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COPENHAGEN
17 – 21 SEPTEMBER 2018
Quality of life

EFFECTIVE MEASURES OF SUCCESS: THE UNITED STATES CONNECTED VEHICLE PILOTS

Intelligent Transportation Systems Joint Program Office

September 19, 2018

Session Introduction

Kenneth Leonard, Director, ITS Joint Program Office (JPO), USDOT

Session Agenda

- 1:30 – 1:35 PM - Session Introduction
  - *Kenneth Leonard, Director, ITS Joint Program Office (JPO), USDOT*
- 1:35 – 1:50 PM - Wyoming DOT Pilot Project
  - *Kevin Gay, Chief, Policy, Architecture, & Knowledge Transfer, ITS JPO, USDOT*
- 1:50 – 2:05 PM - Tampa (THEA) Pilot Project
  - *Bob Frey, Planning Director, Tampa Hillsborough Expressway (THEA)*
- 2:05 – 2:30 PM - New York City DOT Pilot Project
  - *Mohamad Talas, Director of System Engineering, NYCDOT*
  - *Bob Rausch, Vice President, Transcore*
- 2:30 – 2:45 PM - Interoperability Test Summary
  - *Kevin Gay, Chief of Policy, Architecture, & Knowledge Transfer, ITS JPO, USDOT*
- 2:45 – 3:00 PM: Questions and Answers

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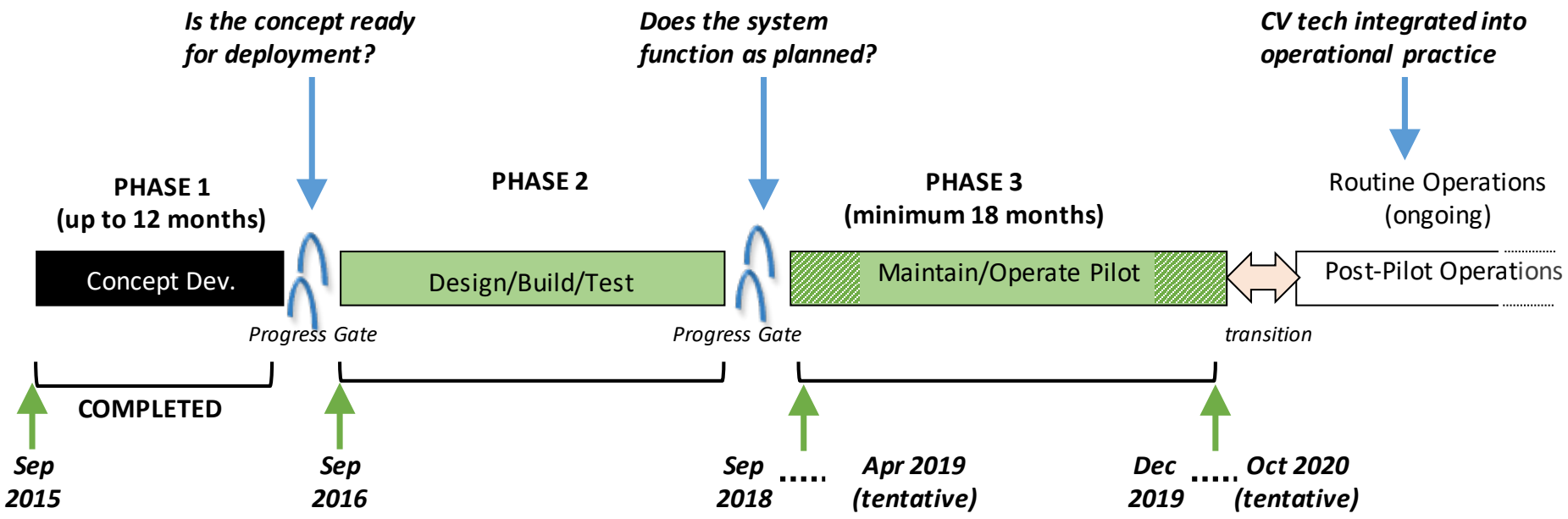
Federal Highway Administration

CV Pilot Deployment Program Goals

Source: USDOT

U.S. Department of Transportation
Federal Highway Administration

CV Pilot Deployment Schedule



- **Phase 1: Concept Development (COMPLETE)**
  - Creates the foundational plan to enable further design and deployment.
- **Phase 2: Design/Deploy/Test**
  - Detailed design and deployment followed by testing to ensure deployment functions as intended (both technically and institutionally).
- **Phase 3: Maintain/Operate**
  - Focus is on assessing the performance of the deployed system.
- Post Pilot Operations (CV tech integrated into operational practice).

Last updated: August 2, 2018

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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.

- 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.

- 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.

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WYOMING DOT PILOT PROJECT

Kevin Gay, Chief

Policy, Architecture, & Knowledge Transfer, ITS JPO, USDOT

WYOMING TRANSPORTATION DEPARTMENT

U.S. Department of Transportation
Federal Highway Administration

THE PROBLEM

Heavy Freight Traffic

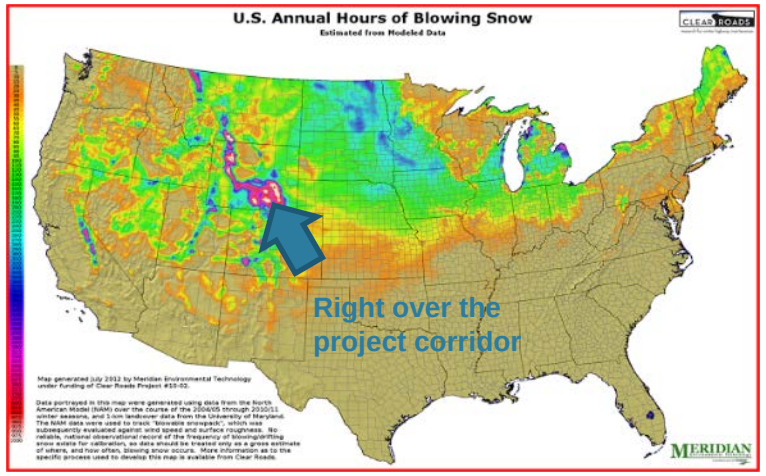
- Major E/W freight corridor
- Freight = over half of annual traffic

Severe Weather Conditions

- Roadway elevation
- Heavy winds, heavy snow and fog
- Severe blowing snow and low visibility

Adverse Impacts on Trucks

- **Higher than normal incident rates**
- **Multi-vehicle crashes**
- **Fatalities**



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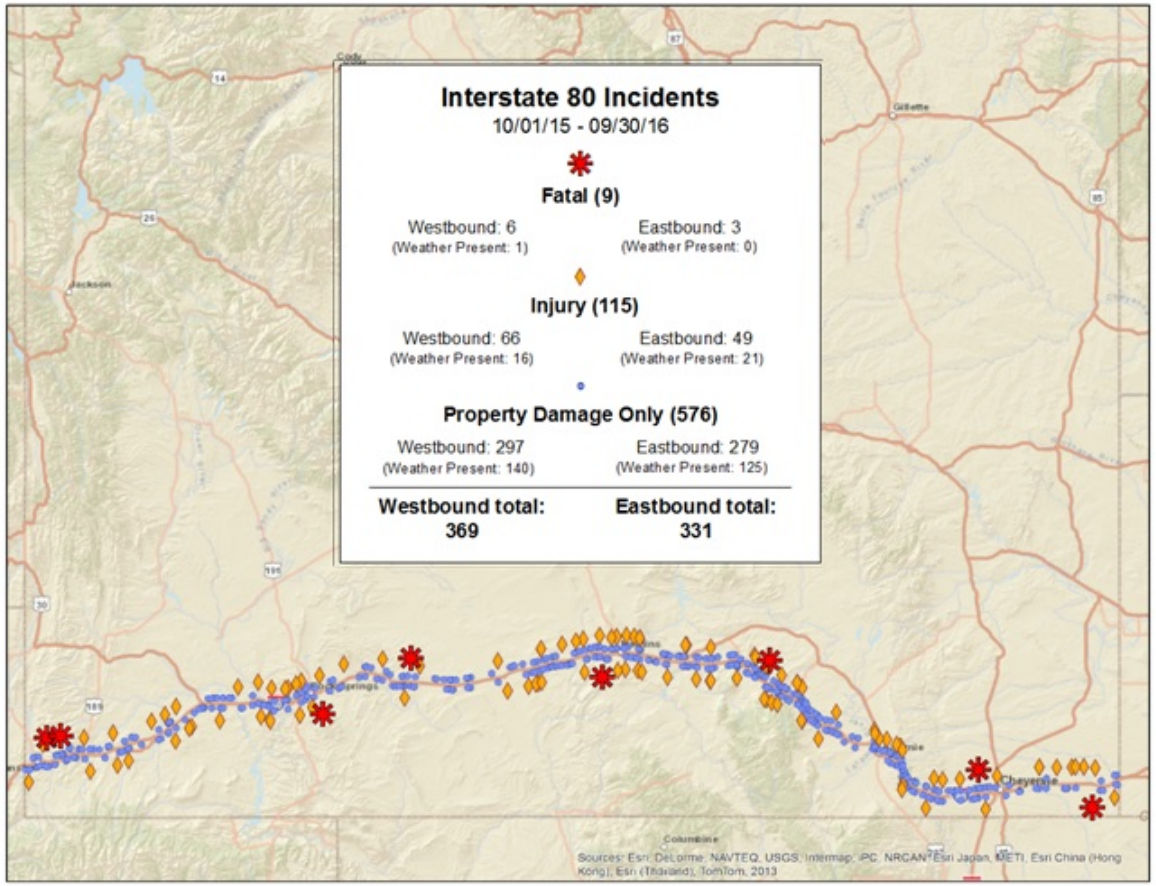
Impact to Freight



Year	Truck Crashes	% of Total
2010	563	33.9%
2011	642	33.6%
2012	569	40.0%
2013	632	36.5%
2014	690	35.4%
2015	555	40.0%
2016	714	34.3%
2017	408 (partial)	63.1% (partial)

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INTERSTATE 80 CORRIDOR

INTERSTATE 80 CORRIDOR

I-80 Corridor

One of the most heavily instrumented rural corridors in the United States

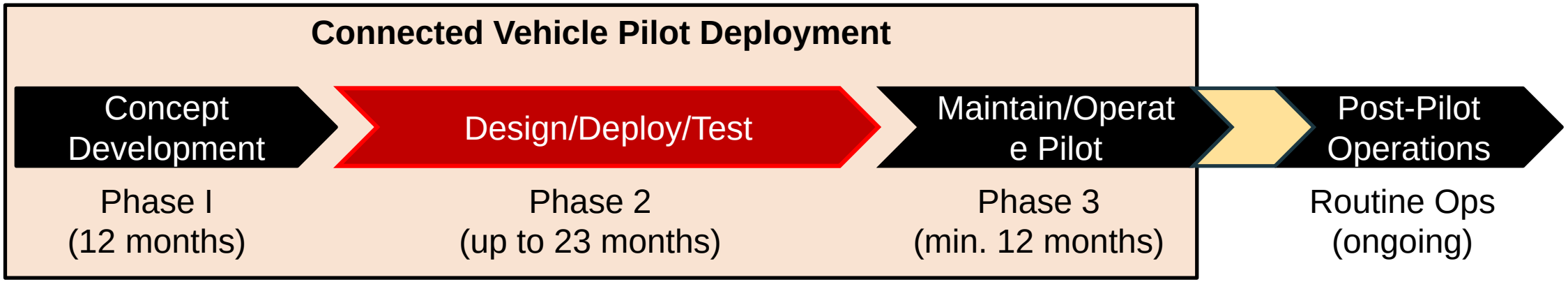
136 Variable Speed Limit Signs
supported by 94 traffic sensors

