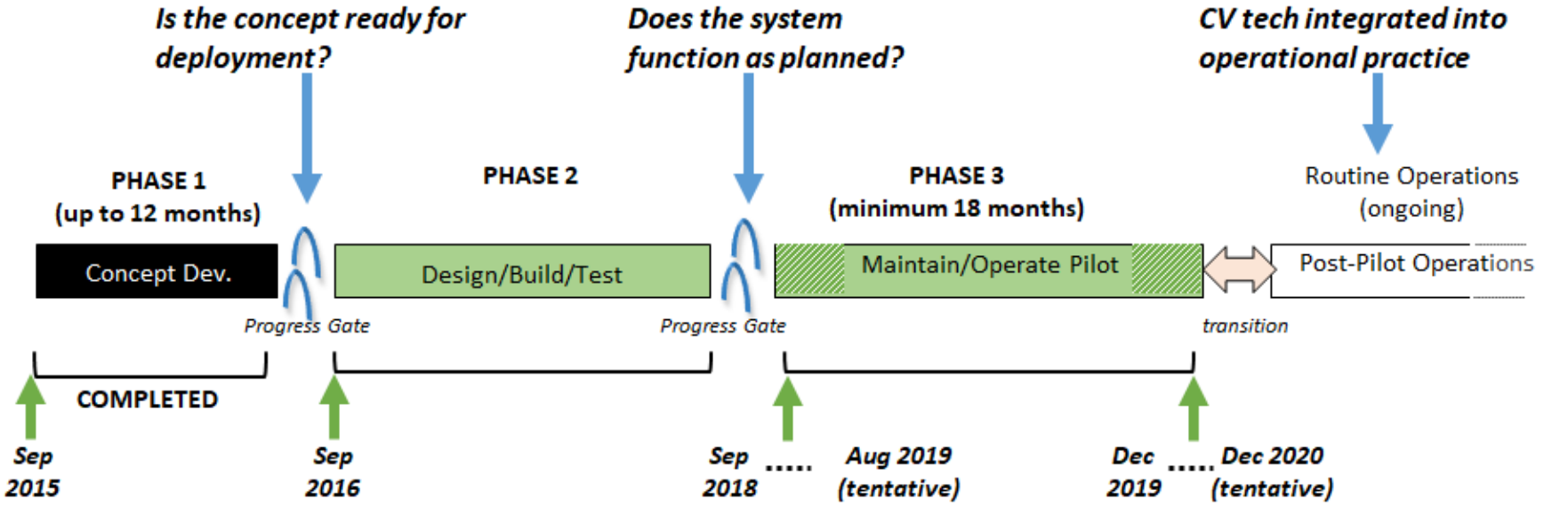
THE THREE PILOT SITES

- 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 8,000 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.

CV Pilot Deployment Schedule



Last updated: March , 2019

CV Device Deployment Status (As of June 2019)

Wyoming Pilot (WYDOT)	Complete	Target
WYDOT Maintenance Fleet Vehicles	25	90
WYDOT Vehicles – COTS OBU	0	25
Private Fleet Partner Trucks	0	255
WYDOT Highway Patrol	0	35
Total Equipped Vehicles	***25***	***~405***
Roadside Units (RSU) along I-80	***75***	***75***

Tampa Pilot (THEA)	Complete	Target
Vehicle Equipped with OBU	924	1,080
HART Transit Bus Equipped with OBU	10	10
TECO Line Street Car Equipped with OBU	8	8
Total Equipped Vehicles	***942***	***~1,100***
Roadside Units (RSU) at Downtown Intersections	***44***	***44***

New York City Pilot (NYCDOT)	Complete	Target
Taxi Equipped with Aftermarket Safety Device (ASD)	1	3,200
DCAS Fleet Equipped with ASD	0	3,200
MTA Fleet Equipped with ASD	2	700
NYCDOT Fleet Equipped with ASD	83	700
DSNY Fleet Equipped with ASD	1	170
Total Equipped Vehicles	***87***	***~8,000***
Roadside Units (RSU) at Manhattan and Brooklyn Intersections and FDR Drive	***98***	***400***
Vulnerable Road User (Pedestrians/Bicyclists) Device	0	100
PED Detection System	2	10

DCAS: Department of Citywide Administrative Services;
MTA: Metropolitan Transportation Authority;
DSNY: City of New York Department of Sanitation.

Wyoming DOT Pilot Deployment

Deepak Gopalakrishna (for Vince Garcia, WYDOT)

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Pilot Overview

Interstate 80 Corridor

- I-80 in Wyoming is one of the busiest freight corridors in the region
  - More than 32 million tons of freight per year.
  - Truck volume is 30-55% of the total traffic on an annual basis—can be as much as 70% on a seasonal basis.
- Difficult environment and terrain
  - Elevations above 6,000 feet across the entire corridor.

CONNECTED VEHICLE PILOT

75 ROADSIDE UNITS

Receive and broadcast messages using DSRC technology along sections of I-80. The units will be installed at locations along the corridor based on identified hotspots.

400 INSTRUMENTED FLEET VEHICLES

Equipped with DSRC-connected onboard units that broadcast basic safety messages, share alerts and advisories, and collect environmental data through mobile weather sensors.

WYDOT TRAVELER INFORMATION

The data collected by fleets and roadside units gives drivers in Wyoming improved travel information through services like the Wyoming 511 app and the commercial vehicle operator portal (CVOP).

WYDOT CV Pilot: Where are we today?

Update these numbers accordingly

RSUs
- 76 RSUs of 77 total on the road
- RSUs are enrolled in the production SCMS
- RSUs and TMC servers and data warehouse are monitored for M&O in production

OBUs
- 25 vehicles equipped of 400
- OBUs are enrolled in the production SCMS
- 23 Pilot Drivers trained

Applications
- Forward Collision Warning, Distress Notification, Event Logging, and Traveler Information Messages are complete
- Applications for Over the Air (OTA) updates are being finalized

TMC Systems in Production
- Operational Data Environment (i.e., CV Data Manager)
- Pikalert (Road Weather Expert System)
- Truck Parking
- Distress Notification Alerts
- Data transfers to the SDC and Public Data Hub

Next Steps

- Certify devices
- Continue to deploy on WYDOT and partner vehicles
- Finalize last few applications
- Start reporting on performance on a monthly basis from mid-2019

Operating at Scale:

WYDOT'S VISION AND CHALLENGES SO FAR

Operating at Scale

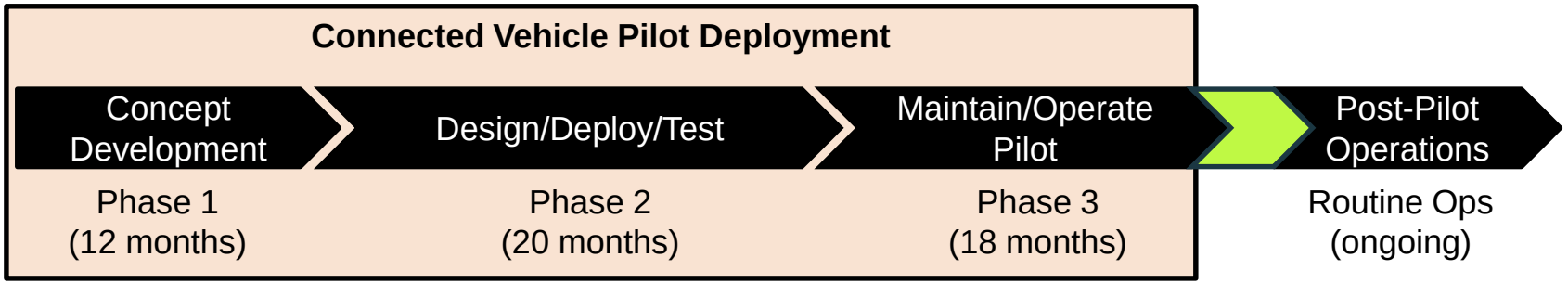
Vision

Fully integrated and secure CV System that transmits and receives data to/from other equipped vehicles and roadside infrastructure.

- **This entails:**
  - Complete integration with existing/future WYDOT systems and infrastructure.
  - Secure data management.
  - Innate interoperability with all external equipment/vendors and neighboring deployments.
  - Continuous maintenance of its robust CV infrastructure.

