CONNECTED VEHICLE PILOT DEPLOYMENT PROGRAM

Kate Hartman, ITS JPO, USDOT
Robert Rausch, TransCore ITS
Deepak Gopalakrishna, ICF
Bob Frey, THEA and Steve Novosad, HNTB

SAE INTERNATIONAL

U.S. Department of Transportation
Intelligent Transportation Systems
Joint Program Office

Session Agenda

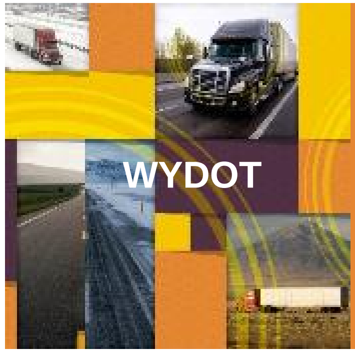
- Overview of the Connected Vehicle Pilot Deployment Program
  - *Kate Hartman, Program Manager, USDOT*
- Challenges to large scale Connected Vehicle Deployment in the Urban Environment, New York City's Connected Vehicle Project: 8,000 vehicles, 400 Roadside Units, 12 Safety Applications
  - *Robert Rausch, TransCore ITS*
- Improving Safety and Freight Operations in Rural Corridors using Connected Vehicle Technology: Update from Wyoming CV Pilot
  - *Deepak Gopalakrishna, ICF International Inc.*
- Vehicle to infrastructure Deployment in Tampa – The Need for Coordination between Automakers and Infrastructure Owners
  - *Bob Frey, Tampa Hillsborough Expressway Authority; Stephen Novosad, HNTB Corp.*
- Moderated Discussion
  - *Kate Hartman, Program Manager, USDOT*

CONNECTED VEHICLE PILOT
Deployment Program

Kate Hartman, Program Manager

CV Pilot Deployment Program Goals

The Three Pilot Sites

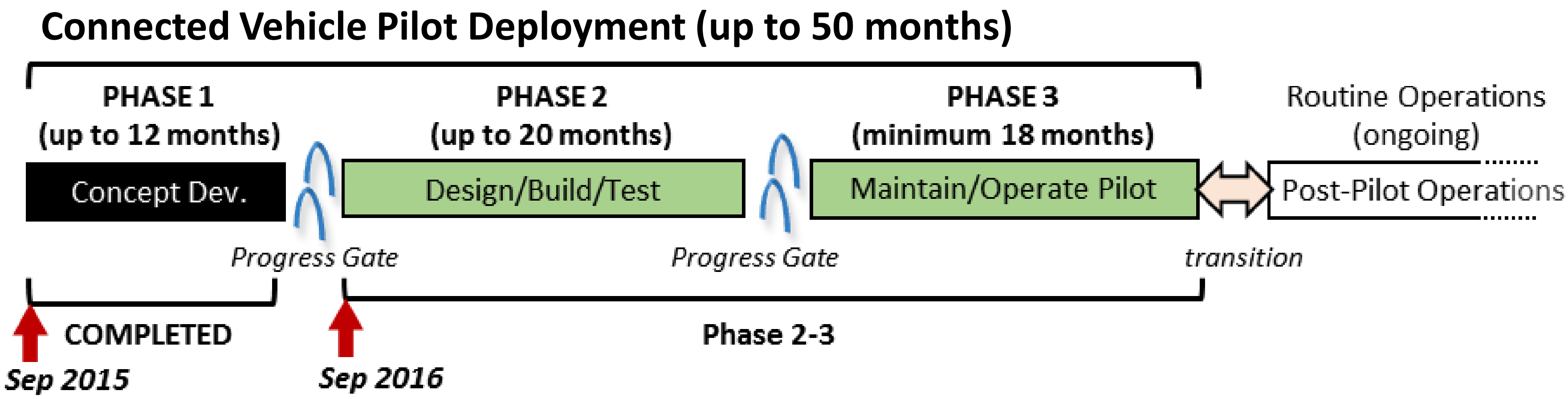


- Reduce the number and severity of adverse weather-related incidents in the I-80 Corridor in order to improve safety and reduce incident-related delays.
- Focused on the needs of commercial vehicle operators in the State of Wyoming.

- 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.

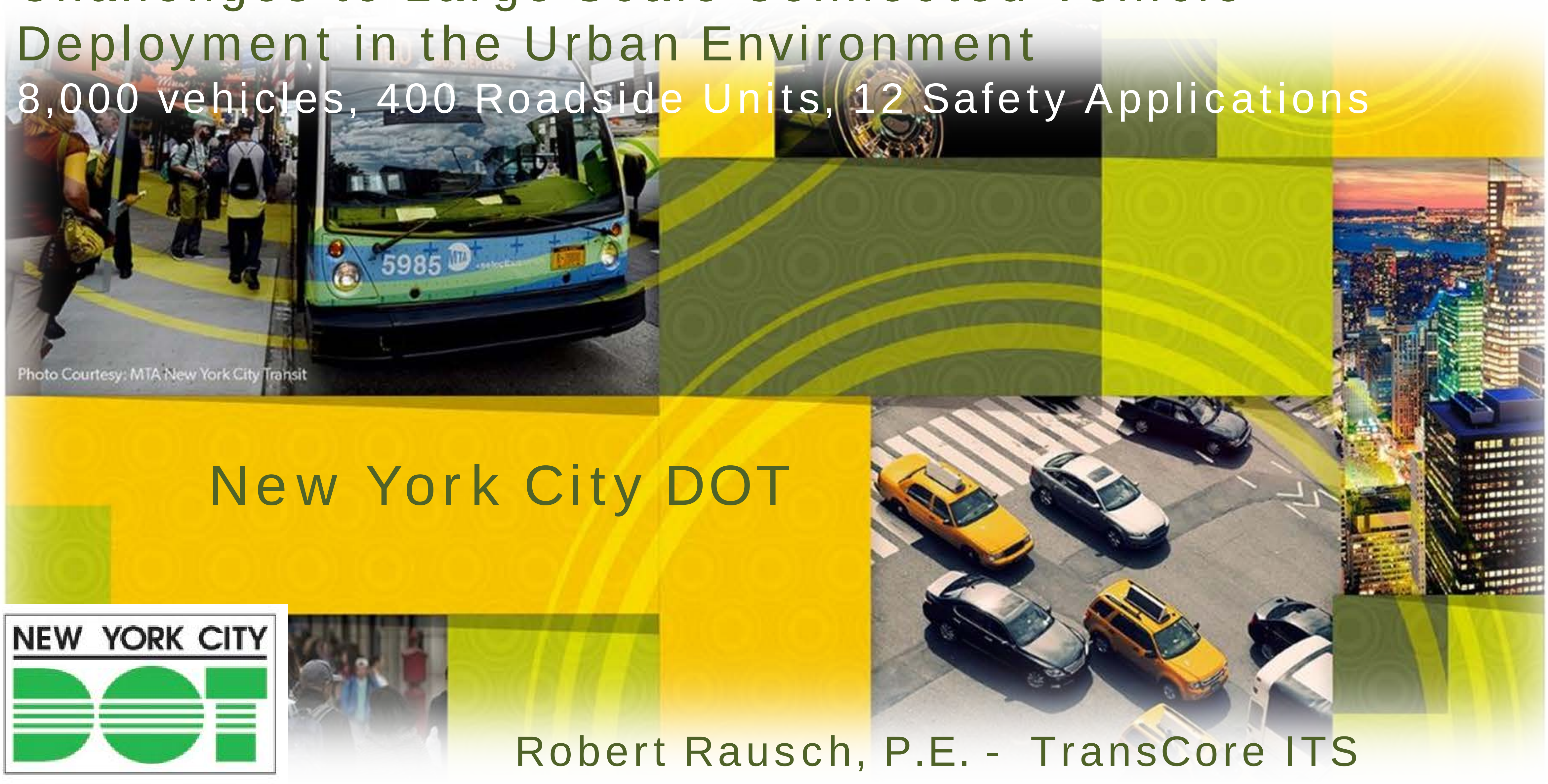
CV Pilot Deployment Schedule



- **Phase 1: Concept Development (COMPLETE)**
  - Creates the foundational plan to enable further design and deployment
  - **Progress Gate: Is the concept ready for deployment?**
- **Phase 2: Design/Deploy/Test (CURRENT PHASE- began September 1, 2016)**
  - Detailed design and deployment followed by testing to ensure deployment functions as intended (both technically and institutionally)
  - Progress Gate: Does the system function as planned?
- **Phase 3: Maintain/Operate**
  - Focus is on assessing the performance of the deployed system
- Post Pilot Operations (CV tech integrated into operational practice)

Challenges to Large Scale Connected Vehicle Deployment in the Urban Environment

8,000 vehicles, 400 Roadside Units, 12 Safety Applications



New York City DOT

Robert Rausch, P.E. - TransCore ITS

Today's Agenda

- CV Technology
  - How It Works – In 3 Minutes
- Overview Of The New York Project
- Challenges Encountered

Connected Vehicle Technology

Photo Courtesy: MTA New York City Transit

The Fundamentals

--- Applied for NYC

V2V DSRC CONCEPT

HOW IT WORKS V2V

Vehicle-to-Vehicle (V2V)
Safety Applications

Vehicles Broadcast
information about their
location, heading, speed, and path history:

Basic **S**afety **M**essage (BSM)

***BSM** Message*

<u>Vehicle Information</u>
Location
Heading
Speed
Path History

Vehicles receive the data –
determine immediate threats –
alert driver – who then takes evasive actions

Note: ***Intersections*** *receive the data – measure traffic conditions, optimize signal timing*

Security Mechanism establishes a “trusted environment”
Messages can be authenticated and encrypted as necessary

I2V/V2I Concept

How it Works V2I/I2V

MAP Message

Intersection Geometric Information
Stop Bar
Lanes
Permitted Movements

SPaT Message

Signal Timing Information
Time when it turns Yellow
Time when it turns Red
Time when it turns Green

