SESSION AGENDA

- Overview of the Connected Vehicle Pilot Deployment Program
  - *Egan Smith, Managing Director, ITS JPO, USDOT*

- Connected Vehicle Pilot in New York City – Safety in a Dense Urban Grid Environment
  - *Robert Rausch, TransCore ITS*

- Connected Vehicle Pilot in Wyoming – Managing a Busy Freight Corridor under all Weather Conditions
  - *Ali Ragan, Wyoming DOT*

- Connected Vehicle Pilot in Tampa, Florida – Managing Safety and Mobility Impacts in Integrated Expressway/Surface Street Networks
  - *Bob Frey, Tampa Hillsborough Expressway Authority*

- Panel Discussion and Q&A
  - *Egan Smith, Managing Director, ITS JPO, USDOT*

**U.S. Department of Transportation**

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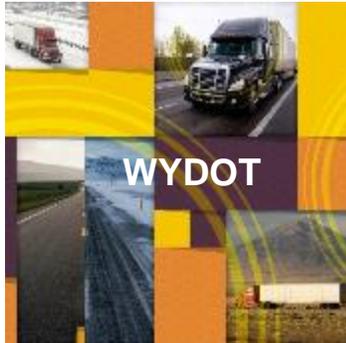
WYDOT
- Reduce the number and severity of adverse weather-related incidents in the I-80 Corridor in order to improve safety and reduce incident-related delays.
- Focused on the needs of commercial vehicle operators in the State of Wyoming.

New York City DOT
- 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.
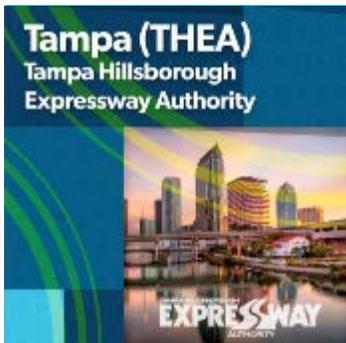
Tampa (THEA)
Tampa Hillsborough Expressway Authority
- Alleviate congestion and improve safety during morning commuting hours.
- Deploy a variety of connected vehicle technologies on and in the vicinity of reversible express lanes and three major arterials in downtown Tampa to solve the transportation challenges.

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CV PILOT DEPLOYMENT SCHEDULE

Connected Vehicle Pilot Deployment (up to 50 months)
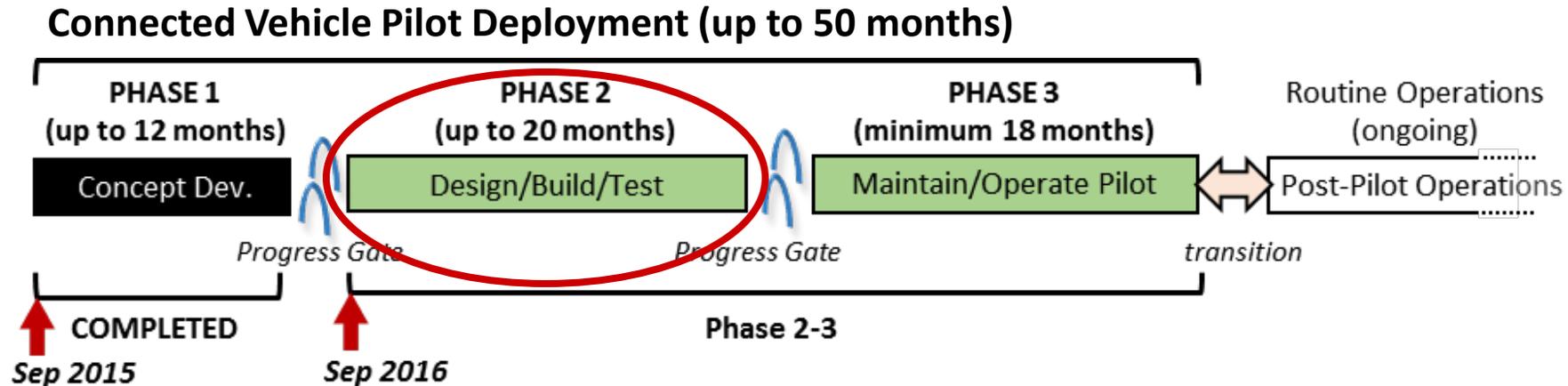
- **Phase 1: Concept Development (COMPLETE)**
  - Creates the foundational plan to enable further design and deployment
  - **Progress Gate: Is the concept ready for deployment?**

- **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)

U.S. Department of Transportation

Connected Vehicle Pilot in New York City – Safety in a Dense Urban Grid Environment