54 Electronic Message Signs

44 Weather Stations

52 Webcams

ACHIEVEMENTS-TO-DATE



Major Achievements

- ✓ End to end BSM data
- ✓ ODE development/integration
- ✓ Installation of IPv6 backhaul
- ✓ RSU installation
- ✓ Equipped 2 vehicles (3-7Km range)

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SYSTEMS OVERVIEW

78 RSUs equipped with DSRC connectivity

▪ Wyoming CV System

- Roadside Units (RSUs)
- Operational Data Environment (ODE)
- Pikalert System
- Data Broker (DB)
- Data Warehouse

~400 vehicles equipped with OBU with DSRC connectivity

▪ Vehicle System

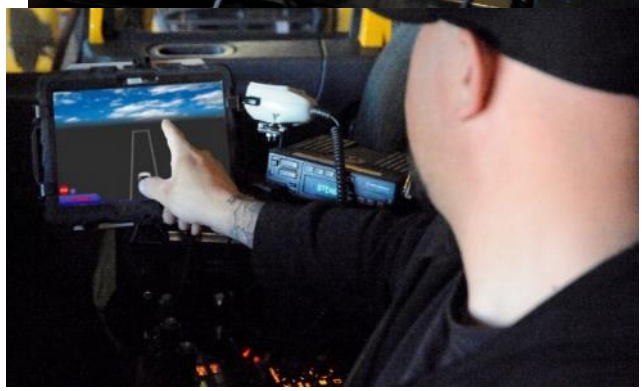
- WYDOT Maintenance Vehicles
- WYDOT Highway Patrol Vehicles
- Integrated Commercial Vehicles
- Retrofit Commercial Vehicles
- Basic Equipped Vehicles

66 snow plows

33 patrol vehicles

188 trucks

121 small trucks & vehicles



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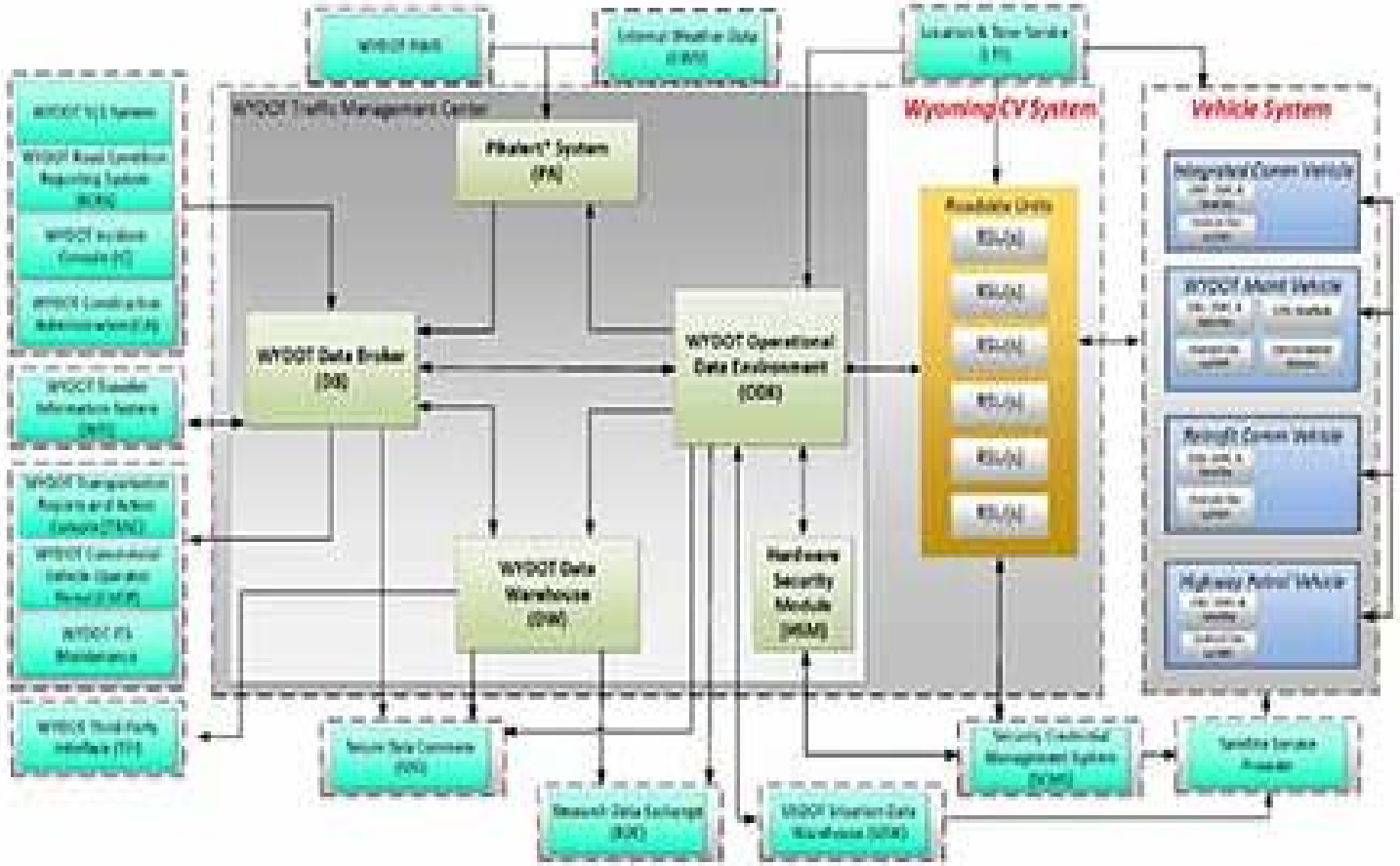
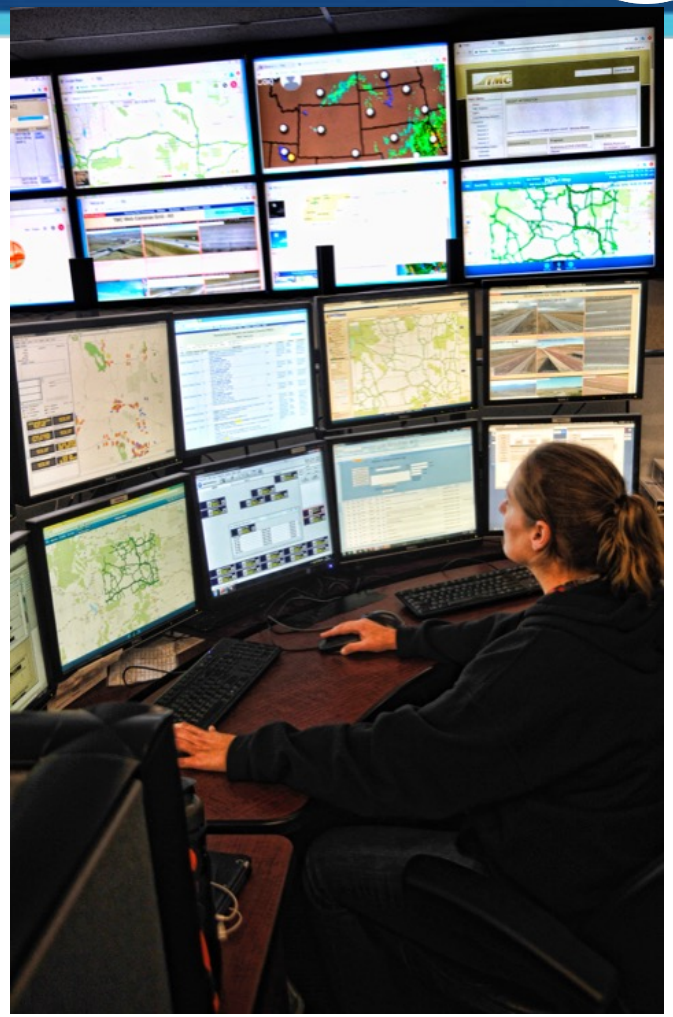
CONNECTED VEHICLE PILOT: INTEGRATION





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Connected Vehicle Pilot: Next Steps

Phase 1

- Planning
- (09/2015 – 09/2016)

Concept Development
System Planning
Deployment Plan

Phase 2

- Deployment
- (10/2016 – September 2018)

System Design
System Build
System Testing and Acceptance

Phase 3

- Demonstration
- (Fall 2018 – 10/2019)

Real-World Demonstration
Evaluation
Maintenance

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TAMPA (THEA) PILOT PROJECT

Bob Frey, Planning Director

Tampa Hillsborough Expressway (THEA)

TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY

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Focused Deployment Area

PARTICIPANTS


PHOTO: THEA


PHOTO: NPR


PHOTO: THEA

PHOTO: THEA

1,600

Privately Owned Vehicles

500+

Pedestrian Smartphones (Android devices only)

10

TECO Line Streetcar Trolleys

10

Hillsborough Area Regional Transit (HART) buses

TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY

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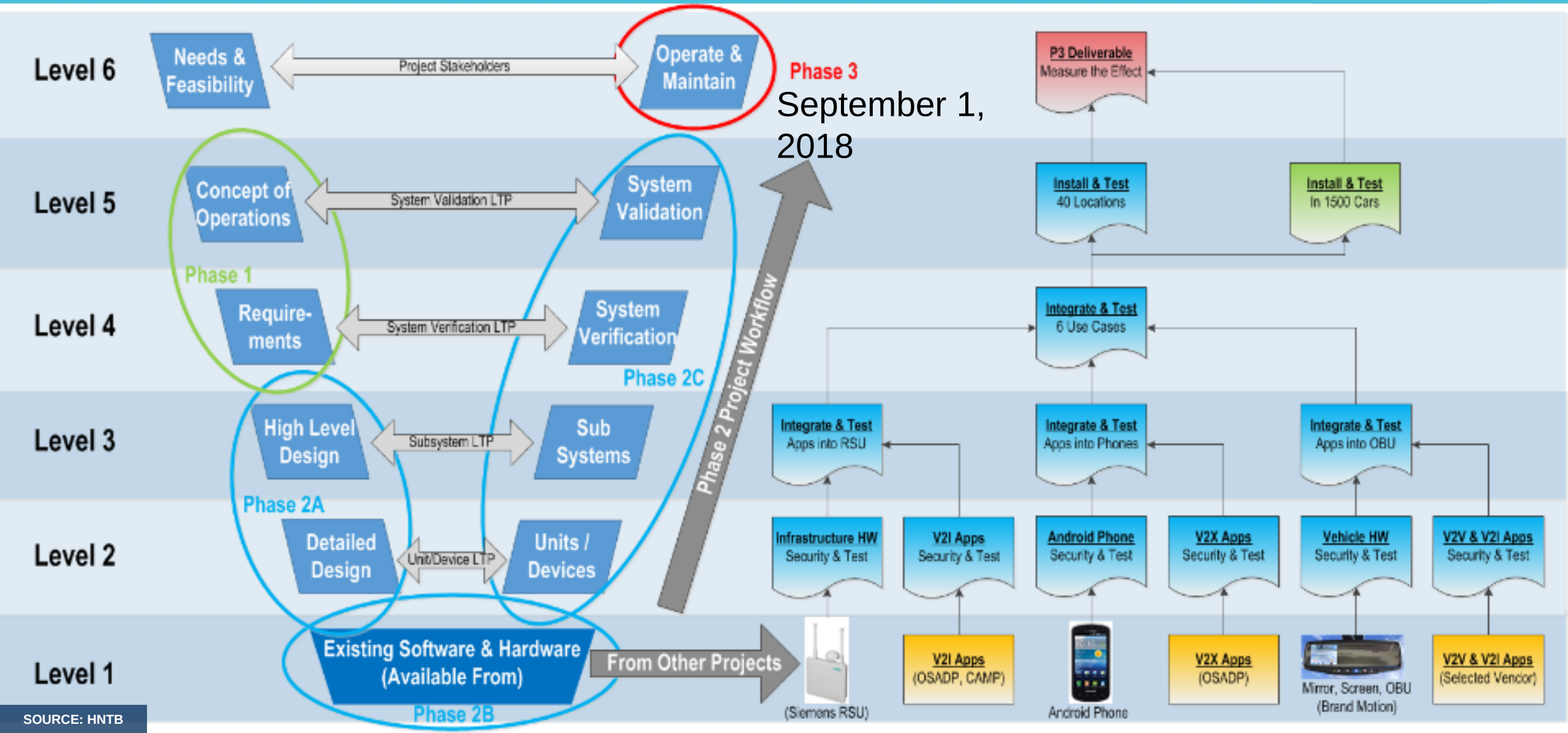
STATUS