BSM Message

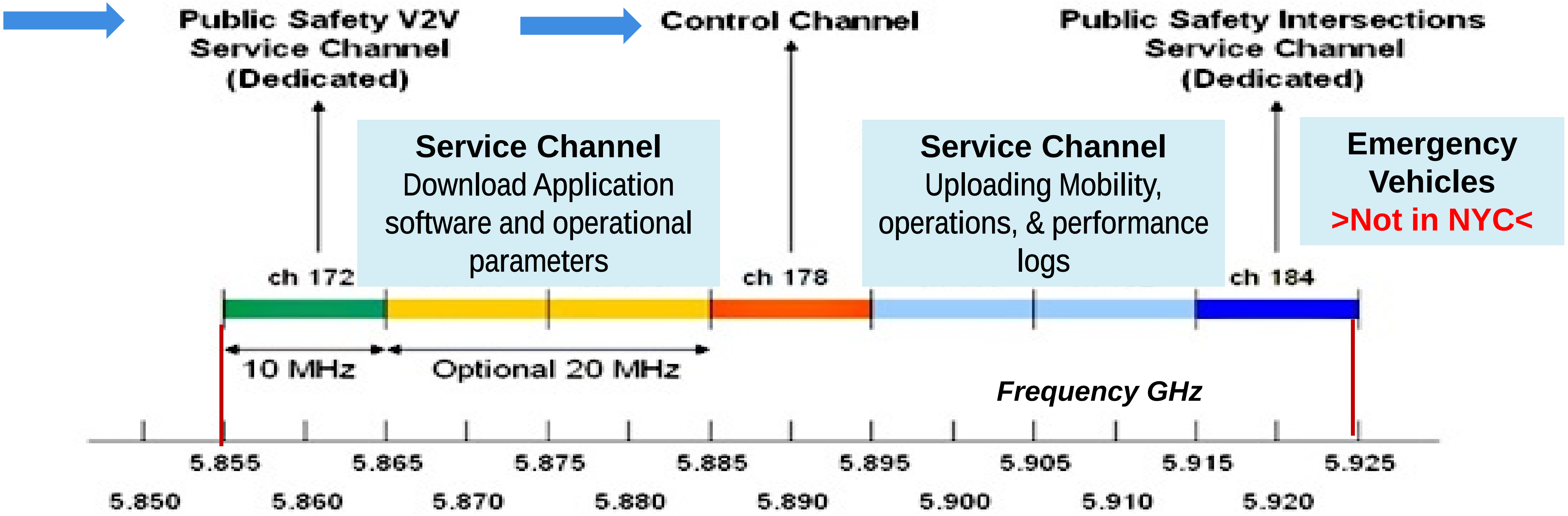
Vehicle Information
Location
Heading
Speed
Path History

Vehicles receive the data – determine immediate threats – alert driver

- **Infrastructure-to-Vehicle (I2V)** messages for additional Safety Applications (RLVW)
  - **Intersections** receive the BSM – measure traffic conditions, optimize signal timing
    - **Other Messages**: **TIM – (Traveler Information Message)** in-vehicle signage
      Basic Infrastructure Message (BIM)
      Priority request//Status (SRM/SSM)
      Pedestrian (Personal) Safety message (PSM)
      Vehicle Event Message

Location Correction (RTCM)

DSRC
DEDICATED SHORT RANGE COMMUNICATIONS



Key Benefits:

- **802.11p technology similar to 802.11a**
- **Low latency communication (<< 50ms)**
- **High data transfer rates (3 – 27 Mbps)**
- **Typically 300M and 360 °**
- **Up to 1000 M for emergency vehicles**

Project Overview

NYC Project Goals

- New York City is aggressively pursuing “Vision Zero”

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

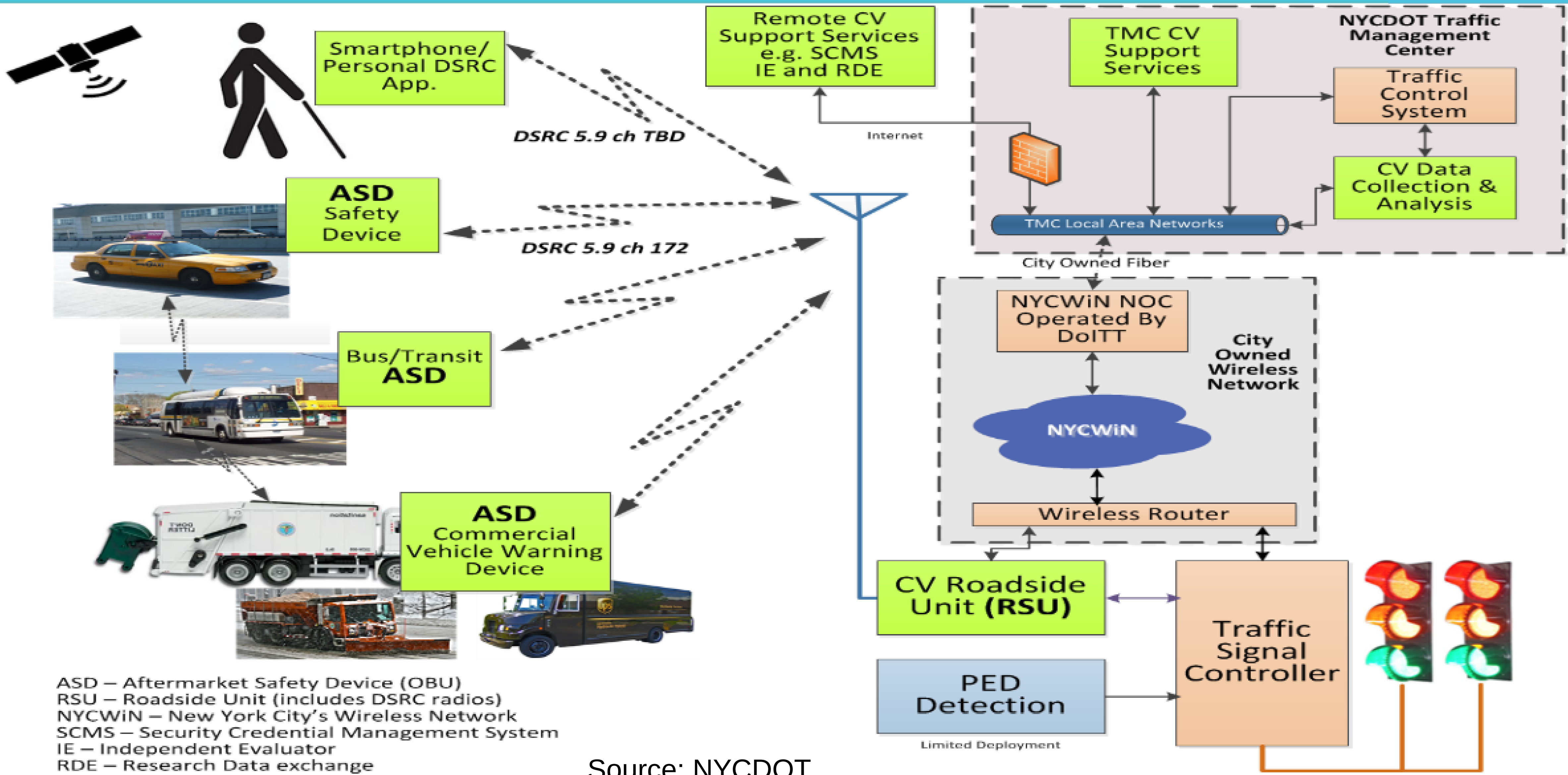
Vision Zero Goal : to eliminate traffic deaths by 2024

- Use CV technology as a new **tool to achieve this goal**
- *The project will evaluate the **safety benefits** and **challenges** of implementing CV technology with a significant number of vehicles in the **dense urban environment.***