ALL OF THIS WITHIN OUR ORIGINAL TIMELINE…

Update these numbers accordingly

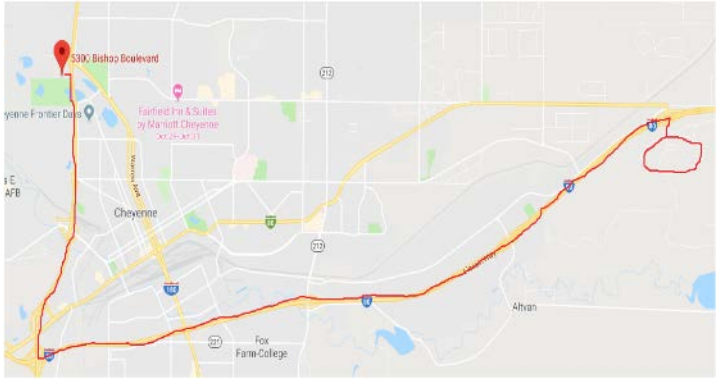


WE'VE HAD SUCCESS TESTING FOR THE PILOT

Interoperability Testing – June 25-28, 2018

- Objective of the test was to check that all vehicles:
  - Received SAE J2735 Basic Safety Messages (BSMs).
  - Authenticate messages as needed.
  - Parse messages.
  - Process messages.
- V2I and V2V Applications tested.
- Messages were exchanged across and understood by all systems.

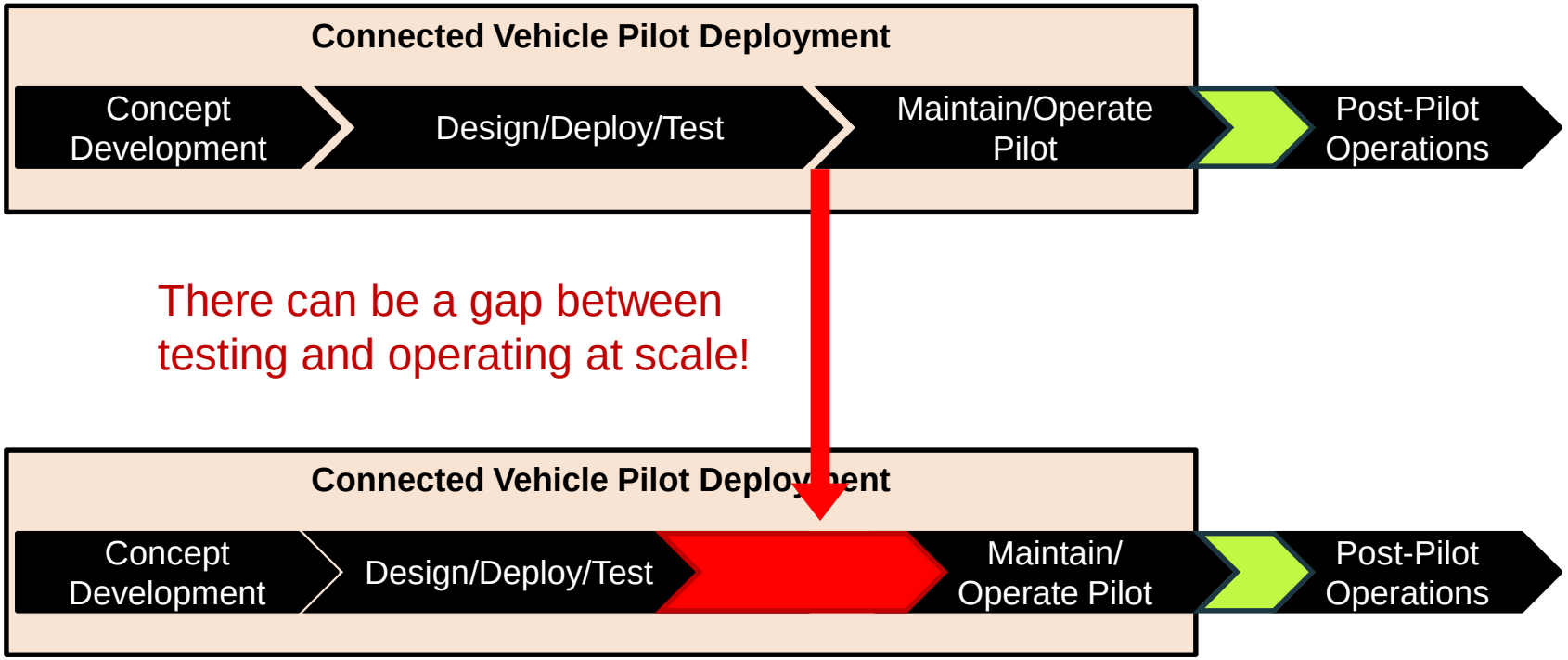
WE'VE HAD SUCCESS TESTING FOR THE PILOT



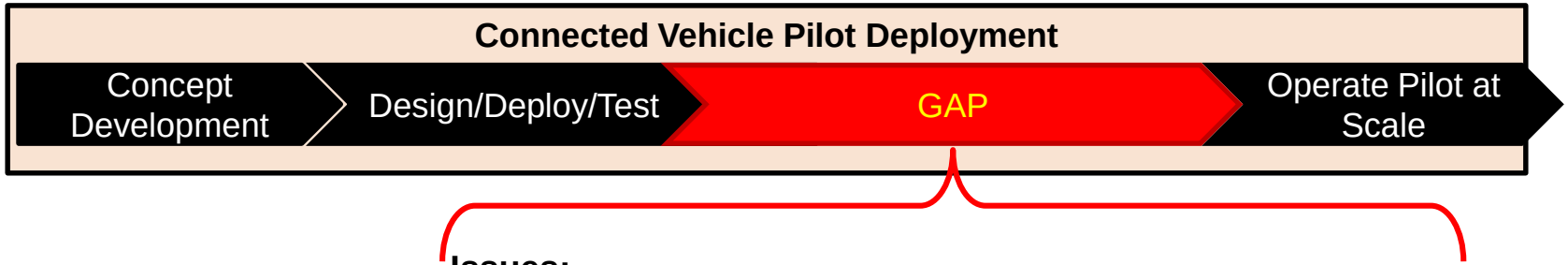
Operational Capability Showcase – October 30, 2018

- 2 snow plows
- 1 Semi-trailer truck
- 2 WYDOT sport utility vehicles (SUVs)
- 1 WYDOT pickup
- 1 Trihydro pickup

HOWEVER…TESTING FOR PILOT ≠ TESTING FOR SCALE



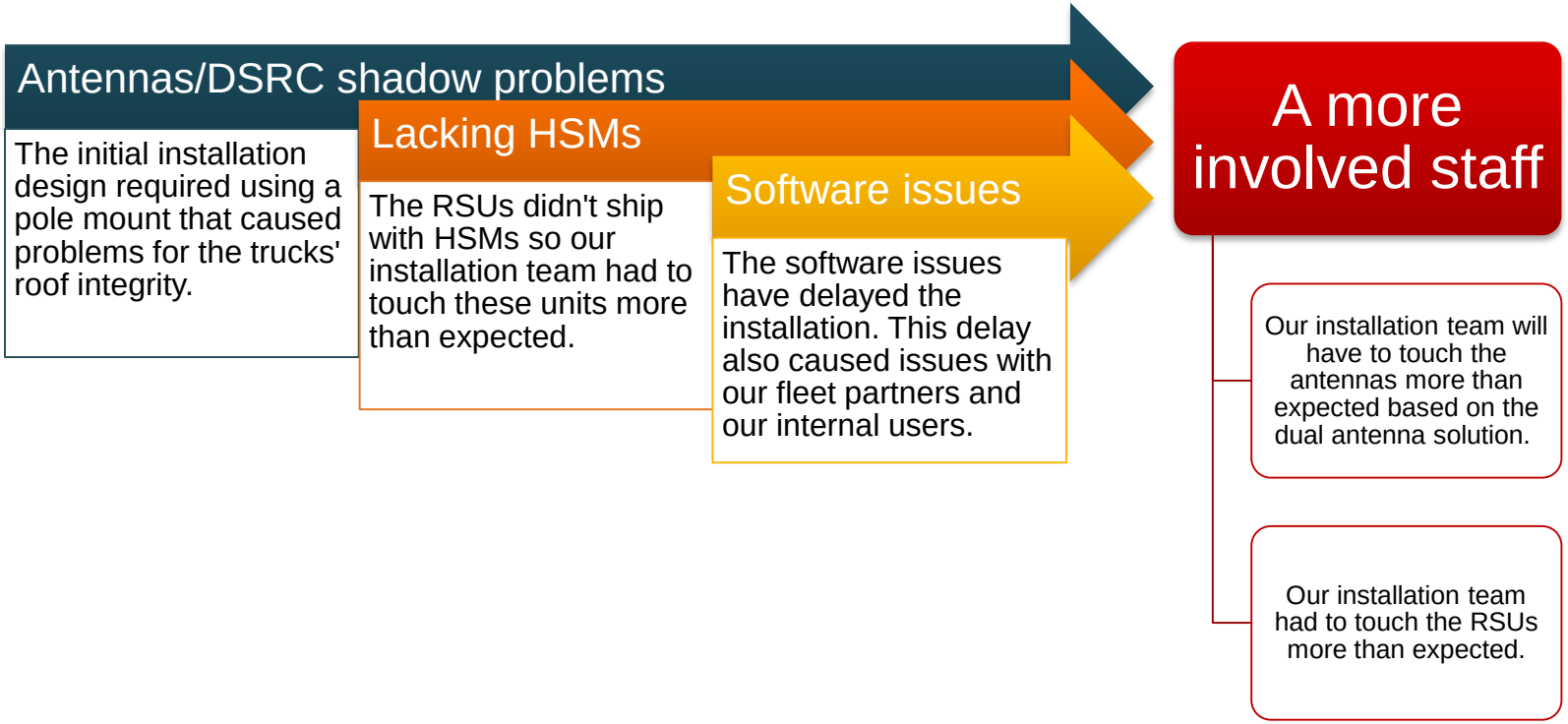
Issues and Challenges



Issues:

- Trucks are not cars. Many standards and solutions do not apply—e.g., antenna location.
- Data volume increasing.
- OBU failing at scale, constant hardware and firmware updates.
- Technical challenges in ensuring a secure network—e.g., SCMS integration and firewall compatibility.
- Getting partners early can be hard.
- Adverse weather presents its own challenges.
- *And more…*

Operational Consequences?



Lessons Learned and Suggestions

- Management issues tend to follow technical issues
- It is critical to manage expectations
- Be prepared to change internal processes
- Engage partners when you are ready

Tampa (THEA) Pilot Deployment

Bob Frey

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WHAT IS THEA?

- **A local, user-financed public agency**
  - Financed through revenue bonds
  - Supported by user tolls
  - No tax funding
  - Tolls stay local

INDEPENDENT
Agency of the State

- **Benefits of Testing at an agency like THEA?**
  - Consistency of Participants
  - Flexibility to outside research design
  - Procurement

Focused Deployment Area
Real Life Problems

Participants and Infrastructure Operational System

1,100

Privately Owned Vehicles

8

TECO Line Streetcar Trolleys

10

Hillsborough Area Regional Transit (HART) buses

44

Roadside Units

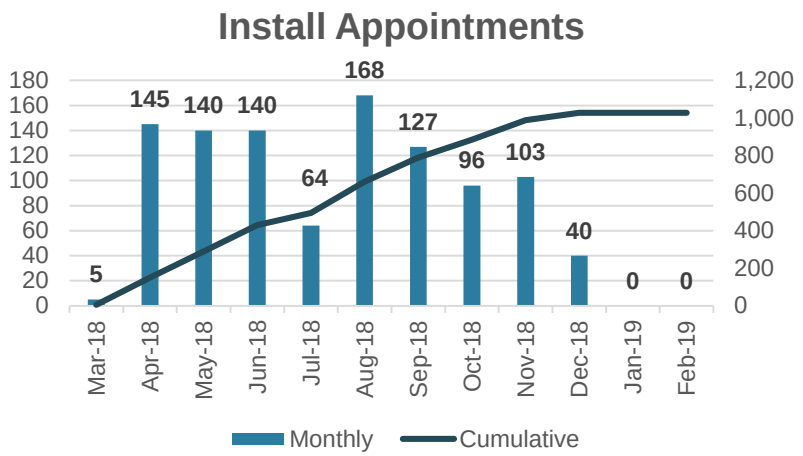
TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY

U.S. Department of Transportation

PARTICIPANT RECRUITMENT

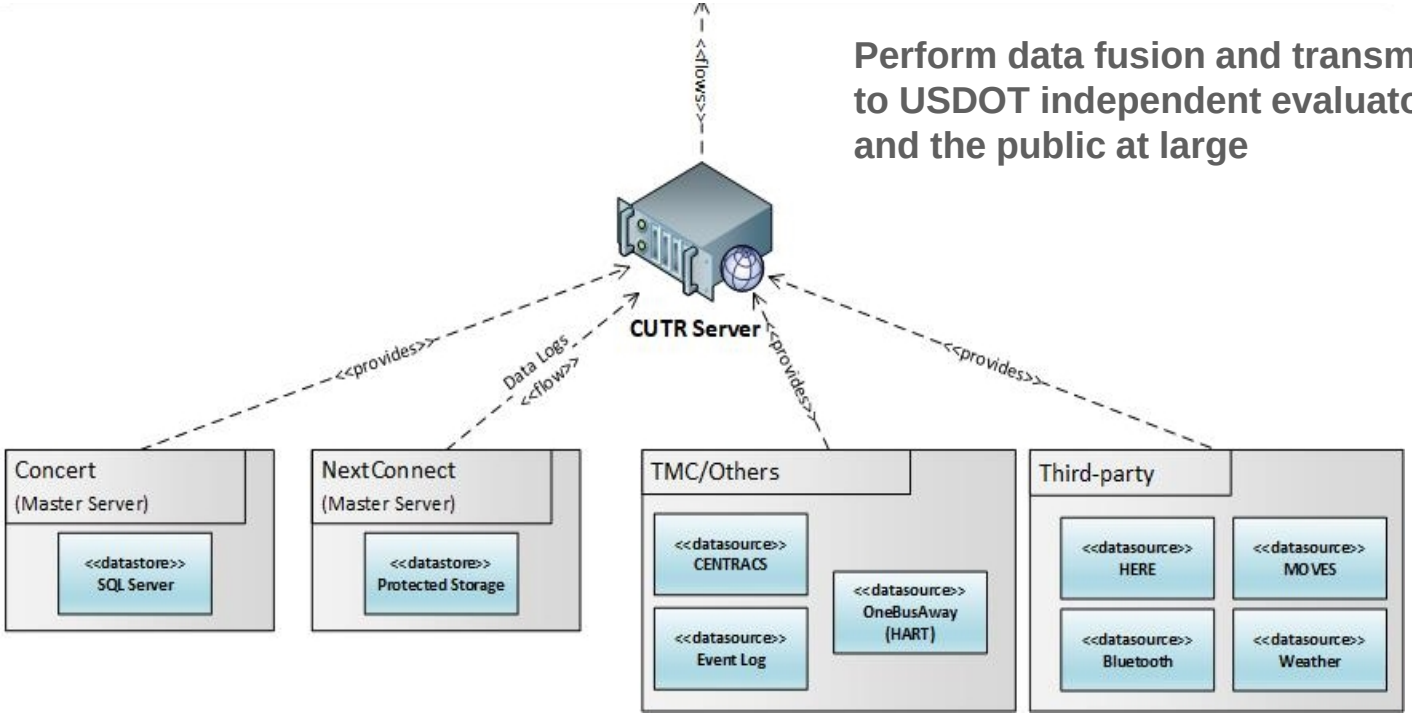
- Total of 1,028 On Board Units (OBU) installations
  - 1,006 are participants.
- Total of 780 participants actively coming to the study area (first two weeks of March 2019)
  - 77.5 percent participation rate
- Continuing support to troubleshoot, install, reinstall OBUs.

OBU Type	Count	Share
Participants	780	94.9
Bus	10	1.2
Trolley	7	0.9
City of Tampa	13	1.6
Friend of the Pilot	7	0.9
Total	817	99.4



Feb. 28 through March 14 Data

PHASE 3 - MEASURING PERFORMANCE



Perform data fusion and transmit performance measures to USDOT independent evaluators, research community, and the public at large