SOURCE: HNTB

PHASE 3 – MEASURING PERFORMANCE

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

Mobility

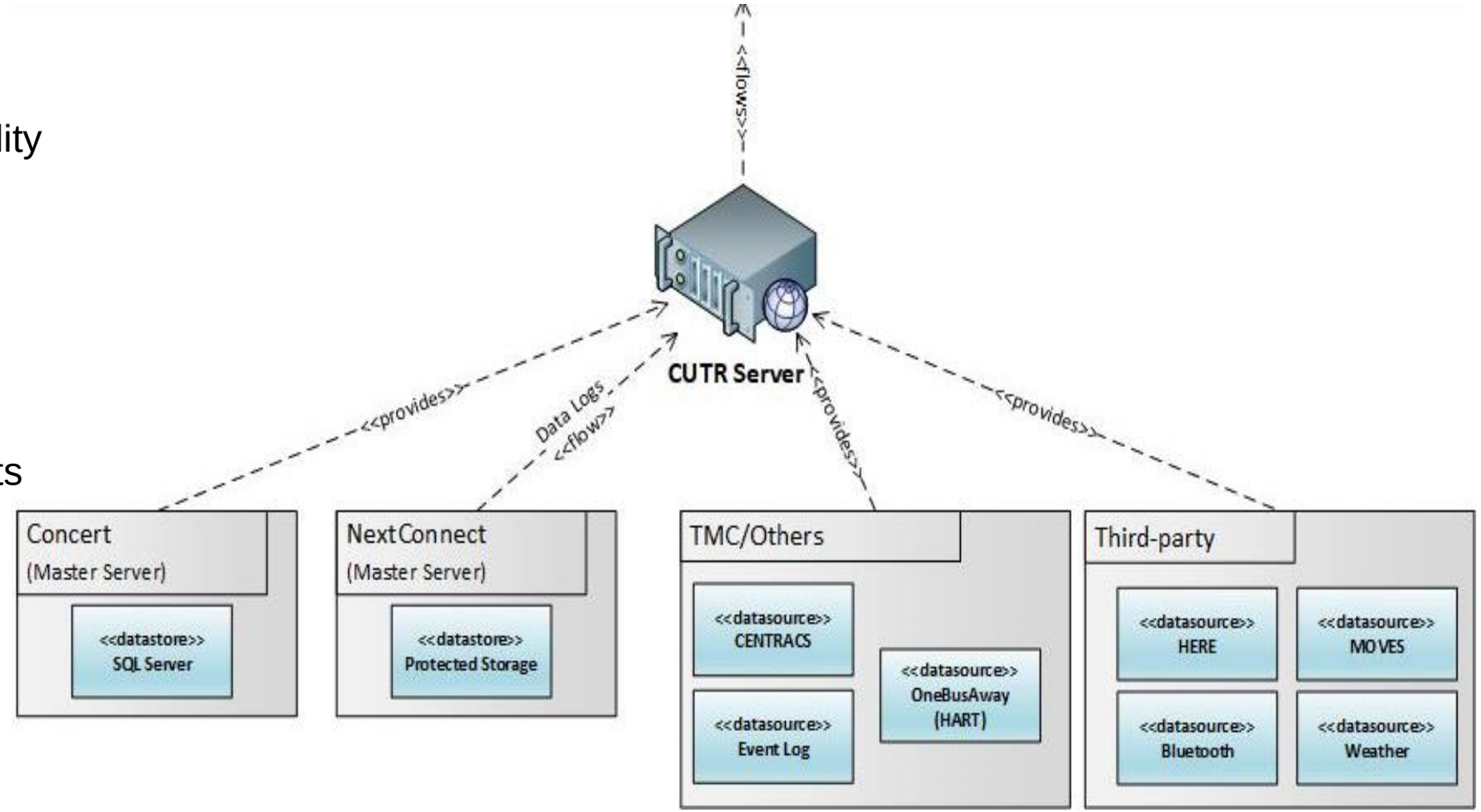
- Travel time
- Travel time reliability
- Delay
- Throughput

Safety

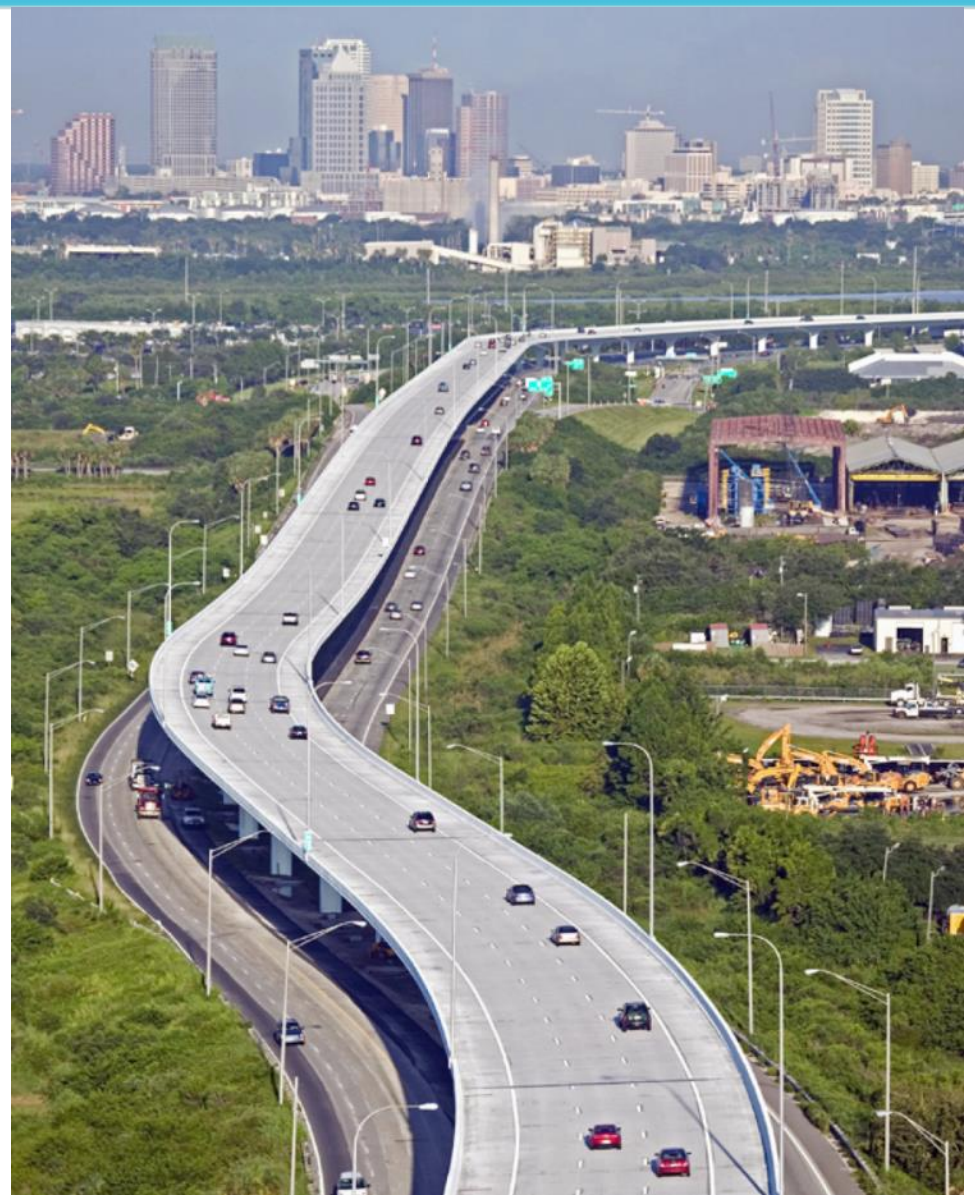
- Crash rates
- Type of conflicts
- Severity of conflicts

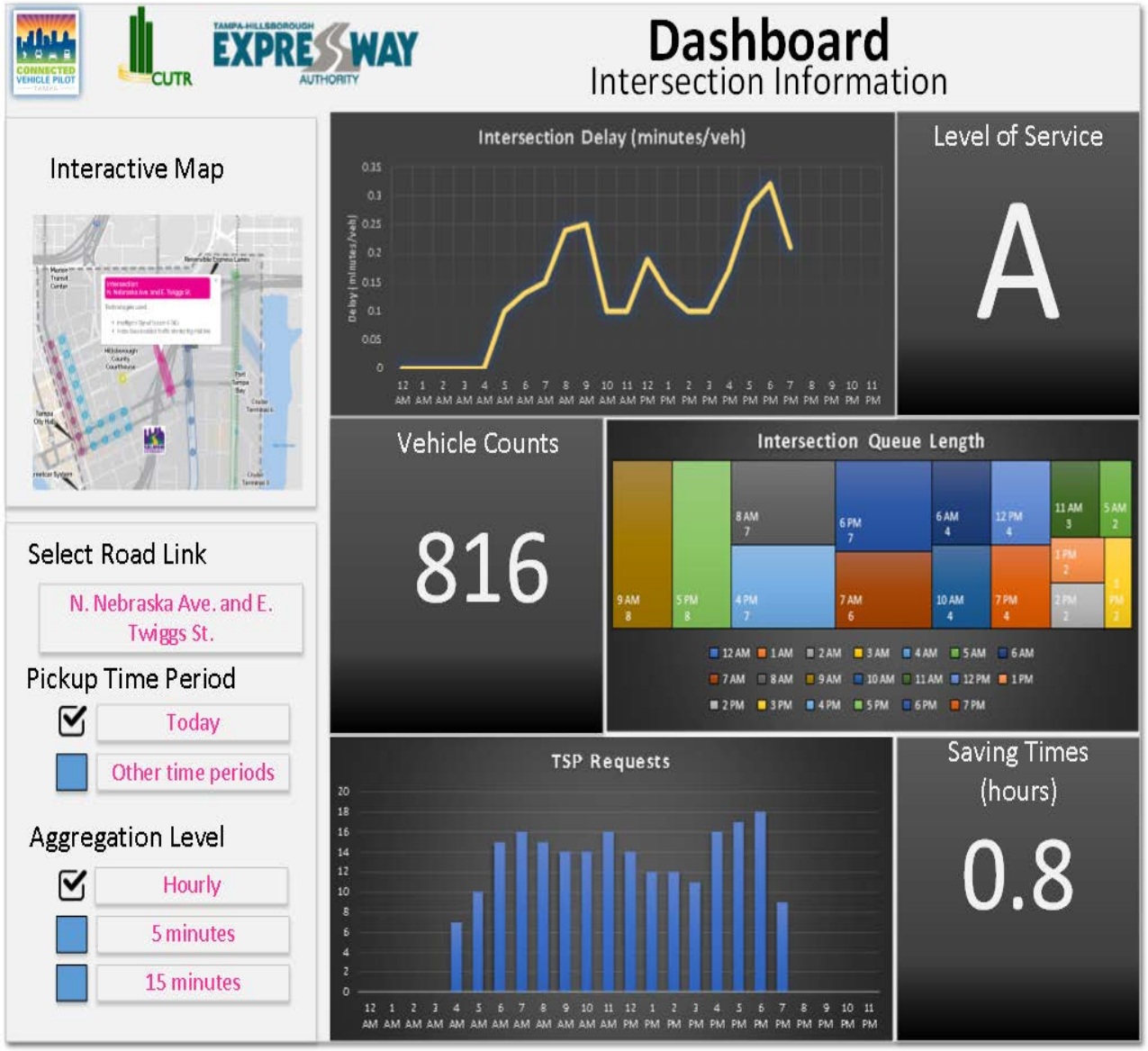
Environment

- Emission analysis



PHASE 3 – REPORTING PERFORMANCE





If We Could Do It Over Again: We Would

- Solidified 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
- Like More Transparency in the Device Certification Process From Vendors
- Complete Integration Testing Before Private Vehicle Installs Begin
- Have Shifted the Focus Much Sooner to a Commercial Security Credential Management System
- Identify the Need to Use Traditional ITS Devices as Part of Solution Earlier

LESSONS LEARNED

- **Standards:**
  - Designed using standards published on Jan 1, 2017. Do not rely on unpublished standards in progress.
  - If a USA standard does not exist, design using international standards (Yeah, that went well…).
  - If no standard exists, refer to USDOT V2I Hub publication.