NEW YORK CITY DOT

U.S. Department of Transportation

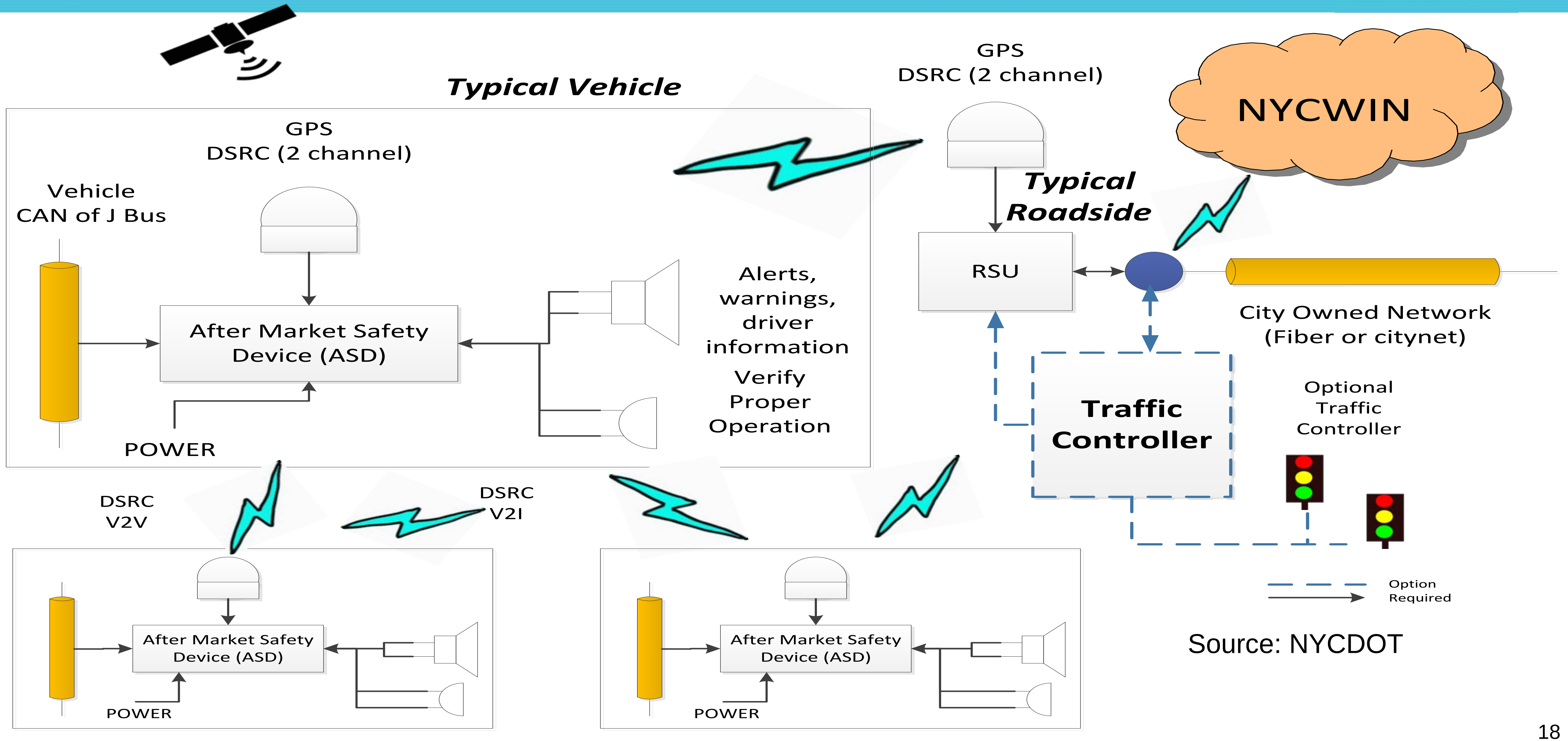
OVERALL PROJECT CONCEPT



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

Source: NYCDOT

FIELD INFRASTRUCTURE CONCEPT



Source: NYCDOT

CV Deployment Equipment - Vehicles

- 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

Source: USDOT

- Pedestrian **PIDs** ~100 units
  - Visually Impaired
- PED in Crosswalk ~10 int.

NEW YORK CITY DOT

CV DEPLOYMENT EQUIPMENT – INFRASTRUCTURE

- 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)

LOCATIONS (MANHATTAN, BROOKLYN)

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

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

The CV project leverages the City's transportation investments

Source: NYCDOT

Vehicle-to-Vehicle (V2V) Safety Applications

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

V2V applications based on existing demonstrations and prior developments and documentation

CV APPLICATIONS - 2

Vehicle-to-Infrastructure (V2I) Safety Applications

- Red Light Violation Warning — RLVW
- Speed **Compliance** — SPD-COMP
- Curve Speed **Compliance** — CSPD-COM
- Speed **Compliance**/Work Zone — SPDCOMPWZ
- Oversize Vehicle **Compliance** — OVC
  - Prohibited Facilities (Parkways)
  - Over Height
- Emergency Communications and Evacuation Information *(Using the traveler information features)* — EVACINFO

V2I applications based on existing demonstrations and/or modifications to prior developments and documentation

CV Applications - 3

Other Applications

- Mobile [Visually Impaired] Ped Signal System PED-SIG
- Pedestrian in Signalized Intersection Warning PEDINXWALK
- CV Data for Intelligent Traffic Signal System I-SIGCVDAT ***Roadway segment travel times***

Operations, Maintenance, and Performance Analysis

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

To Meet USDOT Evaluation Requirements

Our Approach

- Focus on “proven” **Safety Applications -** BAA stressed that R&D has shown the benefits:
  - Pilot Deployment will evaluate the benefits on a much larger scale – dense urban situation
- **Leverage “existing” safety applications** (demonstrated)
  - Manage *(Tune)* the CV applications for NYC
  - Adjust operation for the congested traffic environment of NYC
- Modify several existing applications to encourage speed **compliance**
  - Note that the City reduced city-wide speed from 30 MPH to 25 MPH
- Contract pedestrian applications development
- Leverage existing **standards**, existing infrastructure, and knowledge base
- Use the *Systems Engineering Process* to:
  - Develop operations and maintenance applications
  - Develop data collection applications [for benefits analysis]
  - Develop benefit evaluation applications

Challenges - *Everywhere*

- **Stakeholder privacy** concerns vs. USDOT desire for broad evaluation data
- Stakeholder requirements to avoid **distracting "cockpit"** displays
- **Density** of Roadside **DSRC** Transponders (RSU)
  - ~76 M for short blocks
  - ~200 M for the long blocks (between avenues)

DSRC – Nominal 300M - Channel Assignments & Xmit Power

- **Bandwidth limitations** of the wireless backhaul (RSU to TMC) – *it is IPV4 only*
- Ongoing **maintenance and support** (in-vehicle and infrastructure) of the large scale deployment (8,000+ Vehicles and >350 RSUs)

ONLY DSRC Communications!

- SCMS for all applications & DSRC Over-the-air (OTA) certificate distribution
- OTA [DSRC] data collection – bandwidth limited
- OTA [DSRC] software updates
- OTA [DSRC] parameter management
- Location accuracy in the urban canyons *(both relative V2V and absolute V2I)*
  - Tests, trials, and consideration of alternative sources

Maintenance Support

- Added applications to track DSRC performance
  - V2V – when and where do vehicles see each other?
  - V2I – general sense of effective communications radius ASD
  - I2V – general sense of effective communications radius RSU

Nearest and furthest not every BSM/SPaT

- Positioned RSU's at **fleet** "barns" and airports
  - Update parameters & firmware and retrieve performance data
- SCMS – certificates are only for 1 week
  - Until misbehavior detection and Certificate Revocation List (CRL) distribution is in production
- Purchasing RF test equipment to help track performance and interference!

Challenge: Performance Metrics & Evaluation Methods While Preserving Privacy

Identified the safety needs from ConOps

Identified the safety applications to be implemented

Developed Questions for Evaluation

Identified Performance Measurement Metrics ~47

Reduce Vehicle to Vehicle Crashes

- FCW
- EEBL
- BSW
- LCW
- IMA
- RLVW
- VTRW

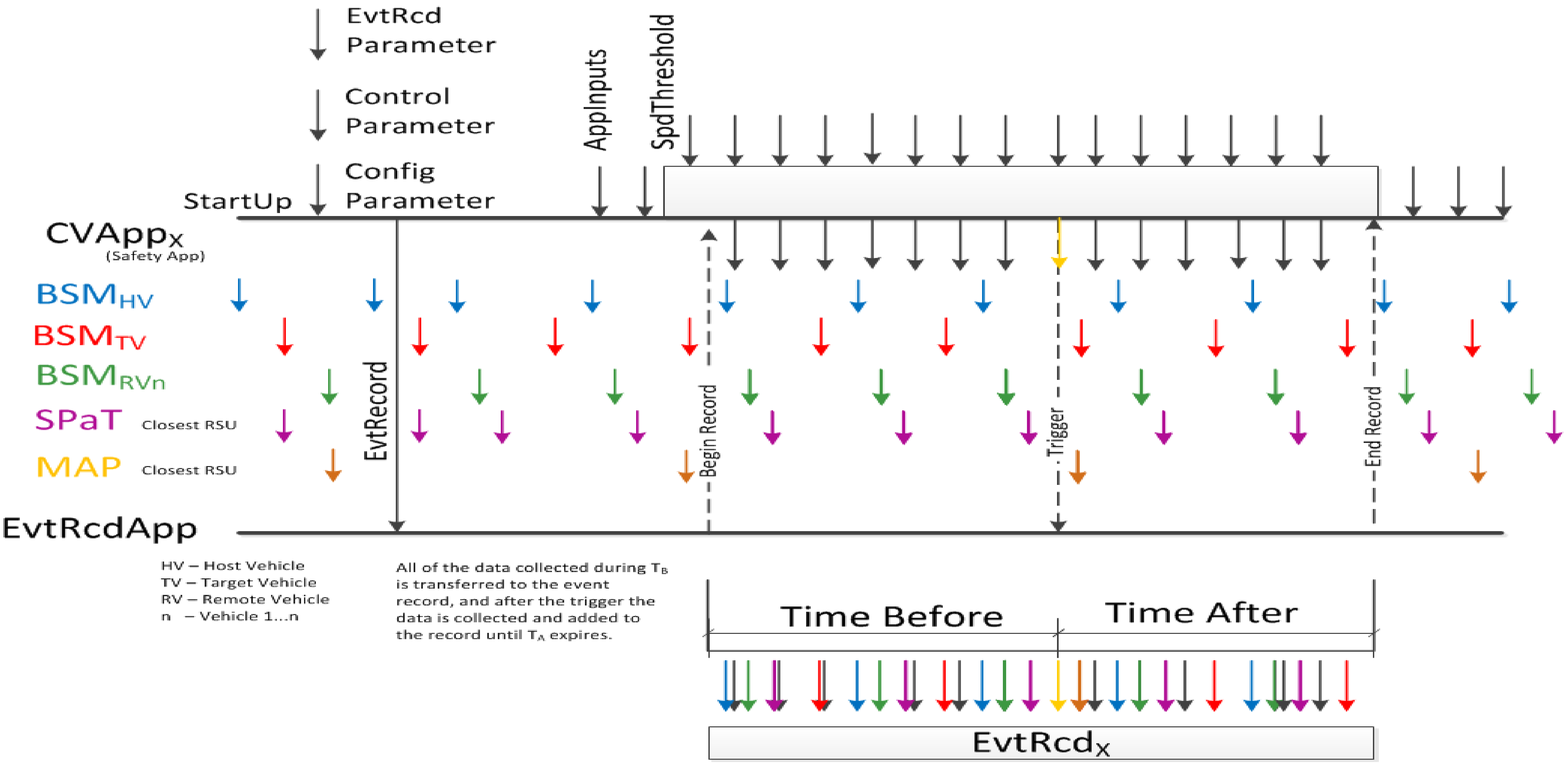
- Do the number of reportable crashes decrease
- Do the number and severity of red light violations decrease
- Do the number of bus / right turn vehicle crashes decrease

- Fatality crash counts
- Injury crash counts
- Property damage only crash counts
- Time to Collision
- Red light violation counts
- Red light violation related crash counts
- Driver actions and/or impact of actions in response to issued warnings
- Bus and right turn related crash counts
- Number of warnings generated
- Right-turning related conflicts

Data collection:

Everything that "occurred" immediately before and after the alert

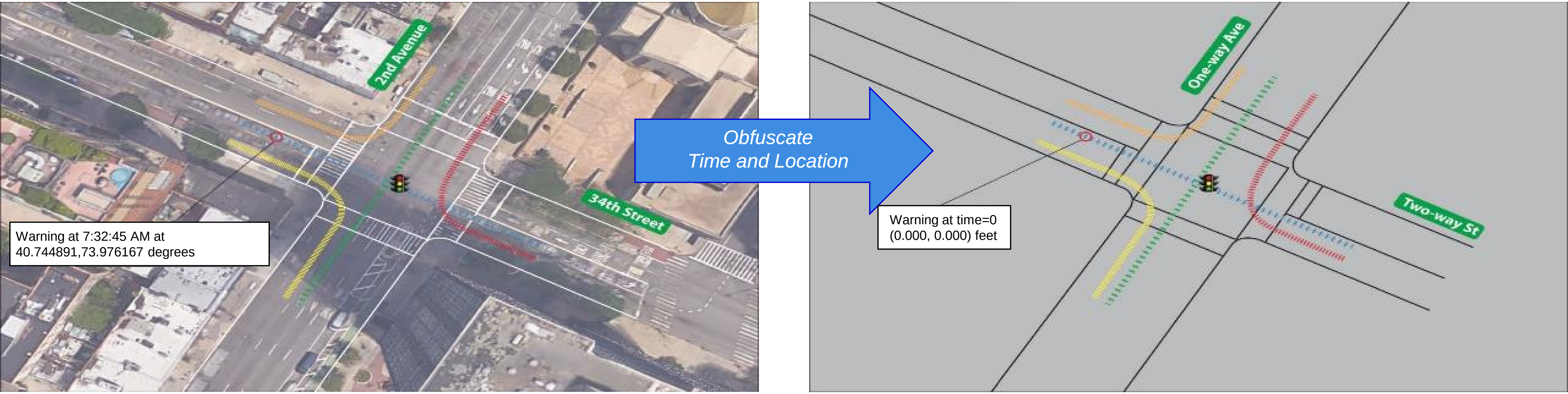
Example of Event Logging



OBFUSCATION OF ASD ACTION LOGS FOR PRIVACY

Raw ASD Action Log Data

Obfuscated ASD Action Log Data



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

Deployment Approach

- **Turn-key ASD and RSU equipment ~400**
- Multiple stage delivery **~8,000**
  - Prototypes (8 week development and 12 week install/test)
  - Award to 2 ASD Bidders (~1/2 each) and 1 RSU Bidder
  - Initial order (first 1000 production units)
  - Bulk order (remaining production units)
- **Concept: Verify the hardware <u>platform</u> early and use OTA updates (firmware, parameters) to verify the applications**
- Installation time for fleets this large takes time (estimate from other's experience and measure actuals)

CHALLENGE – SCALABLE OTA DATA EXCHANGES

- How to push software updates to 8,000 in-service vehicles quickly over **DSRC**
  - **Not WiFi and Not LTE/4G**
- Developed Scheme to support both broadcast and unicast updates
- ASD's read Wave Service Announcements 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 broadcast streams

- Efficient Channel Use
- Privacy is maintained

Our Team

- NYCDOT: single prime contractor for NYC CVPD Phase 2 and 3
- Key staff
  - Project Management Lead: Mohamad Talas, Ph.D., P.E., P.T.O.E.
  - Site Deployment Lead: Robert G. Rausch, P.E.
  - Systems Engineering Lead: David A. Benevelli, P.E.

Stakeholders
Fleet Owners and Users

UPS
MTA
New York City Department of Sanitation
NYC Taxi & Limousine Commission
NYC TAXI
New York City DOT
PASS COALITION

Project Team

New York City DOT
Department of Transportation United States of America
TransCore
Security Innovation
Cambridge Systematics
KLD
University Transportation Research Center

WHERE ARE WE NOW ?

- Phase 2 – 20 Month Deployment
  - Started September 1, 2016
  - Official Kick Off September 23, 2016
  - Twenty (20) Months ***(16 left!)***
    - ***Developing architecture, data management pan, detailed designs, procurement documents, etc.***
  - Phase 3 Evaluation
    - Starts April 2018

As we proceed – USDOT and the Project Teams are sharing ideas, challenges, workshops, and the NY team is aggressively participating in the standards development program!

THANK YOU

Bob Rausch, P.E.
TransCore ITS
Robert .Rausch@TransCore.com

U.S. Department of Transportation
Intelligent Transportation Systems
Joint Program Office

Improving Safety and Freight Operations in Rural Corridors using Connected Vehicle Technology

Update from Wyoming CV Pilot

Deepak Gopalakrishna, ICF

WYOMING'S I-80 CORRIDOR

Heavy Freight Traffic

Major E/W Freight corridor
Freight over half of annual traffic

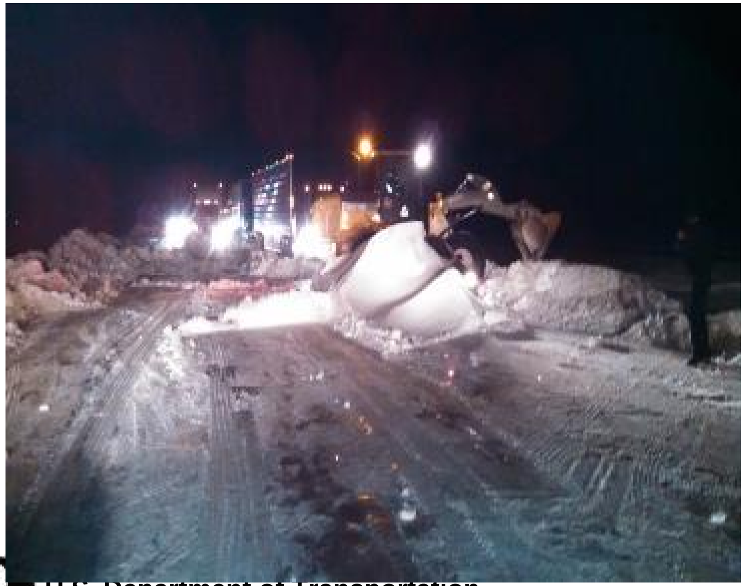
Severe Weather Conditions

Elev. Over 6000 ft
Heavy winds, heavy snow and fog
Severe blowing snow and low visibility

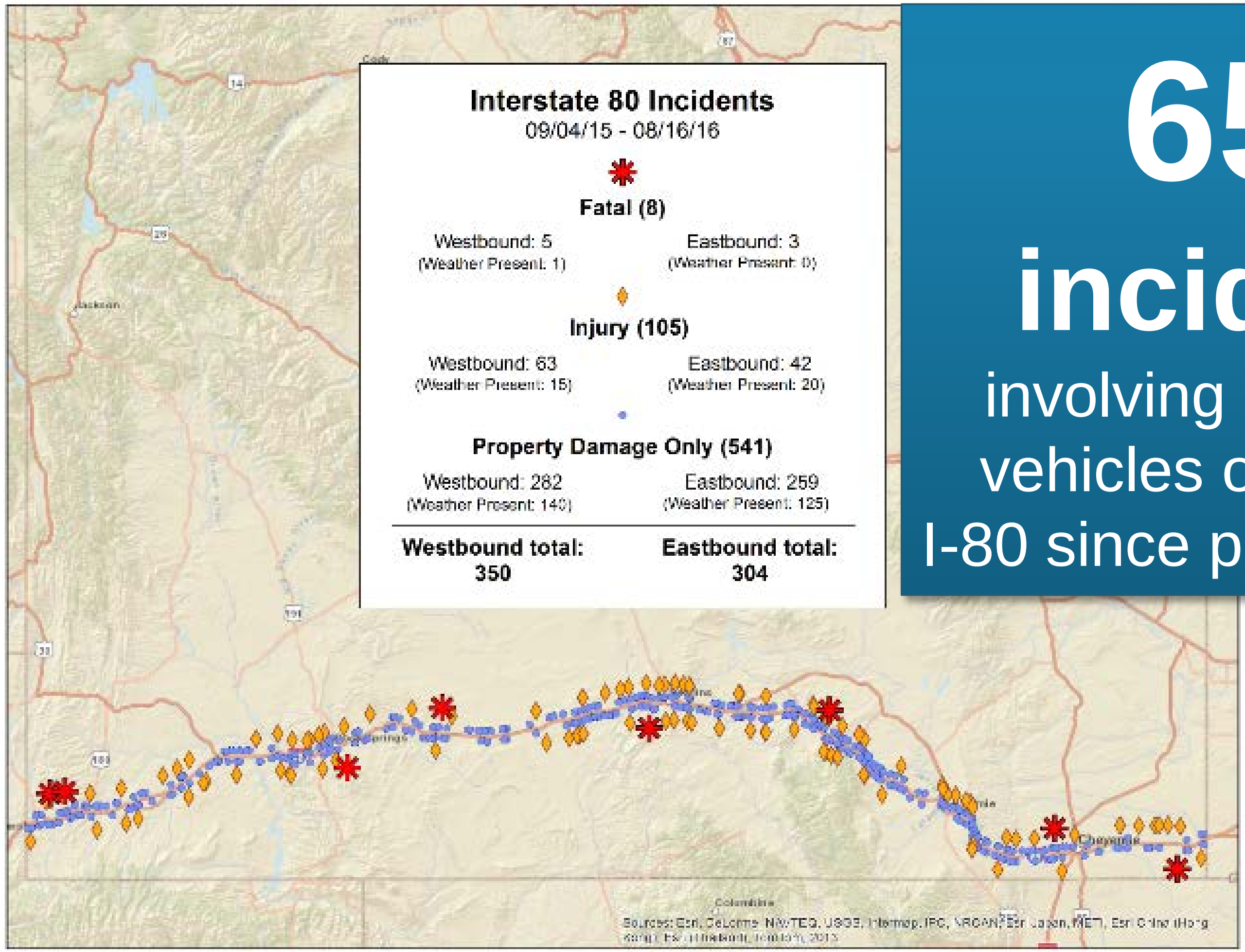
Adverse Impacts on Truckers

Higher than normal incident rates
Multi-vehicle crashes
Fatalities

Source: WYDOT (Dec 17, 2015)