Mobility

- Travel time
- Travel time reliability
- Delay
- Throughput

Safety

- Crash rates
- Type of conflicts
- Severity of conflicts

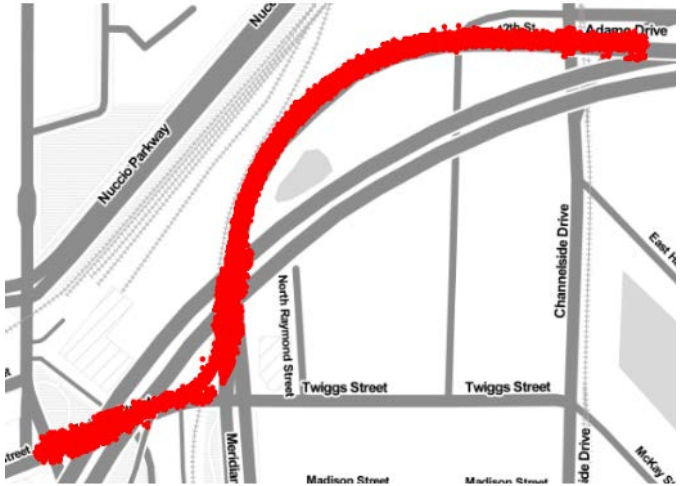
Environment

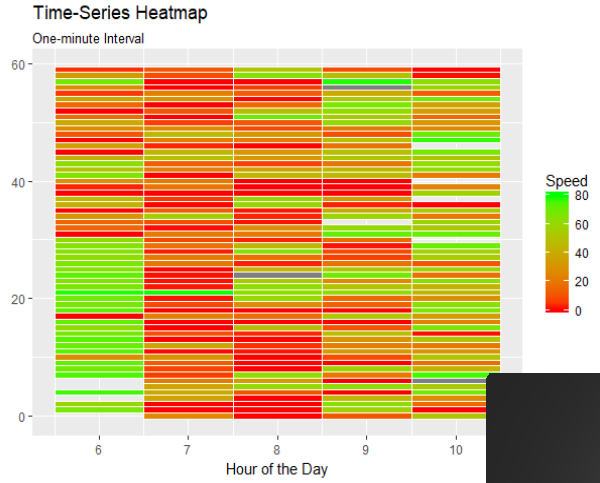
- Emission analysis

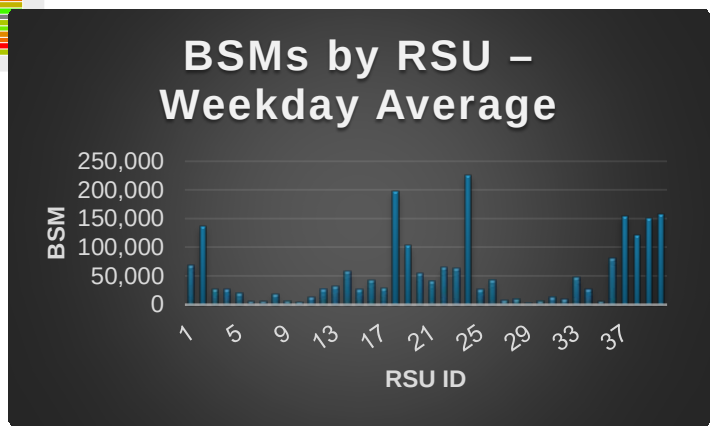
MEASURING PERFORMANCE: CONNECTIVITY

- We have system connectivity!
  - Different than testing
- Everything is not equal
  - Some RSU receive more BSM than others
- Coverage of entire study area ensured
  - Actually covering about 70% of Downtown

PHASE 3 - MEASURING PERFORMANCE: TRAFFIC DATA



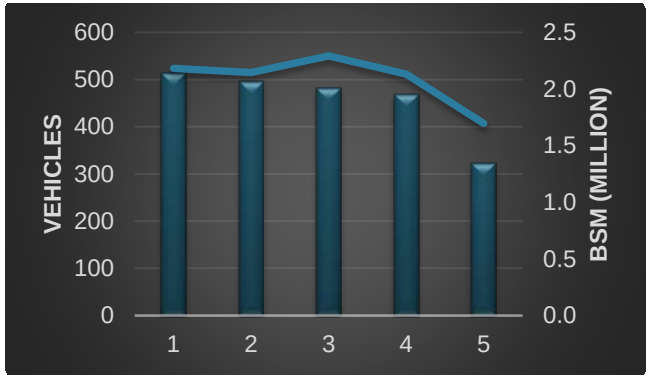


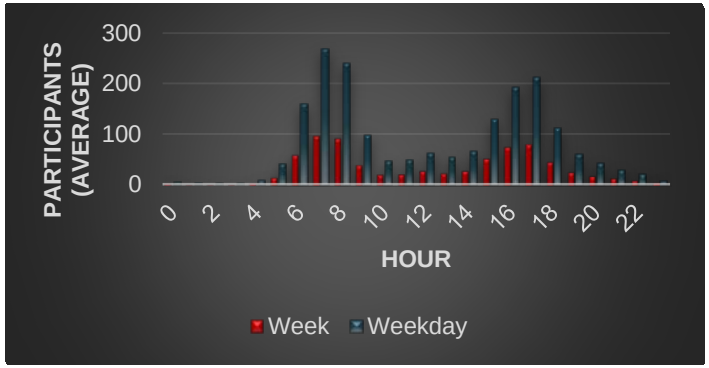


Ground “Truthing”

- Electronic World matching Real World

TRAVEL DATA

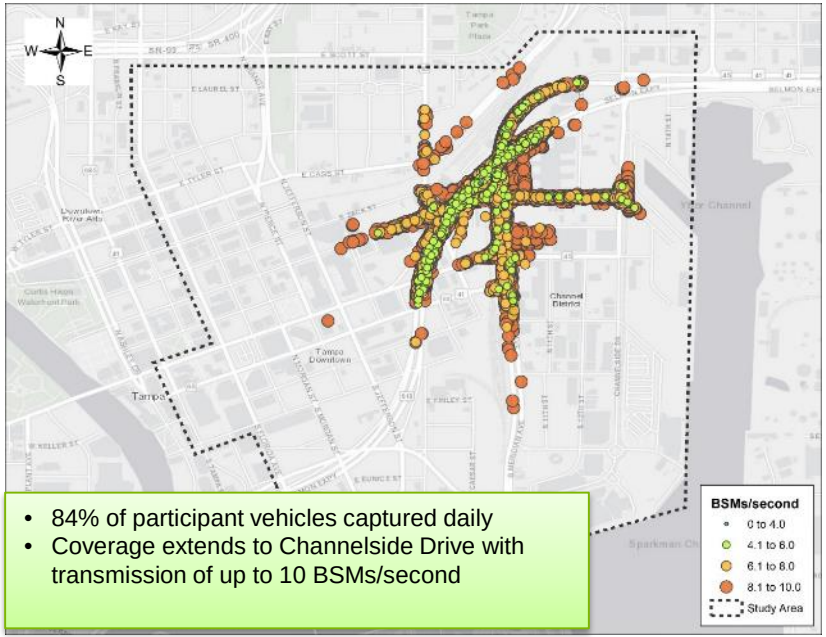




- 800 participant currently enrolled (ongoing)
- Experimental design to evaluate pilot performance with 2 to 1 treatment to control assignment
- Reflect THEA user base
- 55% enter the study area daily (weekday)
- Weekday Travel
  - 500 participants daily
  - Average of 1.9 million BSM/day
  - Travel patterns with a.m. and p.m. peak periods
  - Up to 150 participants per hour on average at a.m. peak hour (7 a.m.)

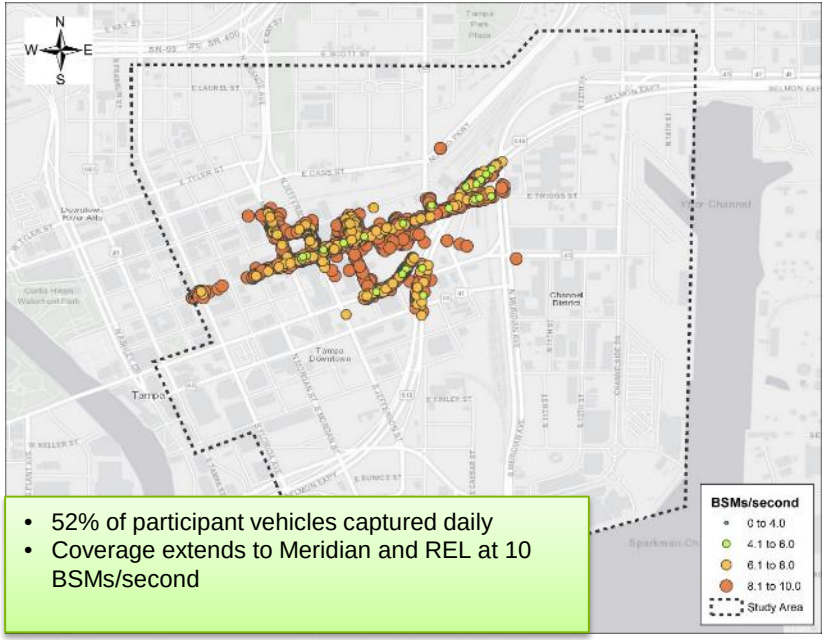
PRELIMINARY ANALYSIS

RSU 2 – Twiggs and Meridian



- 84% of participant vehicles captured daily
- Coverage extends to Channelside Drive with transmission of up to 10 BSMs/second