- **Interoperability:**
  - Identify common requirements that affect interoperability before the design started.

LESSONS LEARNED

- OBUs - Hire auto professionals to manage!
- Multiple Technical Scans using RFPs (with on the road testing)
- Early Sourcing of Suppliers to Create a Collaborative Environment
- Early real-life testing with infrastructure in place to verify end-to-end system/application performance
- Distributed Team Across the Country and in Europe, be careful can they support you from overseas?
- New development efforts - OTA and security - need to be piloted, i.e. tested early in the program
- Adequate incentives with community/media support engage the driver/consumer community
- Recognizing the need for a complete and experience project team - systems, infrastructure, vehicle systems, performance measurement, etc.

LESSONS LEARNED

- Innovative ways to incentivize the public to participate helped
- Contracting – Fixed Fee and “Experimental Sole Source” way to go
- Cross functional coordination is absolutely critical
- Importance of face to face progress meetings
- Deployment in an area undergoing significant redevelopment complicated Pilot to deal with confounding factors
- Establish Communication usage on your channels early, CV is not only allowed user
- Certification process - Certification process was outside of Pilot control, mitigated by Conformance statement to self-certify

TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY

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Federal Highway Administration

STAY CONNECTED

- **Contact for Tamp CV Pilot Project**:
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  - ITS JPO Agreement Officer:
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CONNECTED VEHICLE PILOT THEA

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NEW YORK CITY PILOT PROJECT

Mohamad Talas, Director of System Engineering, NYCDOT

Bob Rausch, Vice President, Transcore

NEW YORK CITY DOT
NYC Connected Vehicle Project
For Safer Transportation

U.S. Department of Transportation
Federal Highway Administration

PROJECT GOALS

New York City is aggressively pursuing "Vision Zero"

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

Vision Zero Goal : to eliminate traffic deaths by 2024

NYC CV Pilot will evaluate

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

LOCATIONS (MANHATTAN, BROOKLYN)

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

The CV project leverages the City's transportation investments

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

Traffic Control System

NYCWiN

Advanced Traffic Controller (ATC)

NYC Connected Vehicle Project
For Safer Transportation

CV Stakeholder/User deployment

Vehicles

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

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

Revenue Vehicles

Pedestrians

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

NEW YORK CITY DOT
NYC Connected Vehicle Project
For Safer Transportation

SAFETY APPLICATIONS

Vehicle-to-Vehicle (V2V) Safety Applications

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

Vehicle-to-Infrastructure (V2I) Safety Applications

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

Additional Applications

Pedestrian

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

Traffic Management

- CV Data for Intelligent Traffic Signal System

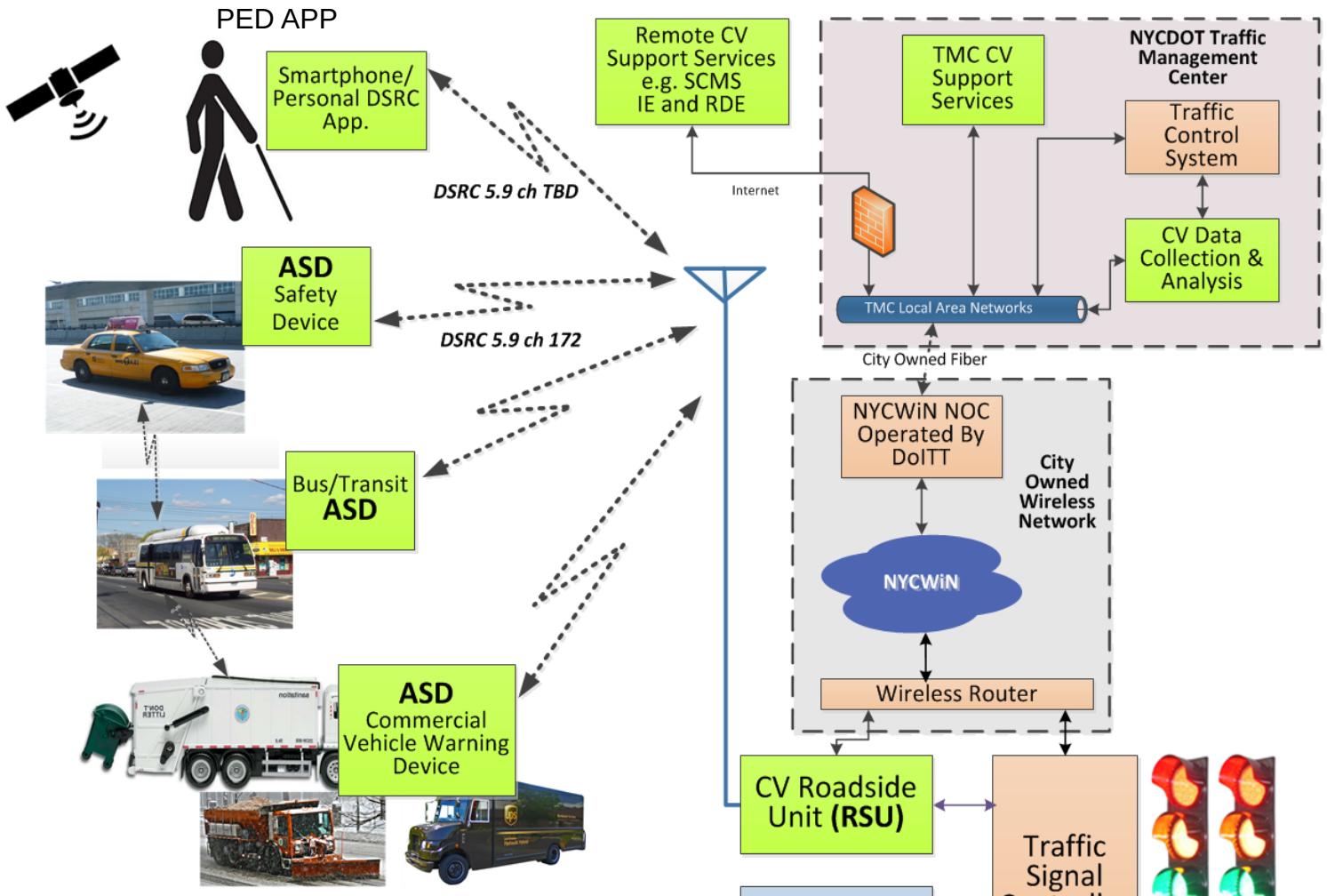
Roadway segment travel times

Operations, Maintenance, and Performance Analysis

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

To Evaluate the benefits

Overall Project Concept



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

Source: NYCDOT

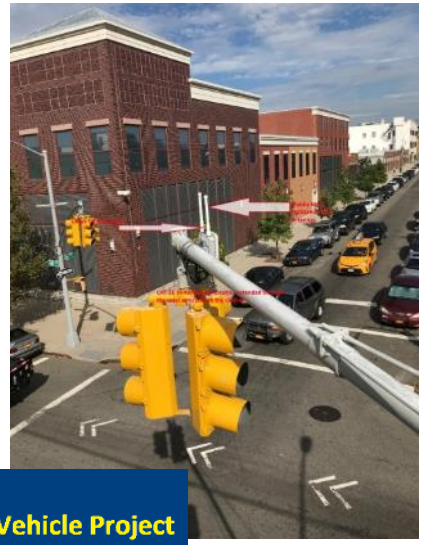
WHERE ARE WE NOW ?

- **Phase 1 – Deliverables**
  - **Concept of Operations**
  - Security Management Operating Concept
  - Safety Management Plan
  - Performance Measurement Plan, System Requirements
  - Application Deployment Plan
  - Human Use Approval Summary, Training and Education Plan
  - Partnership Status Summary, Outreach Plan
  - Comprehensive Deployment Plan, Deployment Readiness Summary

- **Phase 2 – Design & Deployment**
  - Deployment of 100 Prototype ASD and RSU
  - Developing TMC software to support CV
  - Working with a PED application developer – **non DSRC**
  - **Interoperability testing**
  - Preparing for “production” deployment

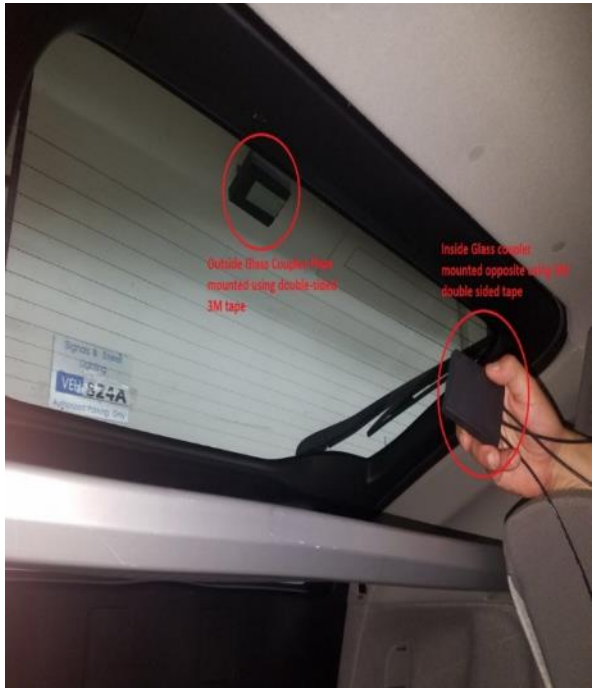
Installation Planning and Testing

- Developing MAP message Content (USDOT)
- Planning RSU installation sites
  - Establishing Installation “partners”
- Developing vehicle installation kit designs
  - Working with vendors
  - Working with Fleet owners
  - Running samples – awaiting prototypes



~350 Roadside Units
36 Units at key locations

VEHICLE INSTALLATION



- 35 Prototype Fleet vehicle installed
- Testing through the glass and drilled mountings
- Working with various different vehicle types