Scope of the Problem



654 incidents

involving commercial vehicles occurred on I-80 since project kick-off

1,600+ crashes

1,923 vehicles

$865.3M

Societal Impact

I-80 Users Need Actionable Road Weather Information

The need for actionable information is growing

Aug 2016

800

26,443

Estimated Firms Subscribed to WYDOT's CVOP

Downloads of WYDOT 511 App*

150

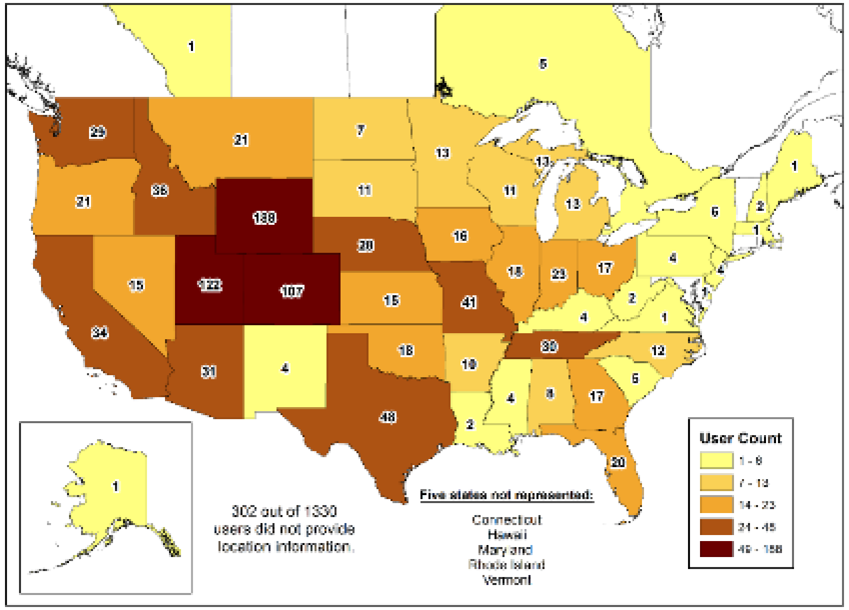
0

Sept 2015

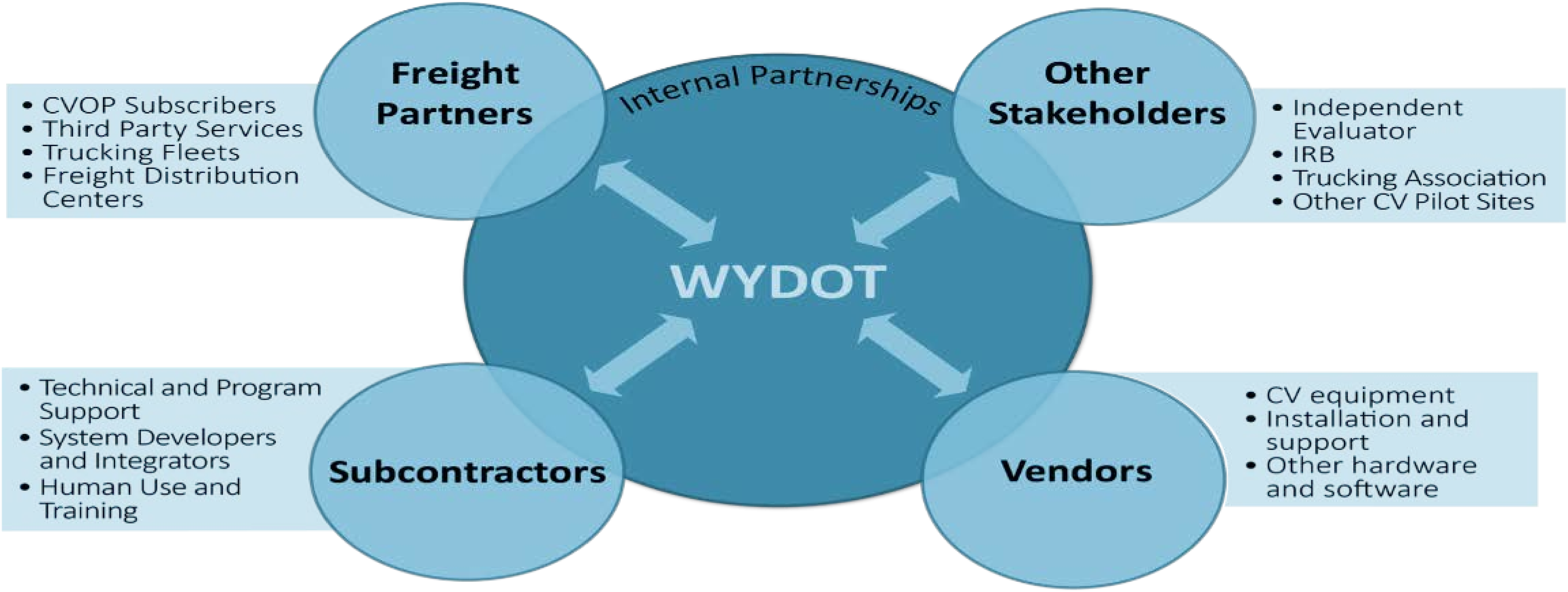
*Downloads since Feb 2016 when app was released

WYDOT's Commercial Vehicle Operator Portal (CVOP

CVOP Users by Location



CV Pilot Partnership



PILOT OBJECTIVES

Road Weather Condition Input

1. Improve road weather condition reports received into the TMC

TMC Information Dissemination

1. Improve ability of the TMC to generate wide area alerts and advisories
2. Efficiently manage closures, restrictions and speed limits
3. Effectively disseminate and receive messages from TMC to en-route vehicles
4. Improve information to commercial vehicle fleet managers

Vehicle/Roadside Alerts & Advisories

1. Effectively transmit and receive V2V messages to reduce incidents and their severity
2. Enhance emergency notifications of a crash

Outcomes

1. Improve speed adherence and reduce speed variation
2. Reduce vehicle crashes

Pilot Elements

CV Environment

75 Roadside Units on I-80

400 Vehicles with DSRC Connectivity

V2V Applications

Forward Collision Warning

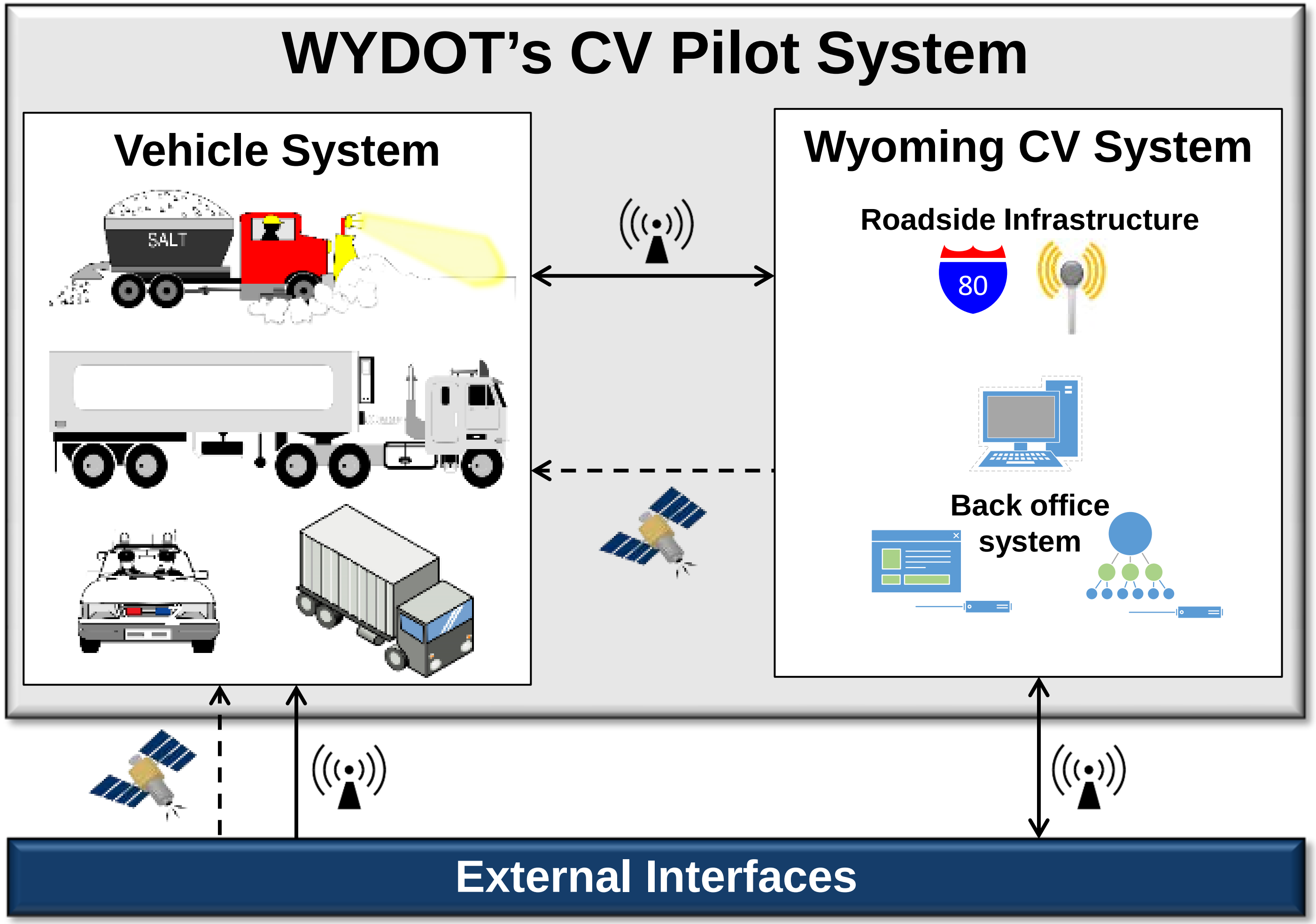
Distress Notification

V2I Applications

Situational Awareness

Spot Weather

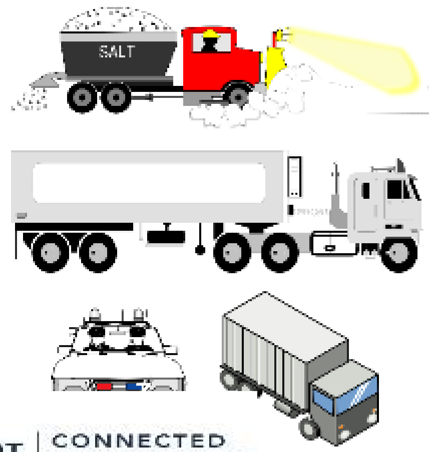
Work Zone Warning



Vehicle System

All vehicles that are part of the vehicle system will have:

- Ability to share information via DSRC with connected devices (vehicles and RSUs)
- Ability to broadcast Basic Safety Message Part I
- Ability to receive Traveler Information Messages (TIM)
- Human-Machine Interface (HMI) to communicate alerts and advisories to driver



Vehicle Sub-Systems

1. WYDOT Fleets
2. Integrated Trucks
3. Retrofit Vehicles
4. Basic Vehicles

On-board Vehicle Technologies

- OBU with DSRC only
- OBU with DSRC and Satellite Receiver
- Human Machine Interface
- CAN Bus Integration (selected vehicles)
- Environmental Sensors (selected vehicles)

CV APPLICATIONS OVERVIEW

On-Board Applications

- Applications available to equipped vehicles

TMC Ops Applications

- Support for WYDOT Traveler Information and Traffic Management

On-Board Applications

The pilot will develop five on-board applications that will provide road condition information to the drivers of equipped vehicles.

- ***Forward Collision Warning (FCW)***
- ***Infrastructure-to-Vehicle (I2V) Situational Awareness (SA)***
- ***Work Zone Warning (WZW)***
- ***Spot Weather Impact Warning (SWIW)***
- ***Distress Notification (DN)***

Project Status

Current Status

Final System Architecture	Submitted to U.S DOT
Ongoing System Design	Working on System Design Document
Ongoing Equipment Bench Testing	4 OBUs are up and running, 2 RSUs are running, Android HMI up and running
Integration of CV Pilot Elements with TMC	Progress on TMDD Interface, participant tracking application, 511 app updates, location for the 75 RSUs identified, Pikalert® instance activate
Procurement	Working on procurement of all on-board devices and RSUs

Next Steps and Activities

- Operational Readiness Testing in early 2018
- System Operations and Maintenance starting May 2018 for 18 months
- Post-Pilot Transition Planning
- Support for performance measurement and evaluation (throughout)
- Standards support (throughout)
- Stakeholder outreach (throughout)

Lessons Learned

Implementing CV Technology in a Rural Corridor

- Clearly defining the State role versus private roles especially with long-term operations in mind
- Need multiple ways of reaching on-road drivers.
- Limited alternate routes. If we miss a decision point, travelers can be stuck for hours
- Leverage existing State-owned fleets as much as possible
- Engage the local community and stakeholder groups early

Implementing CV Technology for Trucks

- Standards are currently focused on light-duty vehicles
- Limited in-cab space for human-machine interface
- Varying makes, model years of participating fleet make CAN integration difficult
- Application development so far has mostly been for light-duty vehicles. Algorithms for trucks-specific instances still a work in progress
- Limited opportunity to take trucks out of revenue service for updates, repairs, installs
- Large geographic footprint means that applications will largely not work when outside Wyoming

ENGAGING THE TRUCKING COMMUNITY

- Formalized agreements with private partners take time.
- Balancing data collection with privacy
- Working with varying capabilities between firms
- Taking advantage of existing or planned driver technology in trucks

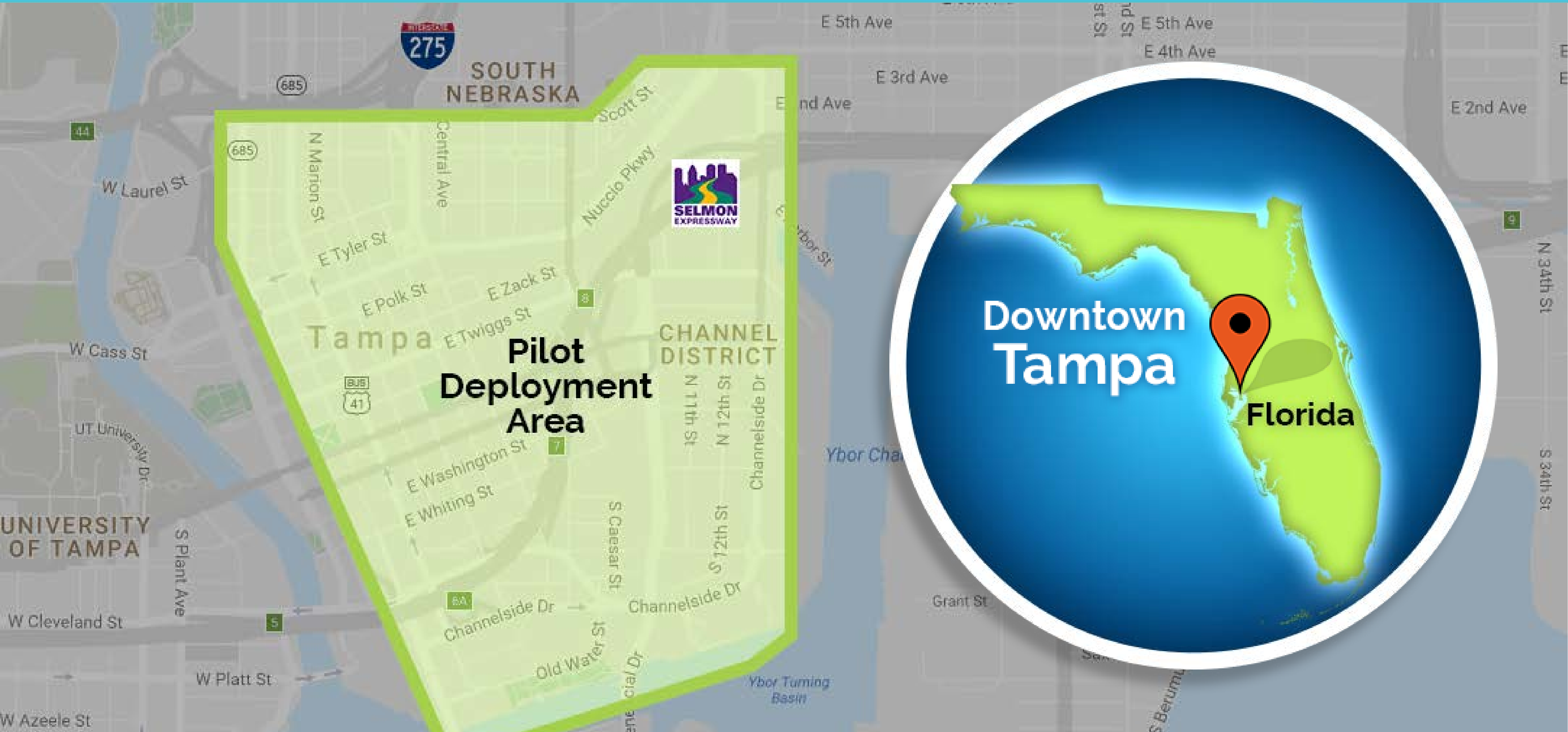
Vehicle to infrastructure Deployment in Tampa – The Need for Coordination between Automakers and Infrastructure Owners

Bob Frey, Tampa Hillsborough Expressway Authority
Stephen Novosad, HNTB Corp.