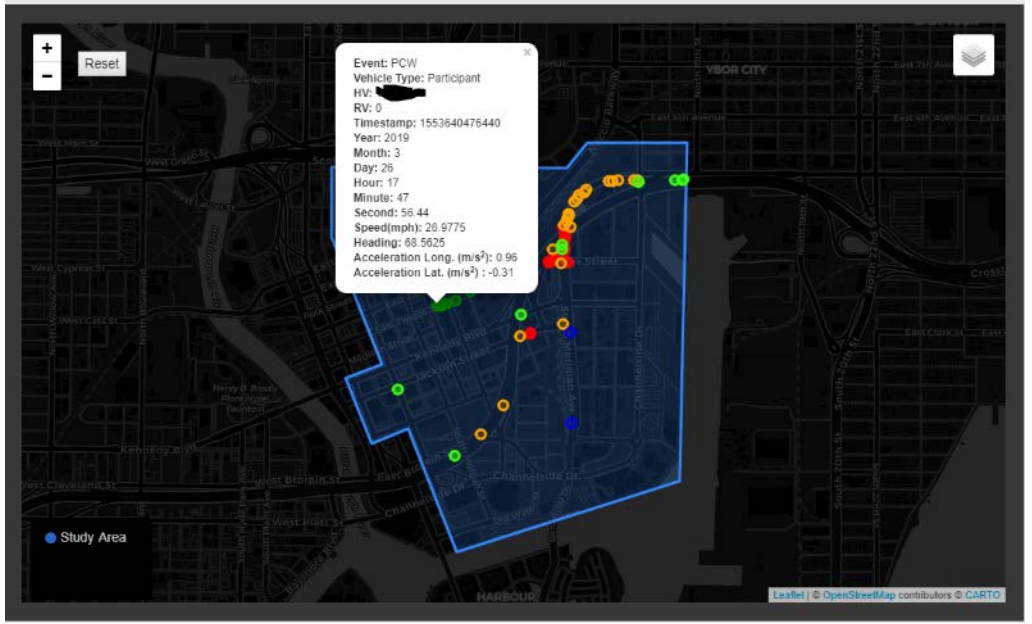
RSU 3 – Twiggs and Courthouse



- 52% of participant vehicles captured daily
- Coverage extends to Meridian and REL at 10 BSMs/second

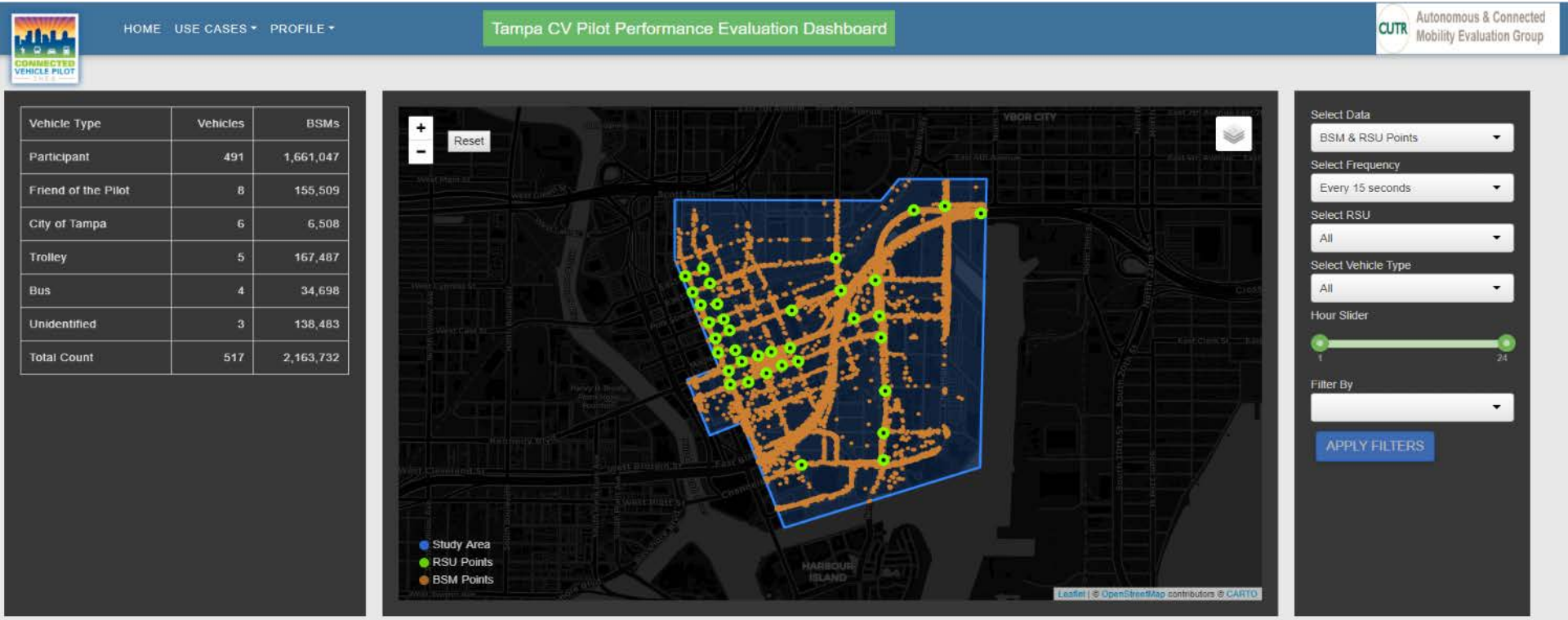
WARNING EVENTS

Event Type	Count
WWE	33
FCW	24
IMA	10
PCW	6
EEBL	2
Total Count	75

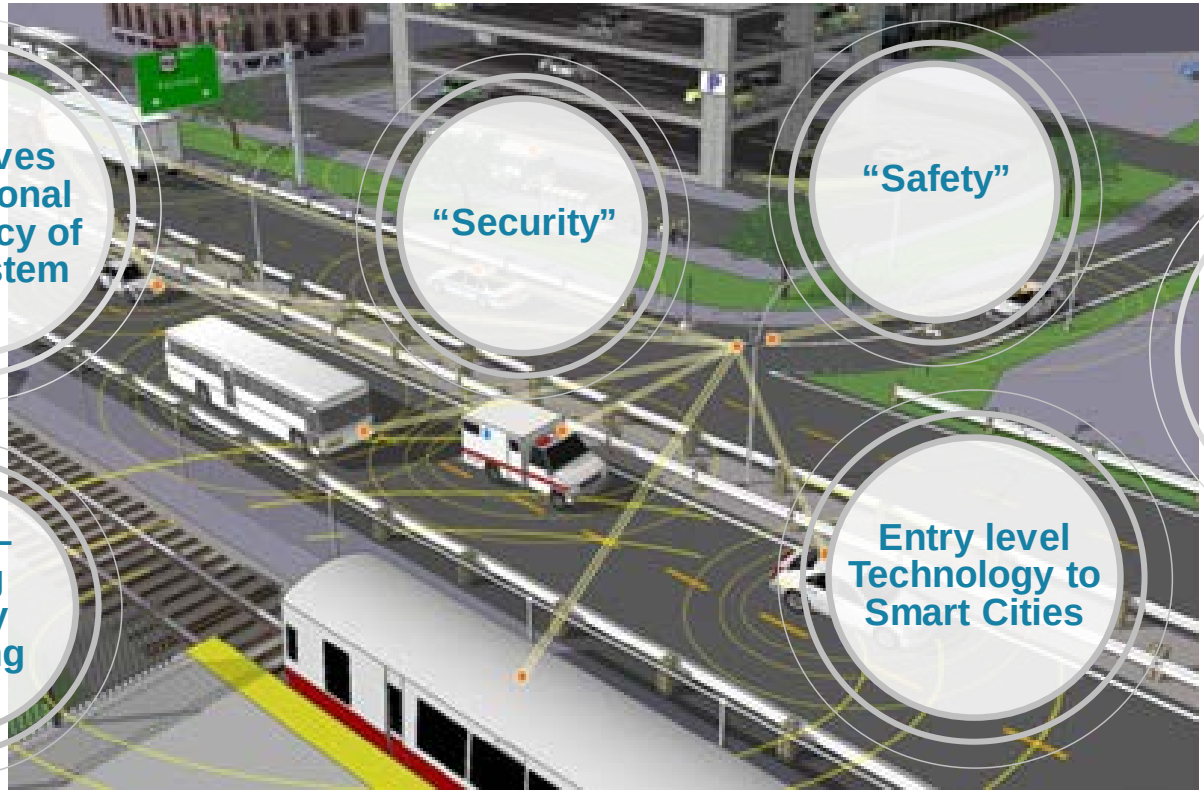


- Warning events generated by participants through April 25
- Still in stealth mode, warnings are actually not displayed on rear view mirror
- We are recording and analyzing data