NYC DOT Installations

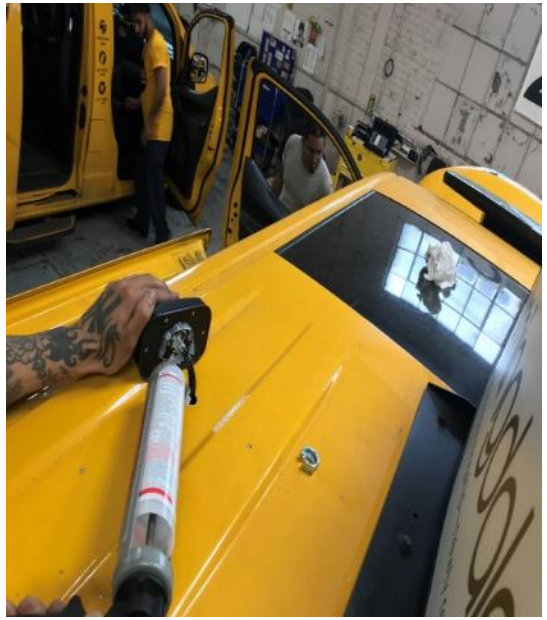
- NYC DOT Installation
  - Various Makes/Models/Year NYC DOT vehicles are being equipped with prototype ASDs in order to fine tune and optimize installation methods and approaches
  - NYC DOT Vehicles 770
    - Toyota
      - Prius, RAV4
    - Ford
      - Fusion
      - F-150 – F-550
    - Chevrolet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

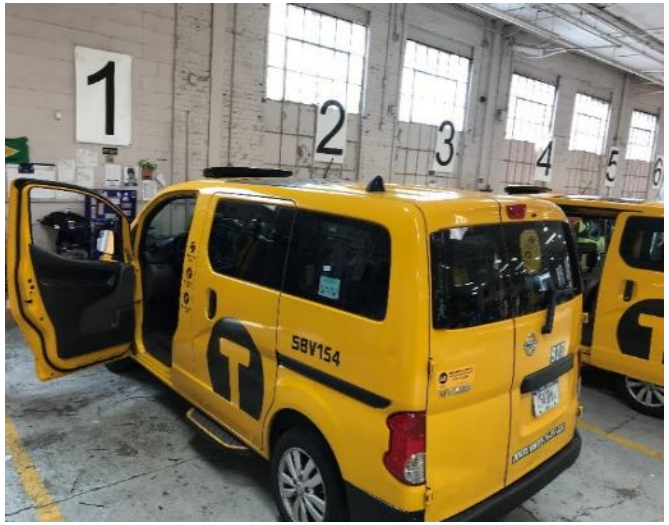
MTA Installation

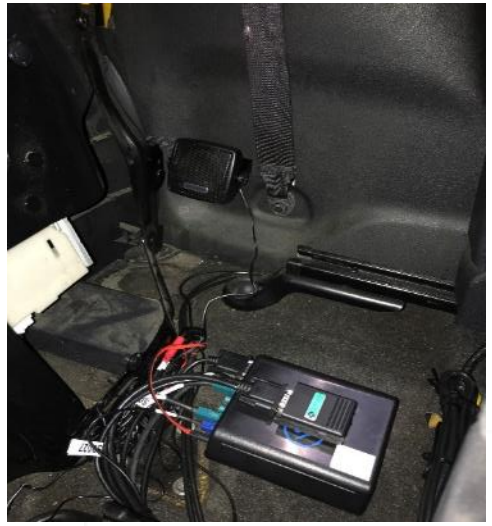
- The buses were installed to test RF DSRC communication with light vehicles, and to develop an installation template
- Key element for MTA – **Through the glass Antenna**

TAXI INSTALLATION

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







CYBERSECURITY IS FUNDAMENTAL TO CV DEPLOYMENT

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

- Message authentication (BSM, SPaT, MAP, TIM, etc.…)
- Data encryption of (To preserve privacy)
- Requires Equipment Certification
- Organizational IT security
  - Physical security of the TMC systems
  - Agency login and security practices
- Protection for all connections and data exchanges
- CV Hardware Impact
  - **Hardware Security Module (HSM) for the TMC system**
  - **HSM inside the ASD/OBU and RSU**

CHALLENGE – SCALABLE OTA DATA EXCHANGES

- Push (10 MB+) software updates to 8,000 vehicles efficiently over **DSRC**
  - **No WiFi and No LTE/4G**

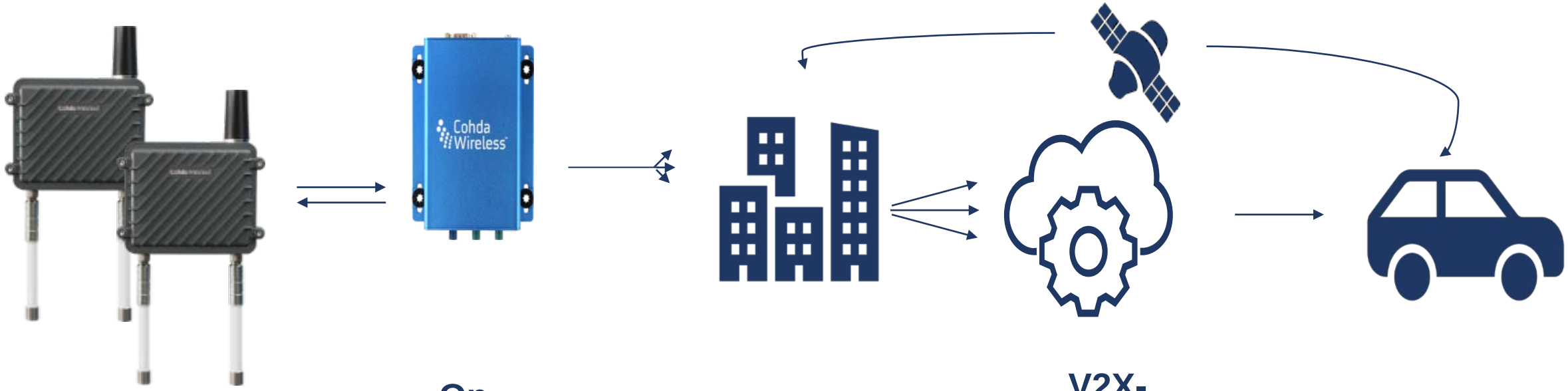
- Developed Scheme to support broadcast updates
  - ASD's read WSA from Control Channel
  - Directed to Service Channel if RSU supports Updates
  - RSU **broadcasts** available updates
    - Some updates broadcast (continuous) some available by unicast
    - Vehicles initiate update using unicast or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

CHALLENGE – LOCATION ACCURACY

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

- **Testing has been promising !**

How V2X-Locate Works



Road Side Unit

On-Board Unit

Multipath Reflections

V2X-Locate Engine

Sensor Fusion

Positioning software achieves sub-meter location positioning and is over 275% more accurate than comparable GNSS solutions

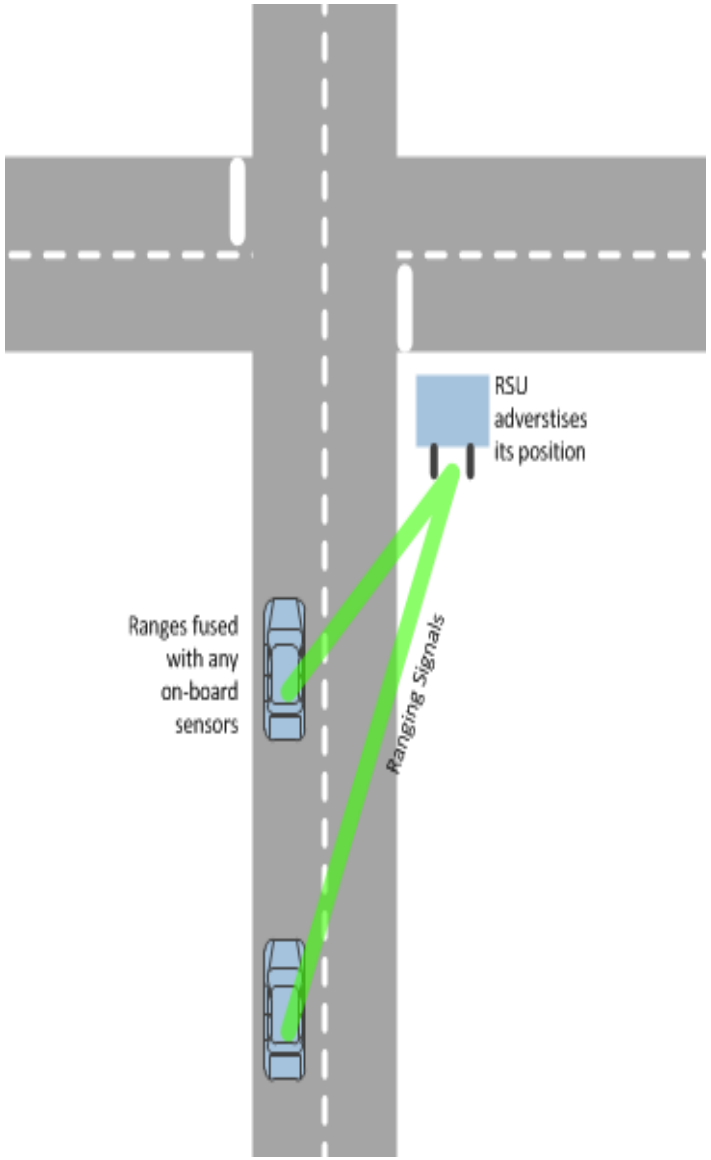
RSU TRIANGULATION

V2X Locate uses

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

RSU location known thanks to standard advertisements

Fuses vehicle sensors and GNSS when available.



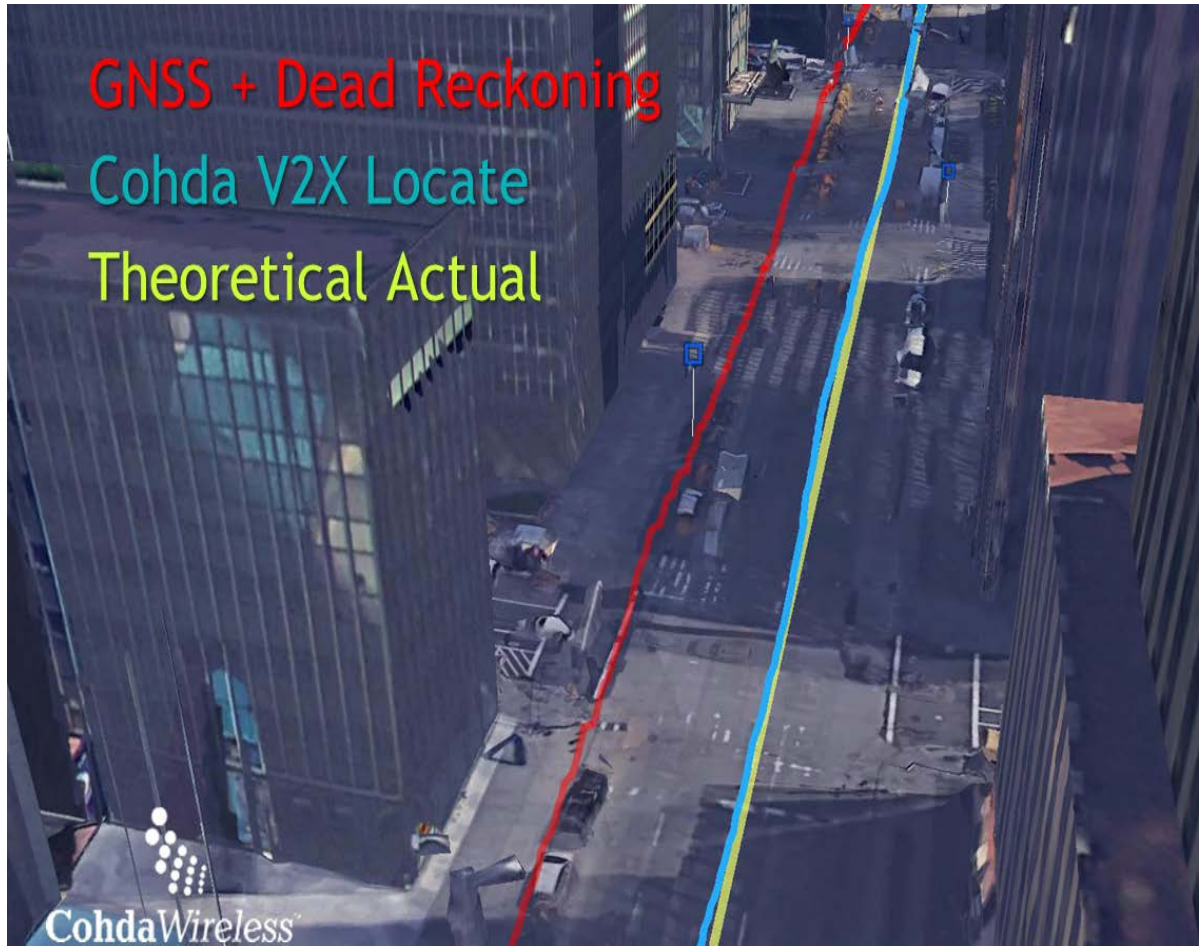
* Based on recommended deployment set-up