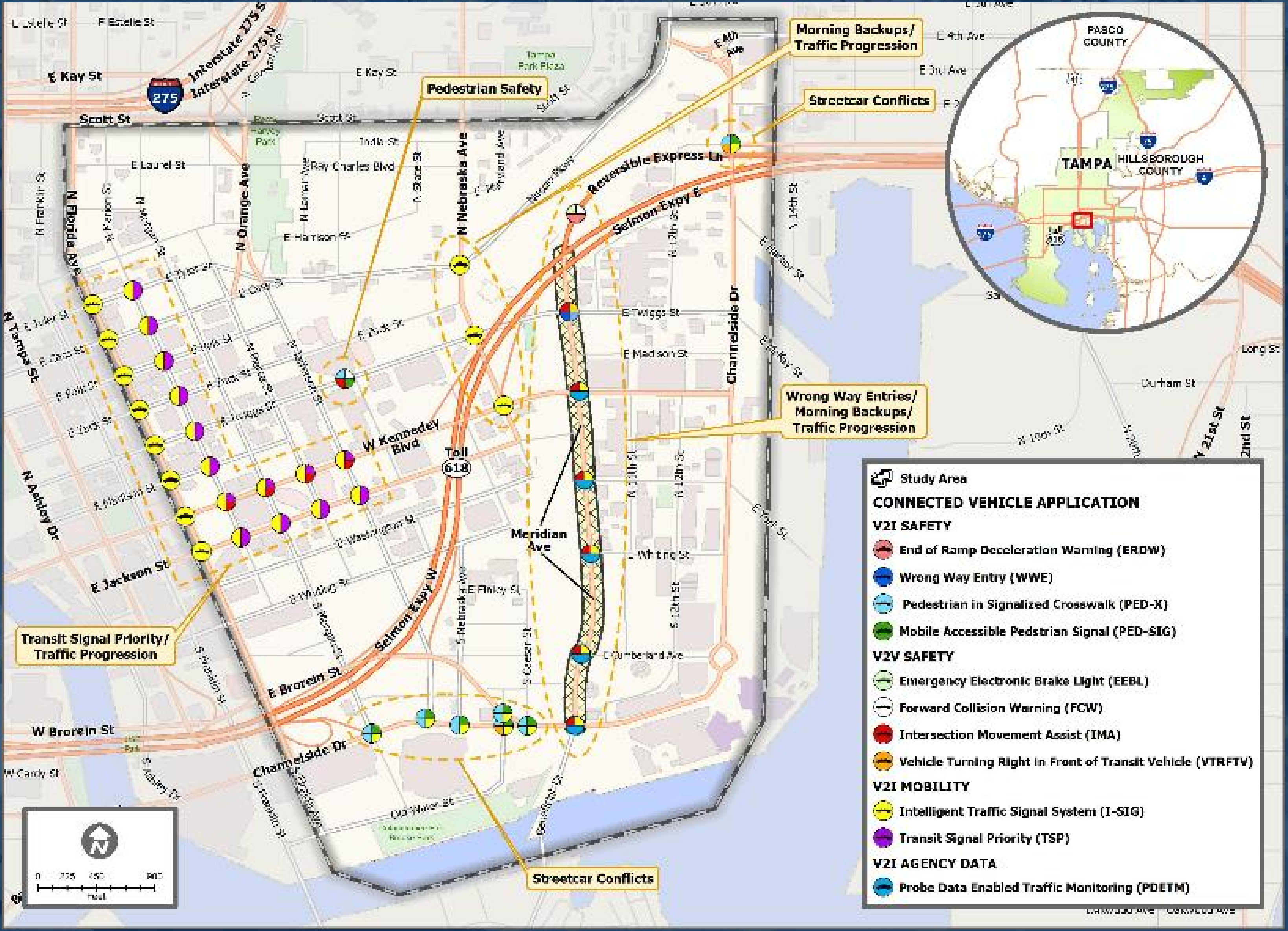
AGENDA

- THEA CV Pilot Overview
- An Infrastructure Owner's Perspective
- How Infrastructure Owners See Automakers
- The Need for Collaboration

Tampa Deployment Area



Focused Pilot Deployment Area



Participants: By the Numbers

1,500

Privately Owned Vehicles

500+

Pedestrian Smartphones (Android devices only)

10

TECO Line Streetcar Trolleys

10

Hillsborough Area Regional Transit (HART) buses

Equipment: By the Numbers

PHOTO: THEA

1,520

On-Board Units (OBUs)

A rear view mirror for passenger vehicles and tablet display for transit vehicles


PHOTO: SIEMENS

40

Road Side Units (RSUs)

Mounted on existing structures throughout the deployment area

Morning Backup

Forward Collision Warning (FCW)

Emergency Electronic Brake Light (EEBL)

End of Ramp Deceleration Warning (ERDW)

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

WRONG-WAY DRIVERS

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

Wrong-way Entry

Intelligent Signal System (I-SIG)

Intersection Movement Assist (IMA)

Pedestrian Safety

Mobile Accessible Pedestrian Signal System (PED-SIG)

Pedestrian in a Crosswalk Vehicle Warning (PED-X)

FCW

IMA

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

Transit Signal Priority

- I-SIG
- Transit Signal Priority (TSP)
- IMA

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

Streetcar Conflicts

Vehicle Turning Right in Front of Transit Vehicle (VTRFTV)

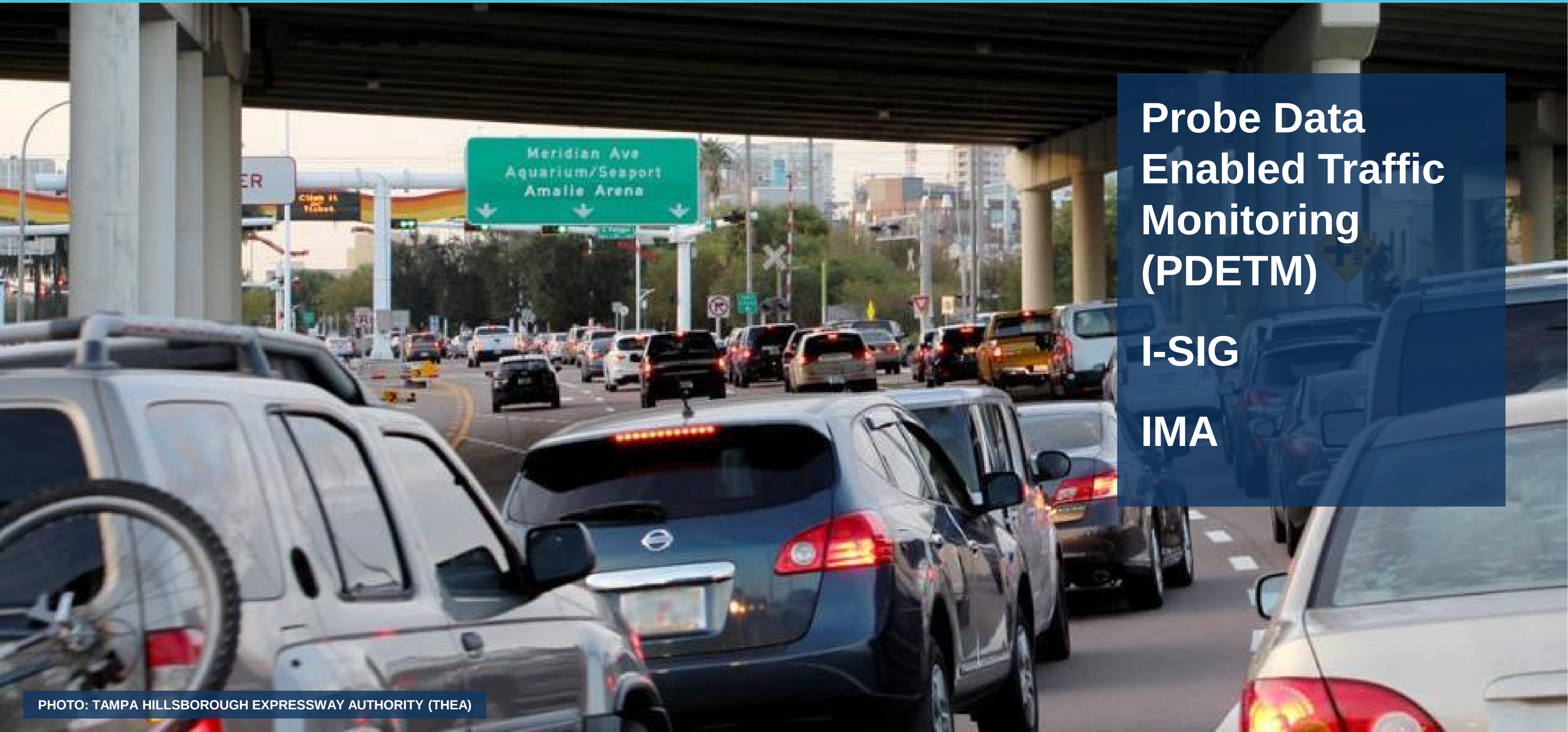
I-SIG

PED-SIG

PED-X

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

TRAFFIC PROGRESSION



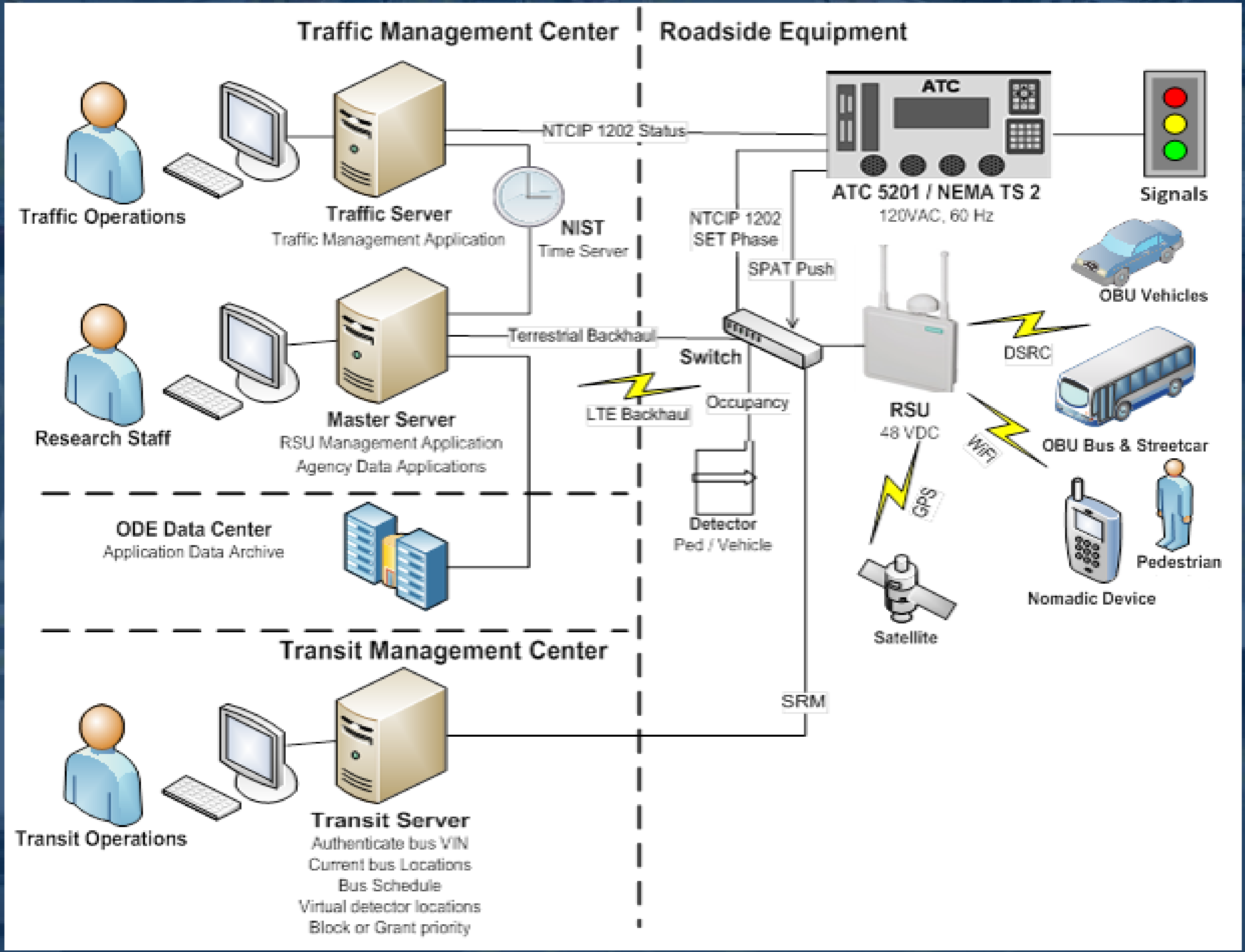
Probe Data Enabled Traffic Monitoring (PDETM)

I-SIG

IMA

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

System Flow



Traffic Management Center
Roadside Equipment
Traffic Operations
Traffic Server
Traffic Management Application
NTCIP 1202 Status
NIST
Time Server
ATC
ATC 5201 / NEMA TS 2
120VAC, 60 Hz
Signals
NTCIP 1202
SET Phase
SPAT Push
OBU Vehicles
Research Staff
Master Server
RSU Management Application
Agency Data Applications
Terrestrial Backhaul
Switch
LTE Backhaul
Occupancy
DSRC
RSU
48 VDC
WiFi
OBU Bus & Streetcar
GPS
Detector
Ped / Vehicle
Pedestrian
Nomadic Device
Satellite
ODE Data Center
Application Data Archive
Transit Management Center
SRM
Transit Operations
Transit Server
Authenticate bus VIN
Current bus Locations
Bus Schedule
Virtual detector locations
Block or Grant priority

INFRASTRUCTURE OWNER'S PERSPECTIVE

Data, data everywhere and only a bit is useful…

What data is useful?
- Operations Data
- Traffic Incident Management

Volume of Data
- Can we handle it?
- Can we afford it?