PERFORMANCE EVALUATION DASHBOARD



Why Connectivity?
Benefits of Connected Vehicle Communication



Improves operational efficiency of the system

"Security"

"Safety"

Ability for all residents to experience benefits of technology…

DSRC – Strong History in Tolling

Entry level Technology to Smart Cities

IF WE COULD DO IT OVER AGAIN:

- Focus on the V2I (including pedestrian and transit) – What Public Agencies can Control
- Remember emerging technologies are bringing new disciplines to our workspace – vocabulary matters
- Solidify Standards Earlier
- Obtain a Better Understanding of “Available” Applications’ Maturity
- Obtain a Better Understanding of “Available RSU and OBU Hardware
- Obtain a Better Understanding of Vendors’ Depth and Resources
- Identify the ability to Use Traditional ITS Devices as Part of Solution Earlier
- Cell phones are not there yet for safety devices
- Treat Security like the Specification
- Manage volunteer recruitment more effectively
- Use Fiber where possible – Cellular Costs ($100 a month per site)
- The several emails you get saying you helped prevent a crash make it all worth it…

NYCDOT Pilot Deployment

Mohamad Talas

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Project Overview

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

NYC CV Safety Applications

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 (RSU)
- Visually Impaired Crossing (PID)

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

Customized Applications

Additional Applications

Traffic Management

- CV Data for Intelligent Traffic Signal System

Operations, Maintenance, and Performance Analysis

- RF Monitoring
- OTA Firmware Update
- Parameter Up/Down Loading

- Traffic data collection
- *Event History Recording*
- *Event History Up Load*

Roadway segment travel times

To Evaluate the benefits

CV STAKEHOLDER/USER DEPLOYMENT

Vehicles

- **Up to 8,000 fleet vehicles with Aftermarket Safety Devices (ASDs):**
  - ~ 3000 Taxis (Yellow Cabs)
  - ~ 700 MTA Buses
  - ~ UP to 5000 DCAS vehicles

Revenue Producing Vehicles

Pedestrians

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

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

CV INFRASTRUCTURE DEPLOYMENT

- Roadside Units (**RSU**) at ~400 Locations
  - ~200 Manhattan Ave
  - ~ 80 Manhattan Cross
  - ~ 30 East River Bridges
  - ~ 30 on Flatbush Ave
  - ~ 8 on FDR *"freeway and restricted route – curve speed warning"*
  - ~ 36 Support locations (airports, river crossings, terminal facilities)
  - Equipment installers to verify initial installation

Will Include Intersection I2V SPaT, MAP, TIM

LOCATIONS (MANHATTAN, BROOKLYN)

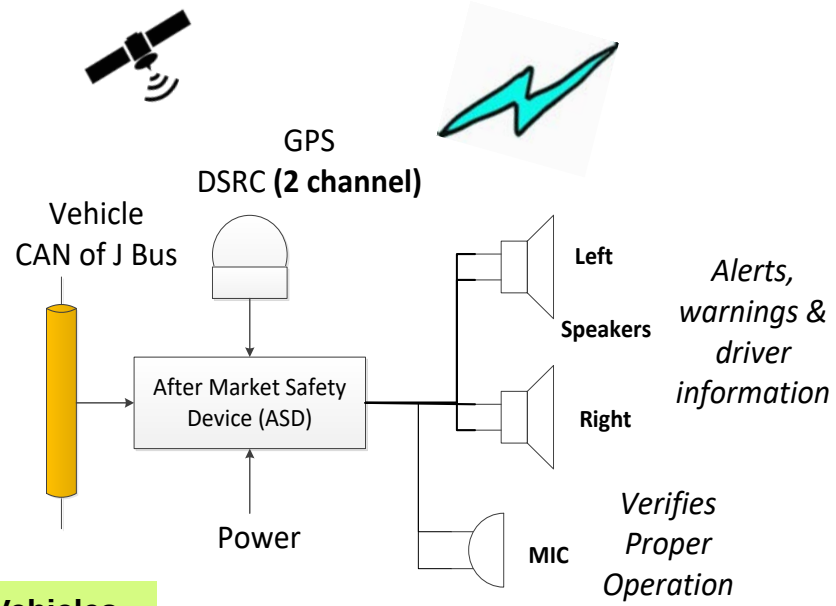
V2I applications work where **infrastructure is installed** (along highlighted streets).

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

The CV project leverages the City's transportation investments

AFTERMARKET SAFETY DEVICE FOR NYC

- Audio output only
  - Tones based on threat
  - Words based on situation
- ASD includes
  - Inertial Navigation
  - GNSS Navigation
  - **Connection to Vehicle data Bus**
  - **Triangulation from RSU signals**



Note that NYC CV uses DSRC to Vehicles:
- Software updates
- Data collection
- All V2V and V2I safety applications

Source: NYCDOT

CHALLENGES FOR DATA COLLECTION

- Privacy
  - Real-time BSM data – combined with other sources
    - Fear of subpoena and FOIA requests
    - Police crash records
  - Data is Encrypted, Normalized, Obfuscated and Aggregated
  - Data ages off the ASD within 48 hours if not collected
- Scalability of the collection scheme
  - Vehicles Transmit 500K **BSM**s/day = 322 GB per day
  - With 36 Data Collection Stations - ~9GB/Day/Site (270 GB/Month!)
  - Add SPaT, MAP, TIM and everything everyone receives . . . .

Not enough "connection time" to upload this amount of data!
Monthly usage (carrier) is too costly
No bandwidth to send over the wireless network!

Current Status

WHERE ARE WE NOW ? PHASE 2

Phase 2 –Design & Deployment Prototype Testing

- Central CV system at TMC to support OTA
- **Working with ASD vendor 96-installed**
- **RSU installed 106**
- Testing **Controller software with security**
  - To provide SPaT data to RSU
  - Providing SPaT data to the PED applications
  - Using NTCIP 1202v3 with DTLS 1.2 Security
- Working with a PED application developer –
- Developing test procedures
  - verify elements and system
- Continuously evaluating safety applications

The Project Teams are sharing ideas, challenges, workshops, and the NY team is aggressively participating in the standards development program!

NEW YORK CITY DOT

U.S. Department of Transportation

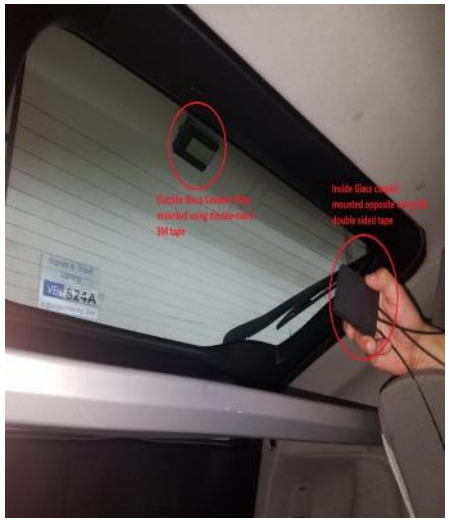
Phase 2 Installation and Testing

- Developed MAP message Content
  - Using USDOT tool
- RSU installation sites
- Established ASD Installation “partners”
- Developing vehicle installation kit designs
  - Working with vendors
  - Working with Fleet owners

INSTALLATION TESTING - 2

- **Develop installation procedures (four Contracts)**
  - Location and orientation of in-vehicle “box”
  - Location and routing of Antenna cables (3 = 2 DSRC + GPS)
  - Interface to vehicle data bus (J bus, CAN bus)
  - Speaker location
    - Note that we are not able to connect to audio system
  - Developing testing and alignment procedures
  - Verify non-interference with existing instrumentation and vehicle operation
- **Procedures to Configure ASD at time of installation** - -
  - Vehicle dimensions or characteristics
  - Center of vehicle – antenna offsets etc.
  - RF adjustments
  - RF sensitivity verification
  - Location calibration and accuracy
  - Group membership

VEHICLE INSTALLATION



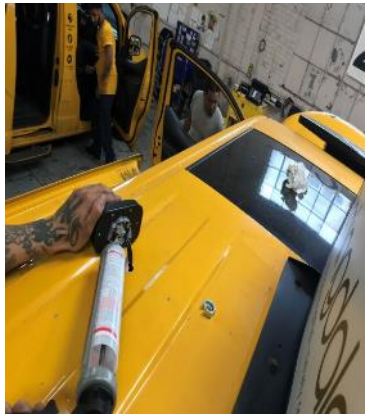
- 96 Prototype Fleet vehicle installed,
- 106 RSU Prototypes installed
- Verified acceptability of through the glass and drilled mountings
- Working with various different vehicle types
- Vendor developed CAN bus interface