Preliminary Accuracy Results

- No additional HW vs conventional V2X City / Car OEM install
- Doesn't require GNSS availability
- Demonstrated in very tough New York 6th Ave
- Results are
- Performance exceeds SAE J2945 requirements
- (68% < 1.5m)

Percentile	Error
68	70cm
90	80cm
95	90cm

Percentile	Error
68	67cm
90	77cm
95	83cm



Other Technical Challenges

- Adjusting the applications for 25 MPH and Freeway speeds

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

- Many different vehicle types and model years
  - Varied installation kits
  - The Good part – they are fleets – we drill holes!

Thank You

For New York City DOT:

Mohamad Talas, P.E., PhD,

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NYC Connected Vehicle Project
For Safer Transportation

U.S. Department of Transportation
Federal Highway Administration

New York City – Connected Vehicle Pilot
Some Lessons Learned and Challenges

Bob Rausch
Vice President
Transcore

NYC Connected Vehicle Project
For Safer Transportation

U.S. Department of Transportation
Federal Highway Administration

A Few Comments Based On The NYC Project

- Standards
- Product Maturity
- Vehicle Integration
- Data Collection
- Security

PILOT VS. DEPLOYMENT

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

NEED STANDARDS FOR THE APPLICATIONS

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

FLEETS VS. OEMS

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

Scaleable and Reliable Deployment

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

SCALEABLE OTA EXCHANGES

- NY System is DSRC 5.9 GHz only
  - 802.11P, 1609.x, J2735/ISO 19091
- Data collection V2I
- Safety applications V2V and V2I
- Software updates I2V

Using 6 of the 7 DSRC channels in the US 5.9 GHz Spectrum!

- Worked to develop a network encoding approach – broadcast update to many vehicles -

Data Recording Issues

This is not an R&D project!

What to collect

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

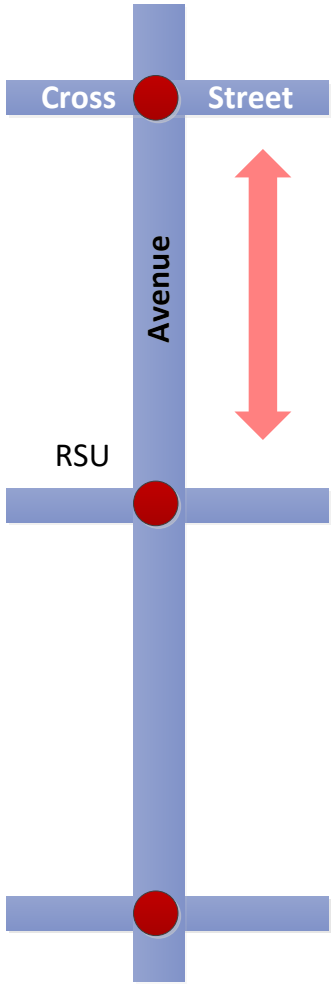
What are the costs

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

Privacy Issues

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

EXAMPLE – TRAVEL TIME



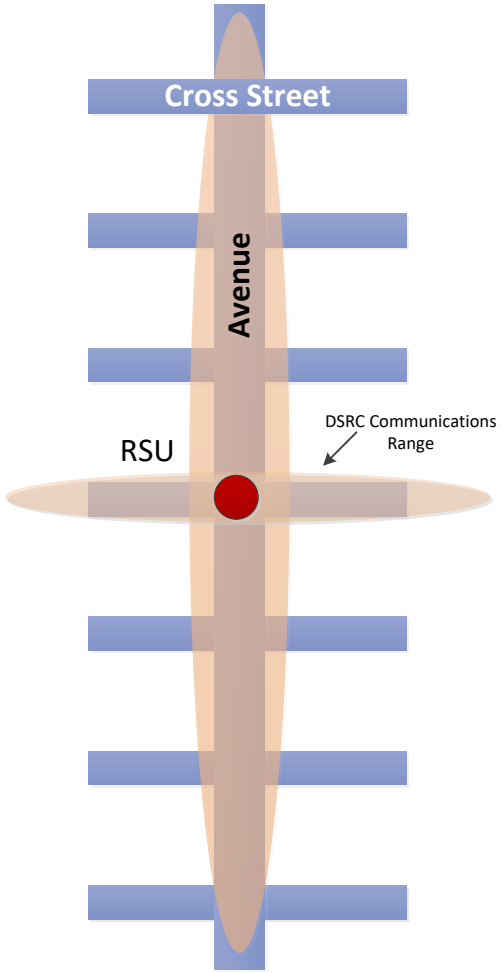
- Block Spacing ~70M Feet (230')
- 20 MPH – 30 feet per second
- DSRC Range ~300M (1000')
- BSMs Xmit @ 10 Hz
- Time between blocks ~8 seconds
- BSMs transmitted 80
- BSMs needed 2 - 3% **a 97% reduction**
- Edge computing @ RSU
  - RSU looks for vehicle entry to Intersection
  - Transmits one BSM to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

Optimized Intersection Control

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

- Send to TMC only what needs to be used
  - Platoon management (Freight priority)
  - Alternate route management/diversion
  - Incident detection
  - Travel Times (average link speed)

PRACTICAL DATA COLLECTION - INCIDENTS

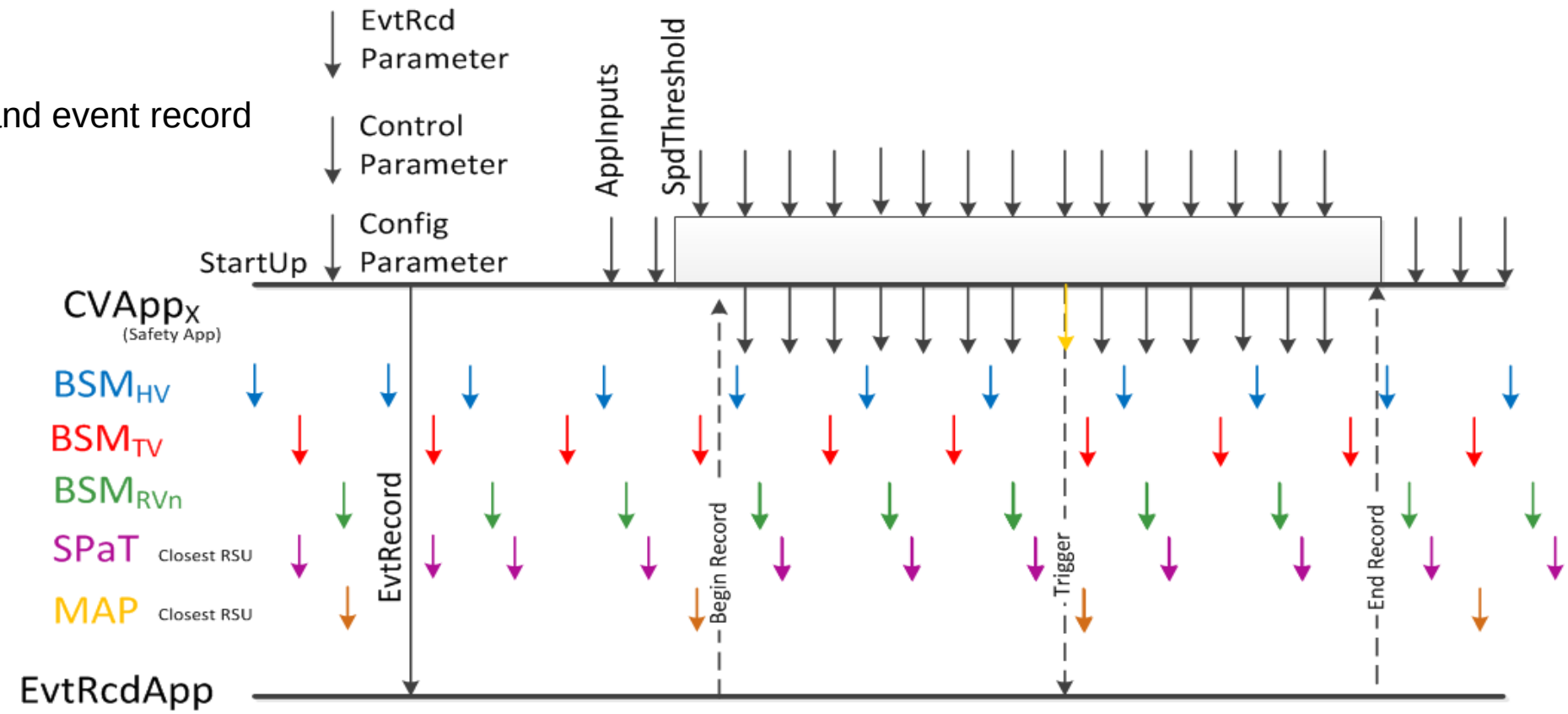


- 1.2 M vehicles in NYC broadcast **83 TB/day**
- 13,000 NYC intersections broadcast **3 TB/Day SPaT & Map**
- 8,000 vehicles collect ***2 TB BSM data/day***
- Data ***needed*** for benefits analysis:
  - How many crashes per day did we prevent
  - How many crashes per day did we mitigate
- Edge computing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

SOLUTION "INCIDENT DATA"

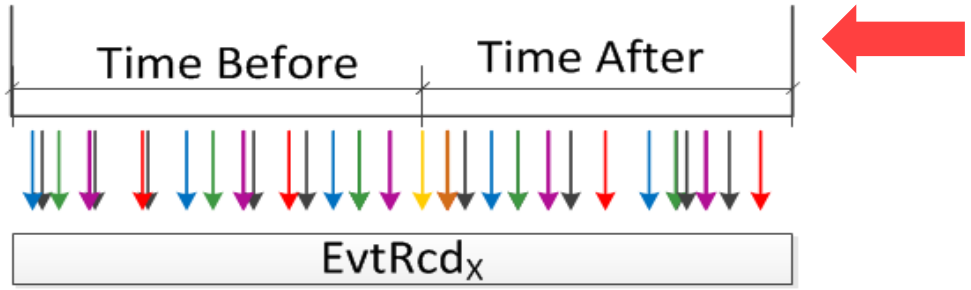
INTERMITTENT LOGGING

"Alert" triggers and event record



HV – Host Vehicle
TV – Target Vehicle
RV – Remote Vehicle
n – Vehicle 1...n

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.