What data would be useful if available?
- Decision Support Systems

USDOT SAFETY PILOT DATA

SPaT

- Expected: Total for 8 RSUs = 6,912,000 messages per day
- Actual: Total for 8 RSUs = **28,821,437** messages per day

MAP

- Expected: Total for 7 RSUs = 691,200 messages per day
- Actual: Total for 7 RSUs = **2,510,384** messages per day

TIM

- Expected: Total for 3 RSUs =259,200 messages per day
- Actual: Total for 3 RSUs = **227,766** messages per day

BSM

- Expected: Total for 26 RSUs = 6,516,458 messages per day
- Actual: Total for 26 RSUs = **16,740,785** messages per day

Storage Size (total file storage + database size per month)

Files	Database	Total
4.6 TB	13.8 TB	18.4 TB

How Much Data?

70 billion connected devices (2050)

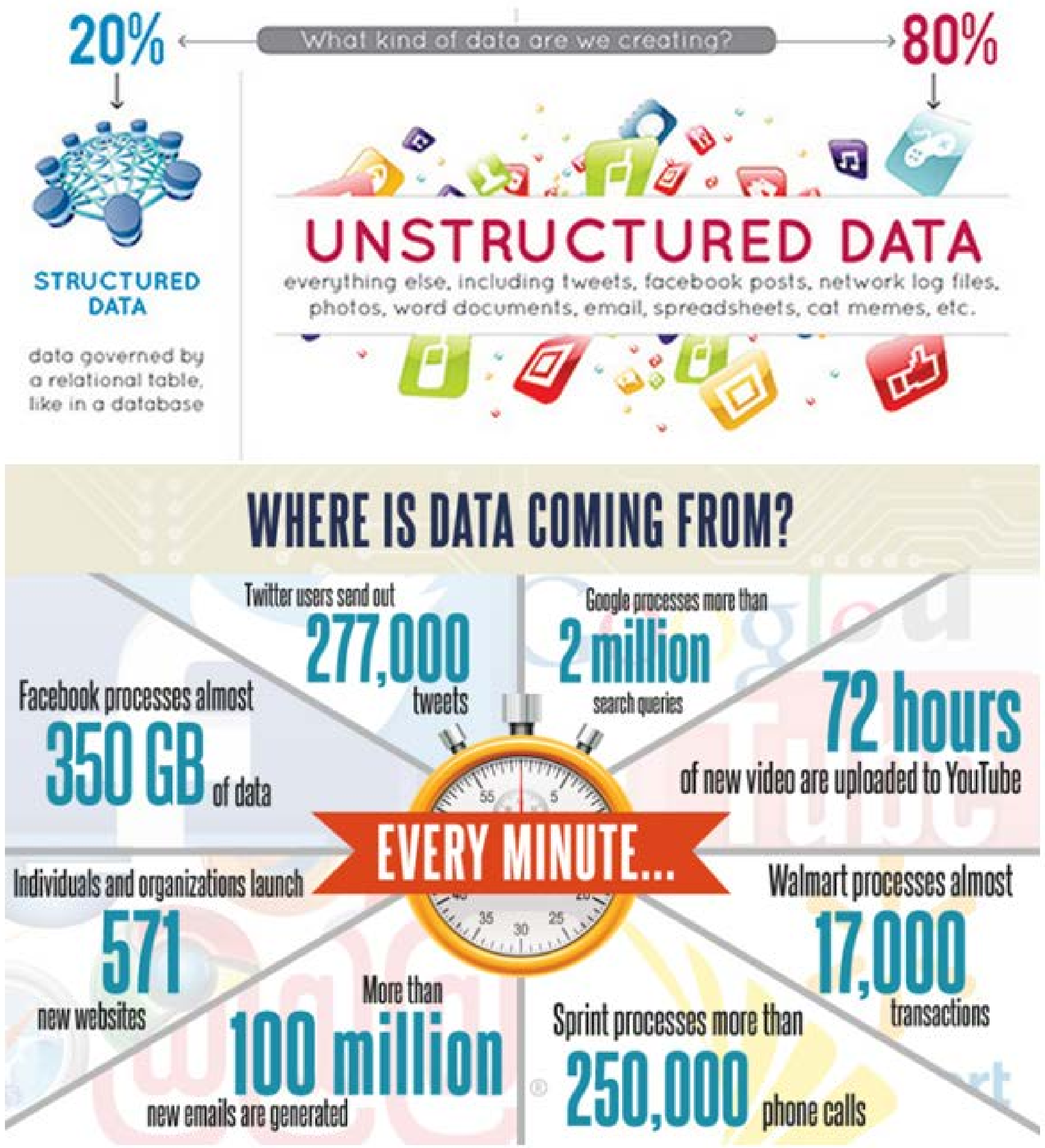
2.8 trillion sensors (2019)

Autonomous Vehicles (L2)

- 80+ processors
- 200+ sensors
- 100M+ lines of code (GM)

2,500,000,000,000,000,000

2.5 Quintillion bytes **EVERY DAY**

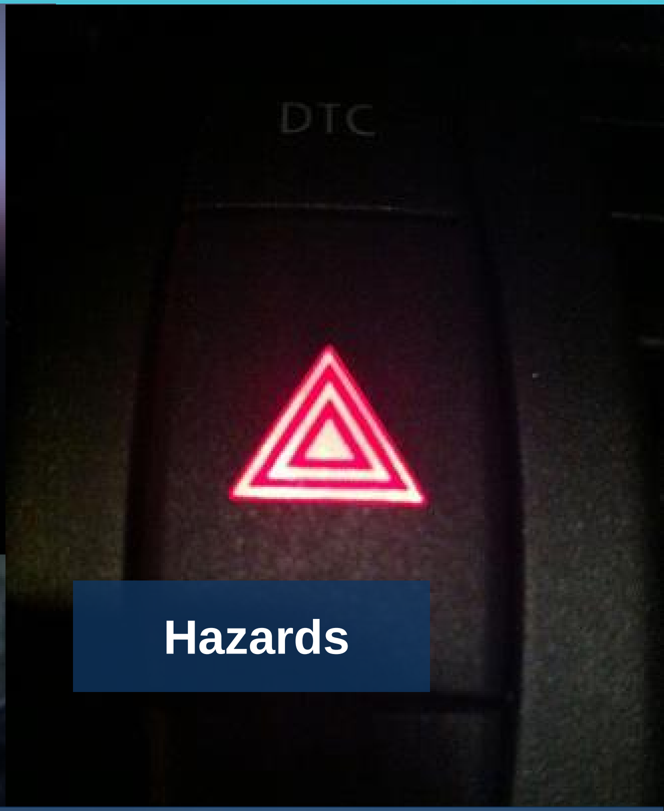


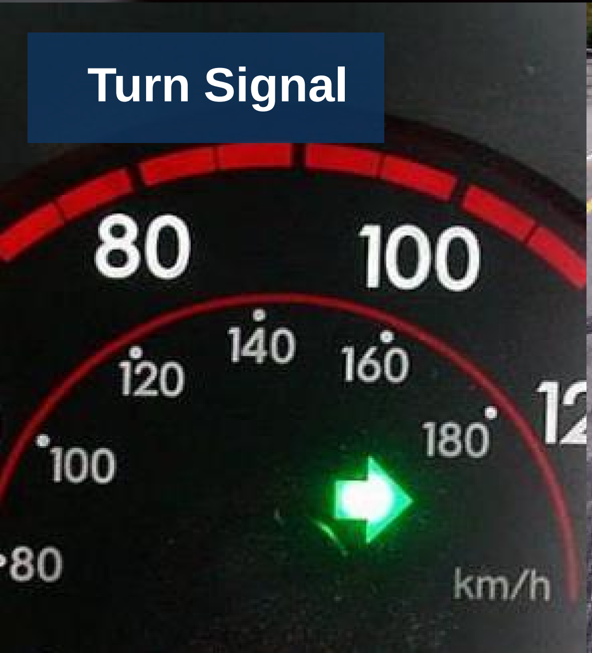
Day to Day Operations

How Infrastructure Owners See OEMs

- No previous relationship
- OEMs focus on Safety and Marketability
- Vehicle Detection

OPERATIONS DATA





Location Speed Direction

The Need for Collaboration

- It’s a new world
- Software replacing hardware/devices
- Security/privacy
- Vehicle connectivity
- Vehicles as part of Decision Support System
- Other device connectivity
- Automated vehicles

We Need Each Other

For more information…

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Moderated Discussion

Kate Hartman, Program Manager

STAY CONNECTED

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- Discover more about the CV Pilot Sites
- Learn the Essential Steps to CV Deployment
- Engage in Technical Discussion

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