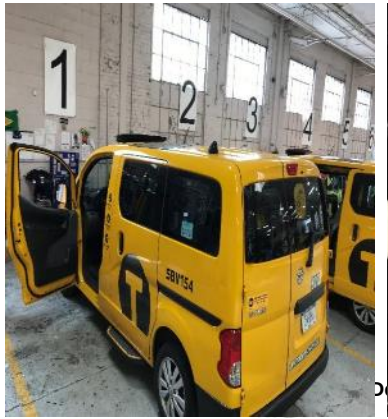
MTA INSTALLATION

- Progress made on installing 2 NYC Transit Buses
  - Nova Bus LFS60102 60FT Articulator (2011)
  - New Flyer T 60FT Articulator (2017)
- The buses were installed to test RF DSRC communication with light vehicles, and to develop an installation template

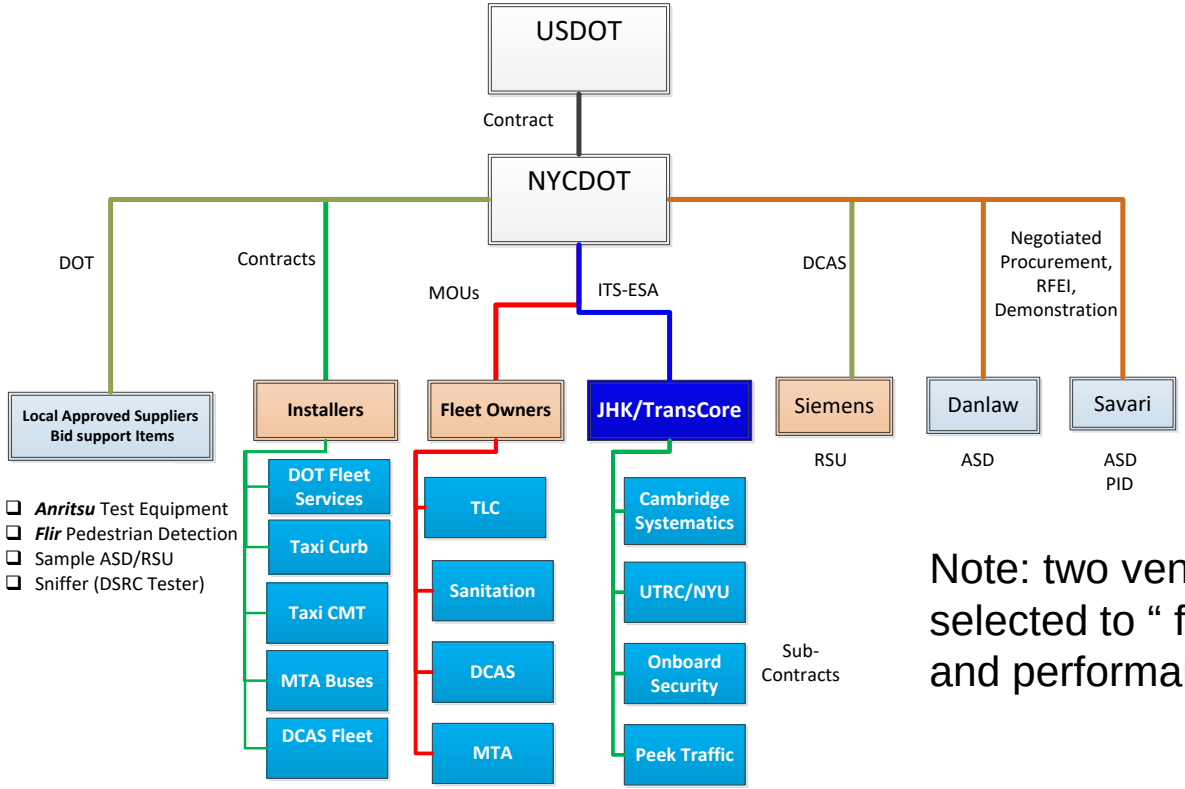
TAXI INSTALLATION

- Taxi Installations are estimated at 3000 vehicles between the participating fleet owners
- Curb and CMT, are 2 authorized technology installers for TLC that have been engaged in installing ASD equipment in their vehicles
- Taxi fleet is expected to include:
  - Toyota
    - Prius
    - Sienna
    - RAV4
  - Nissan NV 200





CONTRACTING STRUCTURE



- ***Anritsu*** Test Equipment
- ***Flir*** Pedestrian Detection
- Sample ASD/RSU
- Sniffer (DSRC Tester)

Note: two vendors were selected to “ for schedule and performance

Contracting Issues

- Contracting practices for “new” technology
  - Not procuring a “standard” product
  - Things need to change
- Cooperative design and testing
  - Needs technical assistance
  - Need for prototype evaluation and testing
  - Need to establish a test facility
- Balancing “open source” requirements with vendor Intellectual Property
- Dealing with new innovations over life of project

Additional Procurement Issues

- Project duration and technology advancement
  - Started in 2015 – Initial Proposal
  - Real experience was only “demonstration”
  - It is now more than 3.5 years later – **change**
    - V2X locate experimental
    - Requiring a solution for 1.5 M accuracy in other than “open sky”
- Project Scale required different approaches
- Using revenue generating vehicles – creates challenges
- Consent for drivers not practical
  - Creates privacy issues

OTHER RSU INSTALLATION NOTES

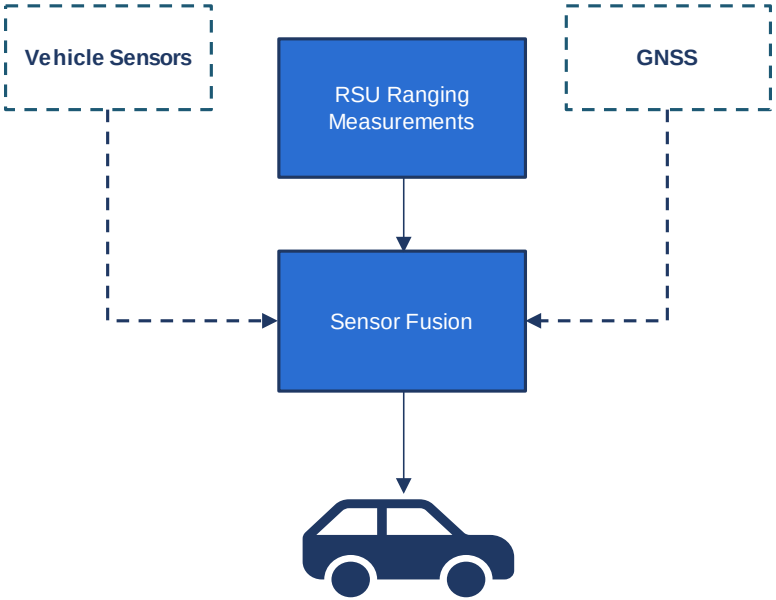
- Focus is on NYCWiN 2
  - Evaluated DIGI solution (uses port mapping – good throughput)
  - Self configuring based on hardwired (cabinet) ASTC address > forms IP address
  - RSU network parameters identical – ease of maintenance
  - RSU-TMC-ASTC communications using DTLS X.509 certs by TMC
  - ASTC communications operational providing SPaT to TMC
  - ASTC software still being tested
    - Only some minor issues for configuration of flashing arrow – been resolved
    - Continue to work with NTCIP 1202 standards for issues and lessons learned
- Asset management system now in place for receipt and tracking of RSUs
- MAP message generation – complete – next step tuning and verification
  - Using City's lidar database

ASD Delivery status

- Testing first 100 prototypes
  - Updated RSU and ASD firmware to improve location accuracy
  - Continued testing of V2V and V2I applications
  - Continued testing and evaluation of location accuracy
  - Expect to release hardware for production quantity
  - 1000 based on available materials ordered at risk 4/8/2019
  - 3000 based on 20 week lead time to start delivery 4/8/2019
  - 4000 based on 20 week lead time to start delivery 7/3/2019
- Initial Production (1000)
  - Delivery at 250 per week – starting 6/14/19
- Second production batch (3000)
  - Delivery of 400 per week – starting 7/14/19
- Third production batch (4000)
  - Delivery of 400 per week – starting 8/23
- Asset management processes in place

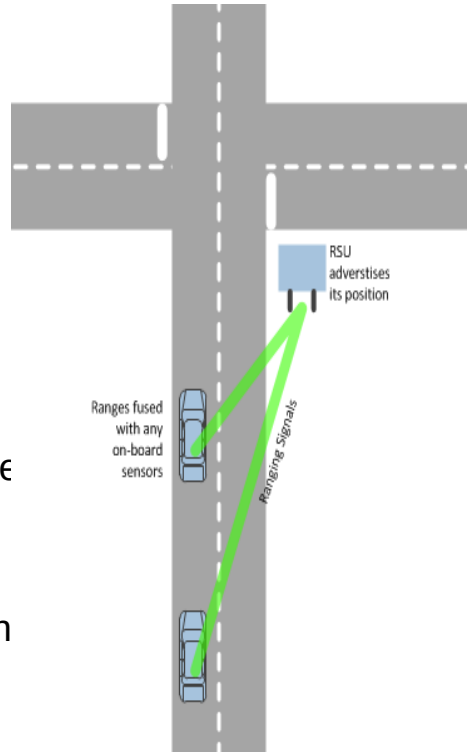
V2X-Locate Architecture

While V2X-Locate is more accurate than traditional GNSS, it is not intended to replace GNSS, but instead integrate and compliment this technology



RSU TRIANGULATION

- V2X Locate uses
  - standard RSUs and ASDs
  - standard V2X messages
- to determine position of vehicle by ranging
- RSU location known thanks to standard advertisements
- Fuses vehicle sensors and GNSS when available.