Data Reduction and Privacy Protection

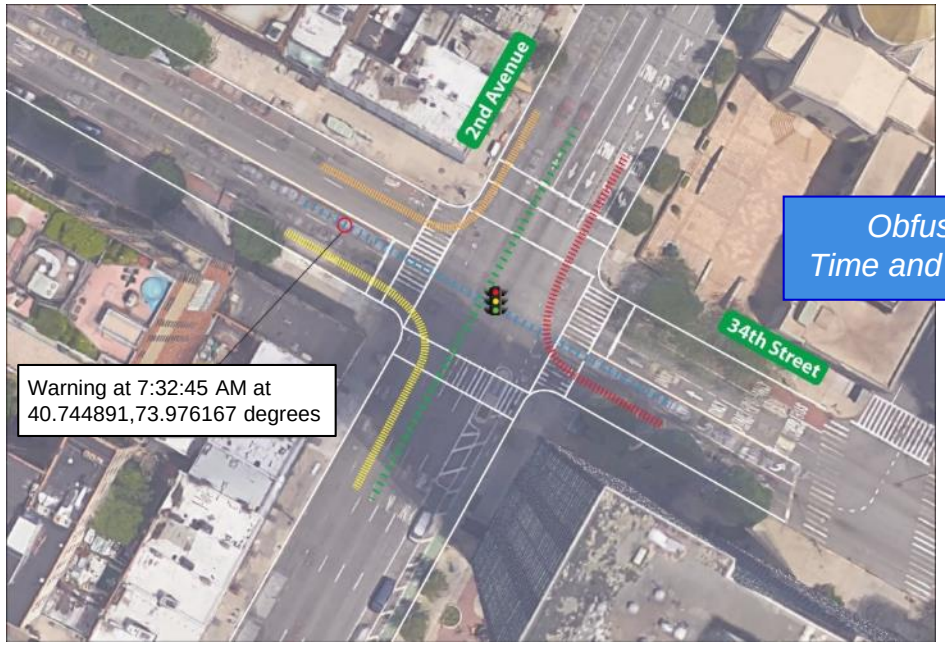
- Instead of 2 TB – only 116 GB per day
  - 17 times less – and more useful detail (@4 events/hour)
  - Includes SPaT and MAP information
  - @1 event / hour /vehicle = 29 GB/day or 67x reduction!

- If BSM data were to be collected - -
  - Provides vehicle locations at 0.1 second intervals
  - Time-of-day Stamped to 0.1 second accuracy
  - Police Records indicate “final position” of vehicles and time of day
  - CV data could be used to recreate the accident scene

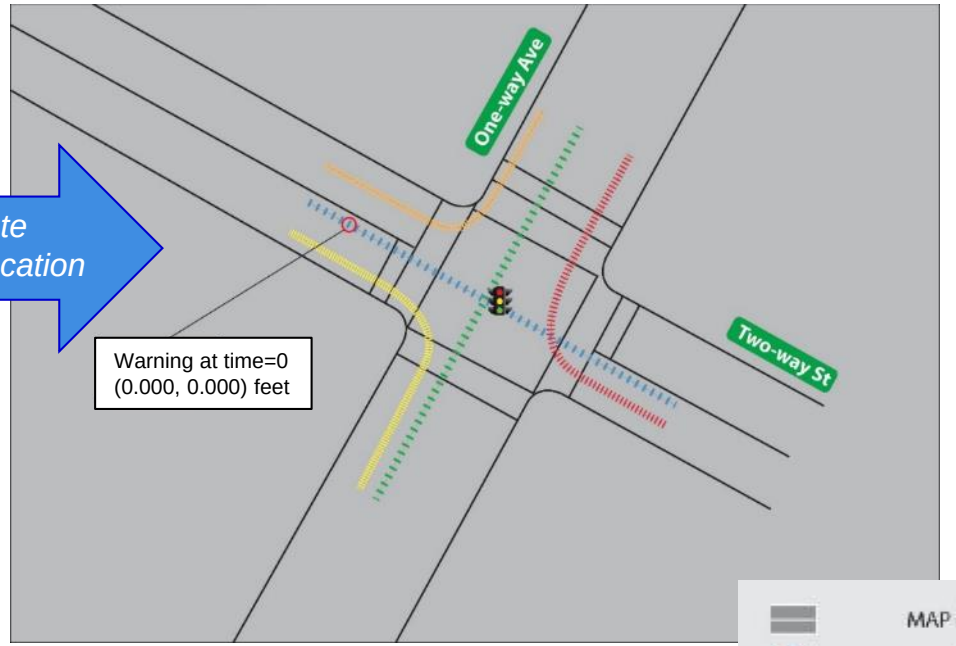
- Even though CV vehicle ID is randomly changed – the raw data can be tracked to an individual vehicle

Obfuscation of OBU Action Logs

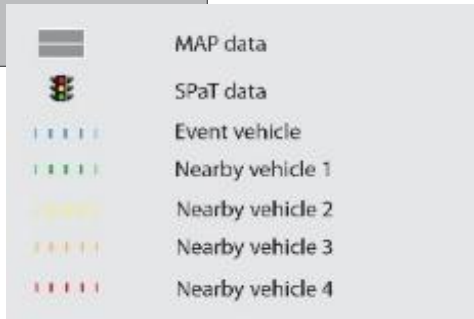
Raw ASD Action Log Data



Obfuscated ASD Action Log Data



Obfuscate Time and Location



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

Other examples – Operations Data

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

Lessons Learned on Data Collection

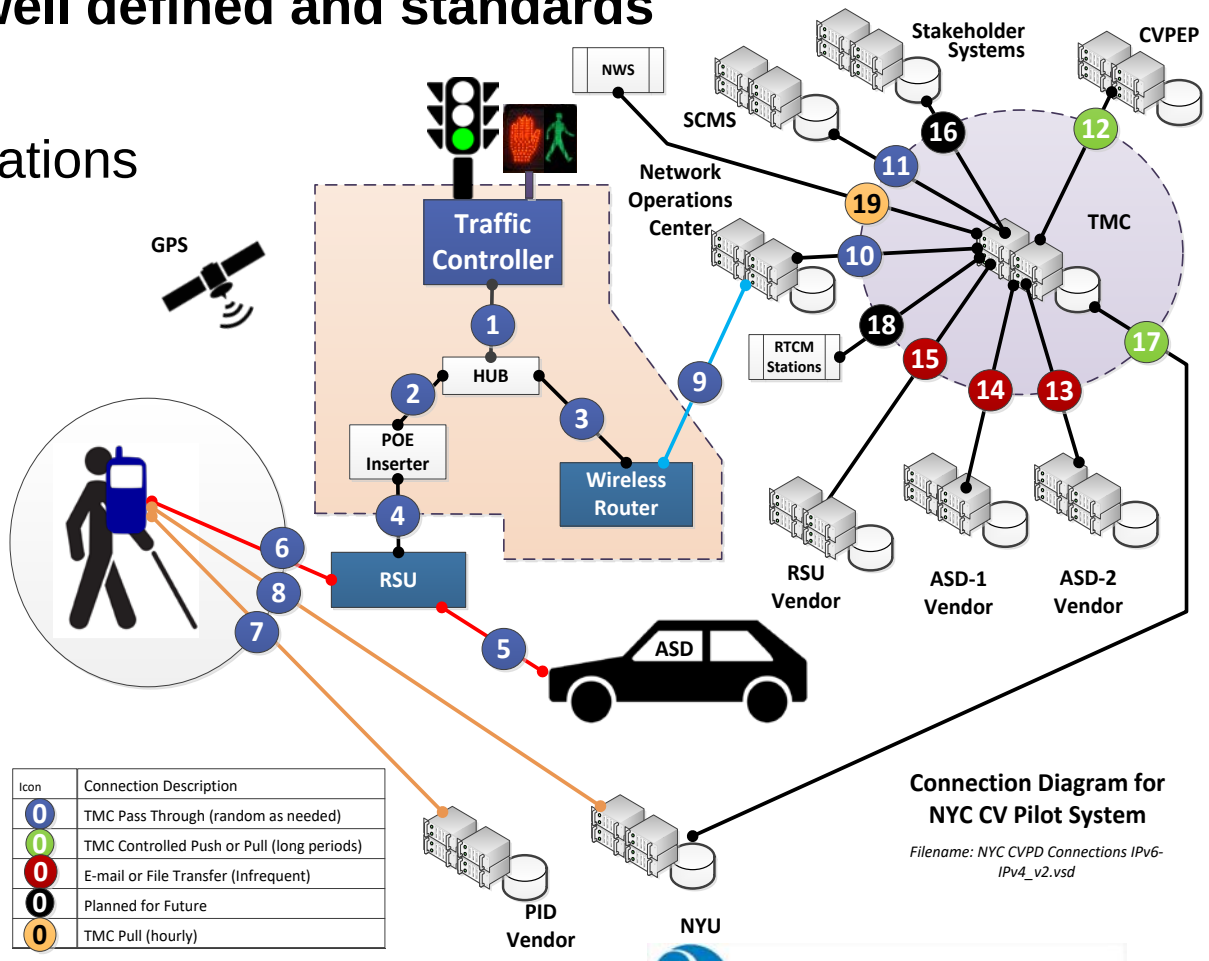
- The CV technology *could* make "mountains of data" available – but there is a cost
  - DSRC Channel time
  - Cellular media monthly limitations
  - Processing and storage
  - Retrieval (FOIA) & Subpoena
- NYC pilot deployment project
  - Tailored data collection to meet needs
  - Concept is to distribute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

NYC System – DSRC only V2I

Security Issues – Extend Everywhere

Connected Vehicle has security requirements – well defined and standards

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



THANK YOU

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Quality of life

INTEROPERABILITY TEST SUMMARY

Kevin Gay, Chief

Policy, Architecture, & Knowledge Transfer, ITS JPO, USDOT

U.S. Department of Transportation
Federal Highway Administration

Overview of Interoperability Test

- Objectives:
  - Test interoperability among connected vehicle (CV) devices from the three sites as well as to identify potential interoperability issues that may require resolution prior to the sites advancing to an operational phase of the CV Pilot Deployment Program later in 2018.

- Interoperability Definition:
  - "*A vehicle with an onboard unit (OBU) from one of the three CV Pilot sites is able to interact with OBUs and roadside units (RSUs) from each of the other sites in accordance with the key connected vehicle interfaces and standards*."

NYCDOT **Tampa (THEA)** **WYDOT** **USDOT**

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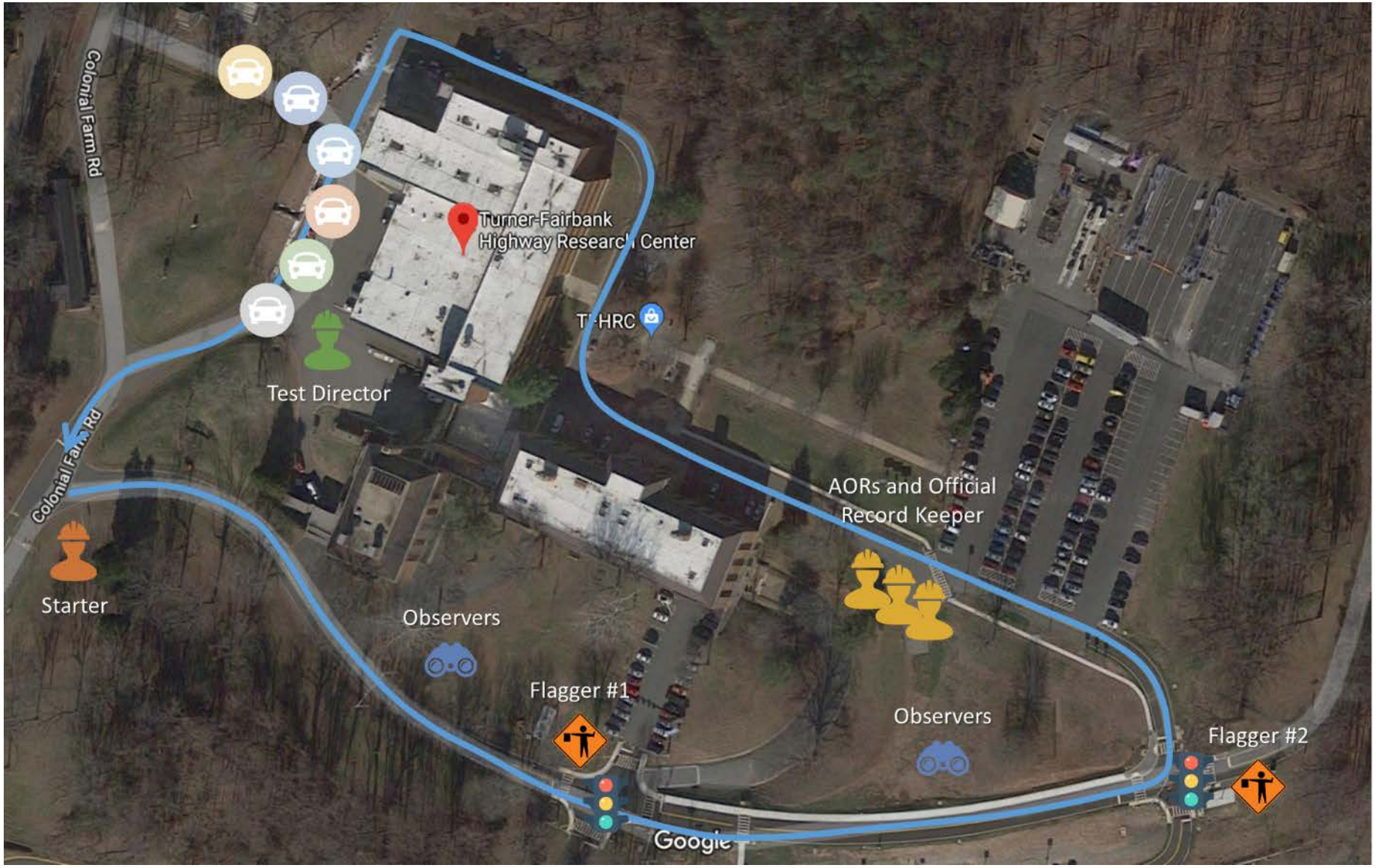
INTEROPERABILITY TEST INFORMATION

- Dates/Location: June 25 – 28, 2018 at FHWA Turner-Fairbank Highway Research Center (TFHRC)
- Participating Organizations (63 attendees in total):
  - USDOT, technical support contractor (Noblis), Saxton Laboratory (STOL) contractor (Leidos)
  - New York City Pilot: NYCDOT and Transcore
  - Tampa Pilot: THEA, HNTB, Siemens, CUTR and Brandmotion
  - Wyoming Pilot: ICF and Neaera Consulting Group
  - OBU/RSU Vendors: Commsignia, Danlaw, Lear, Savari, Siemens and Sirius XM
  - Others: Certification (OmniAir), CV Pilots Independent Evaluator (TTI), Photographers (BAH)

Testing Map and Equipment



- **NYC OBUs:**
  - Danlaw
  - Savari
- **Tampa OBUs:**
  - Commsignia
  - Savari
  - Sirius XM
- **Wyoming OBU:**
  - Lear
- **TFHRC RSUs:**
  - Siemens RSUs loaded with NYC/Tampa software

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Overview of Test Plan

- CV Pilots Phase 2 Interoperability Test demonstrated interactions among different site's OBUs and among selected OBUs and RSUs.
  - OBU Interactions :
    - Receive Basic Safety Messages (BSMs) transmitted by the other site's OBUs via DSRC; authenticate them as needed; parse them; and process them in accordance with SAE J2945/1.
    - CV applications: Forward Collision Warning (FCW), Electronic Emergency Brake Light (EEBL), and Intersection Movement Assist (IMA) - only NYC/Tampa
  - OBU and RSU interactions:
    - Signal Phase and Timing (SPaT) and MAP (only NYC and Tampa)

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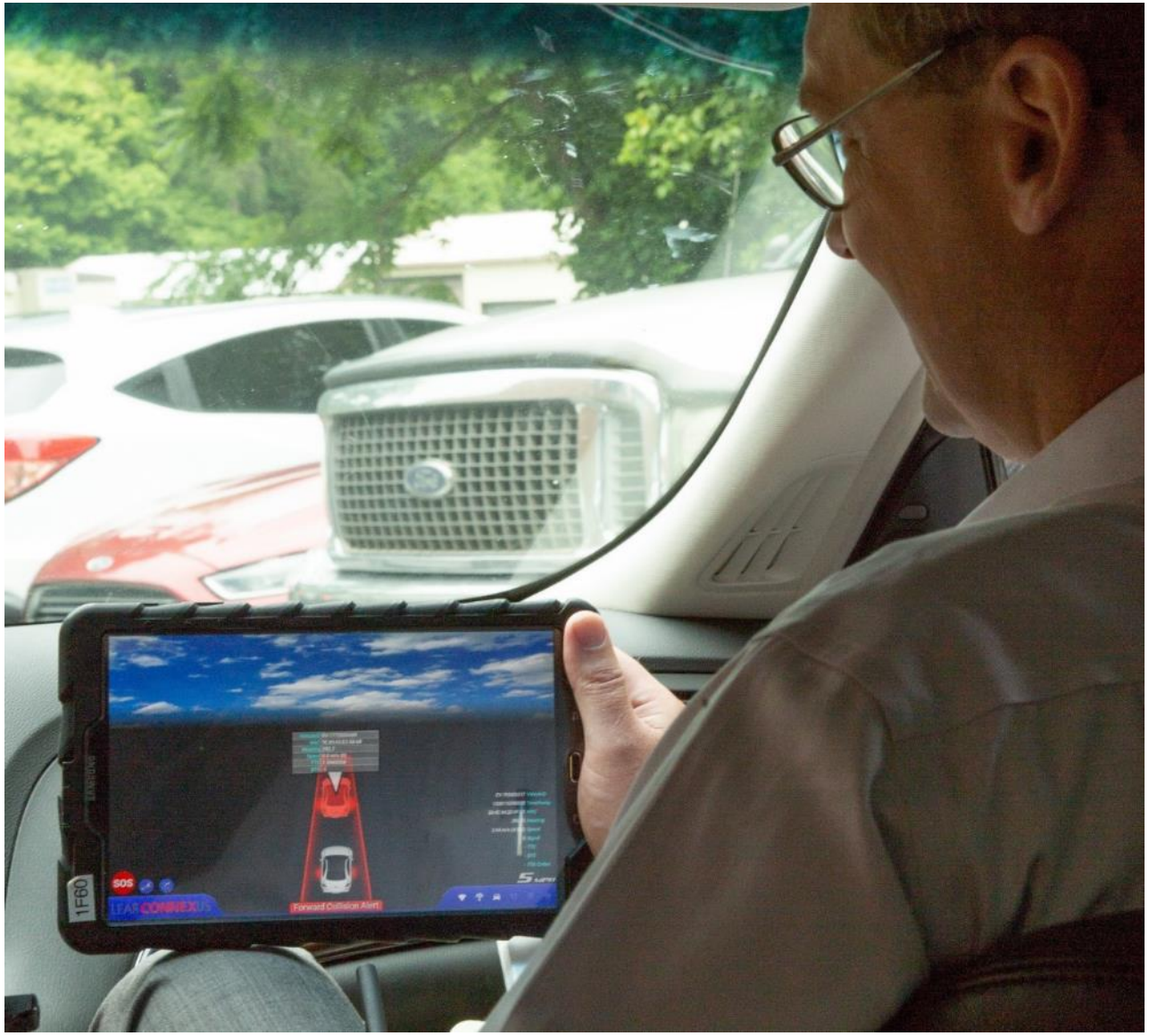
FCW Stationary Remote Vehicle - Same Lane



- To have an OBU from each CV Pilot deployment project demonstrate that they can produce a FCW to a driver when receiving BSMs from one of the other site devices.

- Photo: a Wyoming (Lear) vehicle received a FCW alert from a stationary NYC (Danlaw) vehicle in the same lane.

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FCW Stationary Remote Vehicle - Adjacent Lane

- To have an OBU from each CV Pilot deployment project demonstrate that they do not produce an FCW warning when approaching another vehicle producing BSMs in an adjacent lane.
- Photo: a Tampa (Commsignia) vehicle drove in an adjacent lane without triggering a FCW alert from a stationary NYC (Savari) vehicle.

Reception of SPaT/MAP Messages

- To have an OBU from the NYC and THEA CV Pilot sites demonstrate that they can receive SPaT and MAP messages from the other CV Pilot deployments RSUs.
- Photo: a Tampa (Savari) vehicle approached an intersection with a TFHRC RSU (Siemens) configured for NYC.

IMA Host Vehicle Stopped

00:00.00

- To have an OBU from the NYC and THEA CV Pilot sites demonstrate that they can produce an IMA warning to a driver when receiving BSMs from one of the other site devices.
- Video: a Tampa (Commsignia) vehicle received an IMA warning being triggered by a NYC (Danlaw) vehicle.

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FCW Stationary Remote Vehicle - Same Lane with Parallel Platoon

00:00.00

- Add-on Test: To have an OBU from each CV Pilot deployment project demonstrate that they can produce a FCW alert to a driver when receiving BSMs from one of the other site devices with a parallel platoon in an adjacent lane.
- Video: a Wyoming (Lear) vehicle received a FCW alert being triggered by a NYC (Savari) vehicle with the other four vehicles driving by the adjacent lane.

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SUMMARY OF KEY RESULTS

- **More than 100 test runs within three days.** In total, 102 interoperability test runs were conducted for four test cases – FCW, IMA, EEBL, and SPAT/MAP Messages and 90% plus were successful.
- **Successful message transfer via multiple communications.**
  - Results of the testing indicated successful transfer of messages between the six vehicles from five different vendors. Out of the five vendors, four used DSRC and one used DSRC and SiriusXM Radio.
  - Additionally, equipment from each vendor demonstrated the successful transfer of messages between the RSUs and each sites' OBUs.
- **SCMS enrollment permitted sites to sign messages and change certificates without issue.** All devices used for the test were enrolled with a commercial security credential management system (SCMS) that the sites plan to use for their Phase 3 Operational Phase.
- **Nearly 5 GB of test data generated for analysis**.
  - Data was collected by each site and its vendors and will be uploaded to the USDOT's Secure Data Commons (SDC).
  - The USDOT plans to continue to work with the CV Pilot sites to develop a Test Report documenting the results of the Phase 2 Interoperability Test.

Testimonials with Respect to Value

- Test Team did outstanding job planning and organizing tests.
  - Test plan was generally thorough, clear, and concise.
  - Installation of equipment went relatively smoothly.
  - Sites well prepared for test.
  - Overview and Q/A discussion added before each test proved beneficial.
- Everyone had a good experience with the testing.
  - Good to interact with other teams.
  - Allowed developers to test applications using equipment they don't generally have.
  - It was the most successful CV testing they had ever participated in.
  - A unicorn event - six vendors, three sites, multiple communications media - and it worked!
- A test of this nature had never been conducted before.
  - A watershed moment for connected vehicle technology, and an important milestone in the maturation of these technologies for operational deployment.
  - Just from the security standpoint alone, more than worth the effort to conduct.

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Federal Highway Administration

Question and Answers

NYCDOT

Tampa (THEA)

WYDOT

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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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