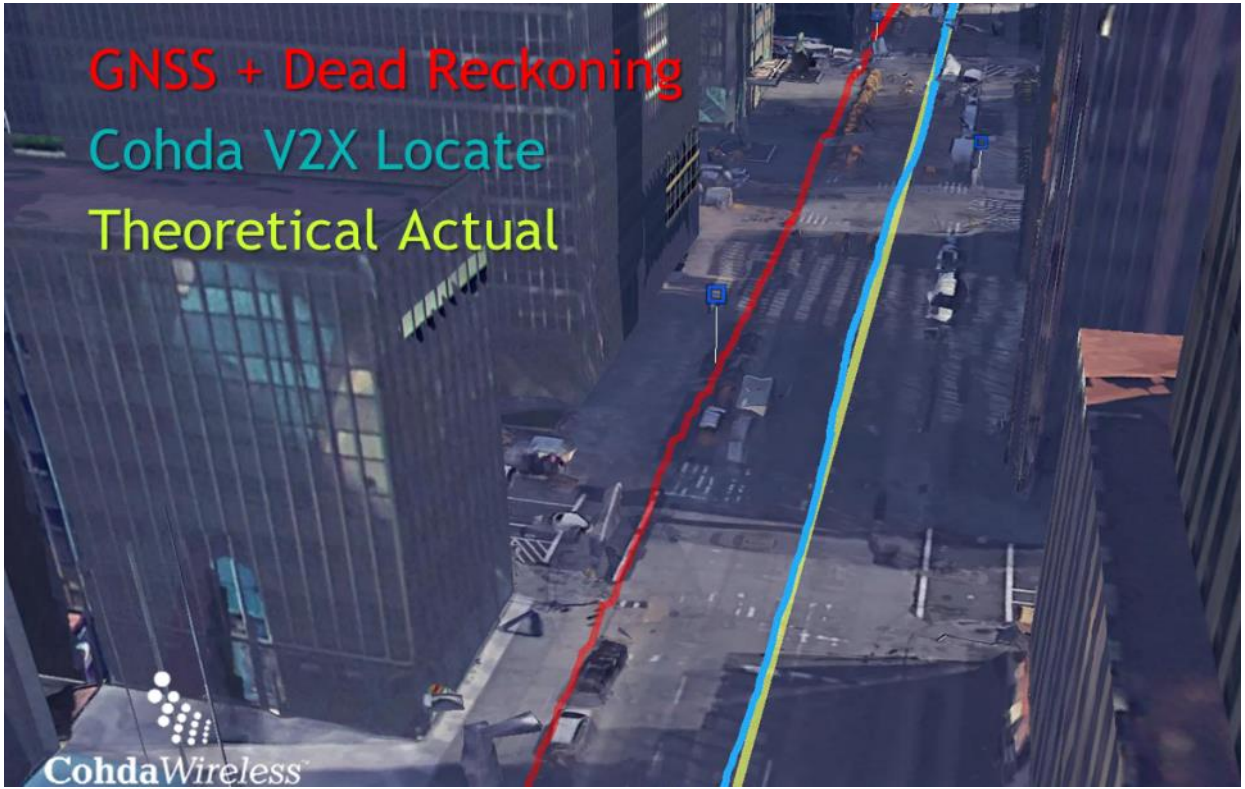


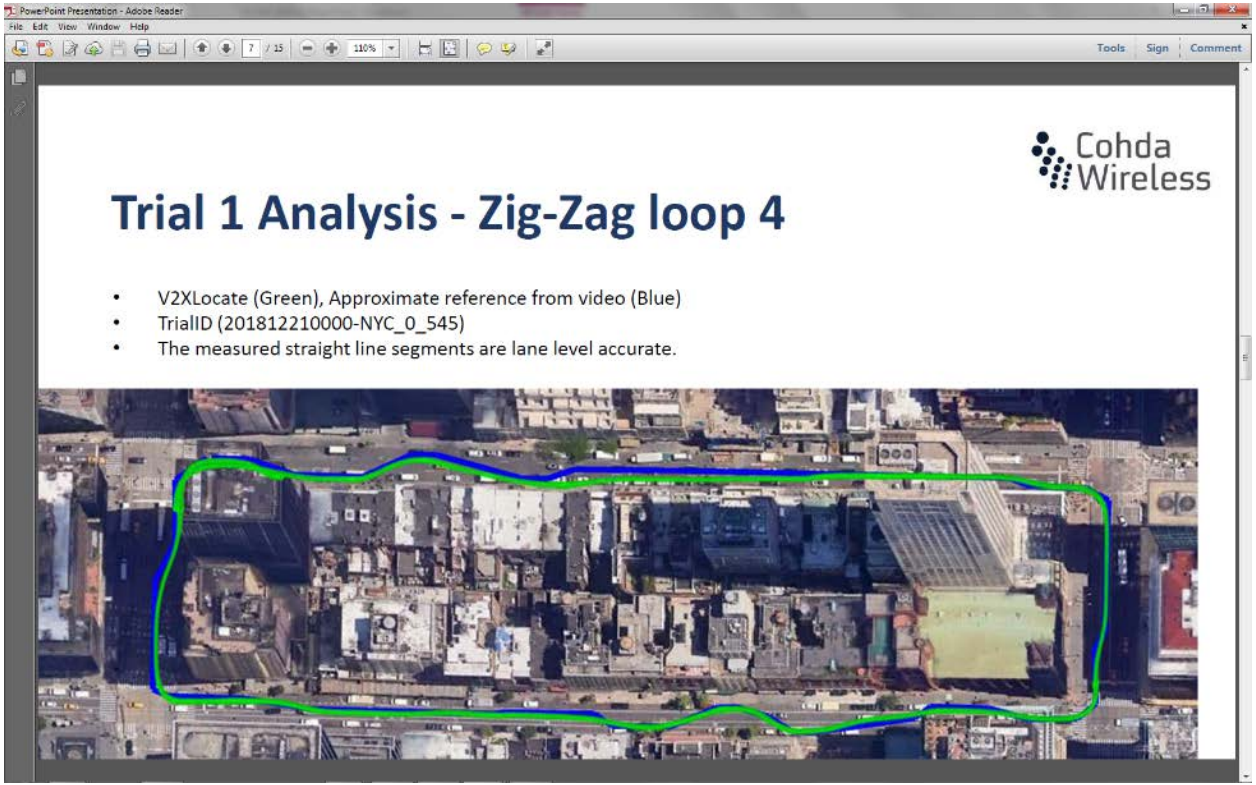
EXPECTED PERFORMANCE

- All proposed V2V and V2I goal of satisfactory performance is me
  at 90% of the time.
- Continued work to fine tune the Apps and the location accuracy
- Optimize the installation of the RSUs to support the triangulation

*

Examples of Accuracy




PowerPoint Presentation - Adobe Reader
File Edit View Window Help
Tools Sign Comment
Cohda Wireless
Trial 1 Analysis - Zig-Zag loop 4
• V2XLocate (Green), Approximate reference from video (Blue)
• TrialID (201812210000-NYC_0_545)
• The measured straight line segments are lane level accurate.

PHASE 3 CV PILOT DATA COLLECTION SUMMARY

- CV Device Data
  - ASD Action Log Data
  - RSU Mobility Data
  - PID Log Data
  - System Operations Data
- Non-CV Device Data
  - Crash Data
  - Operations Conditions Data
  - Confounding Factors Data

Q&A

NYCDOT

Tampa (THEA)

WYDOT

USDOT

STAY CONNECTED

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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/

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