New York City DOT

Photo Courtesy: MTA New York City Transit

NEW YORK CITY DOT

Robert Rausch, P.E. - TransCore ITS
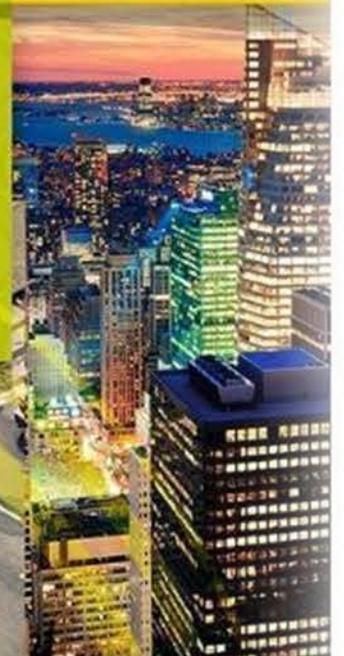
Connected Vehicle Technology

Photo Courtesy: MTA New York City Transit

The Fundamentals
--- Applied for NYC

CONNECTED VEHICLES

Coming Soon to a Road Near You...
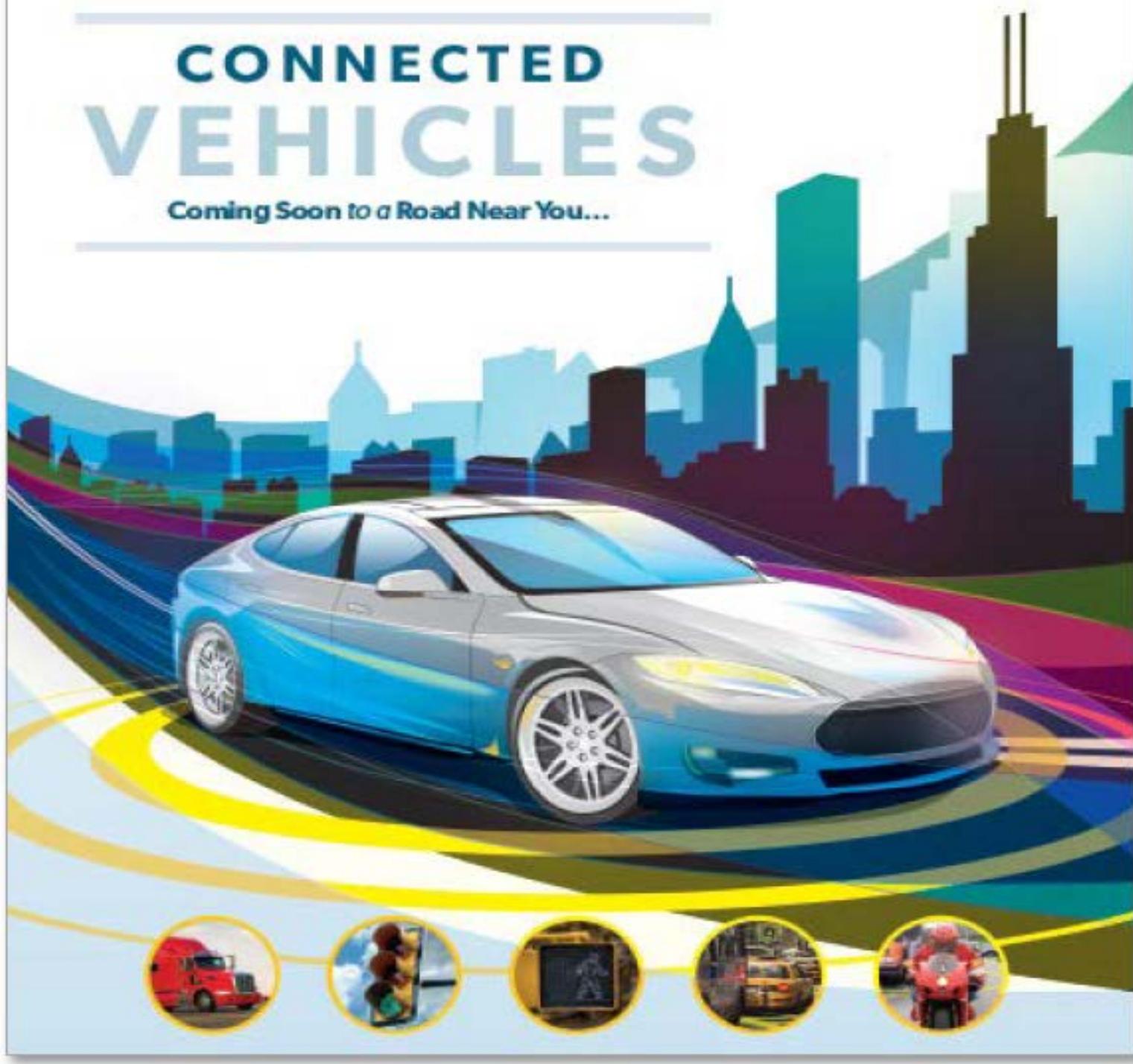
Vehicles Broadcast:
Basic Safety Message

Vehicles receive the data –
- Determine immediate threats
- Alert driver
- Driver takes evasive actions

Traffic Controllers can monitor the data – measure traffic conditions, optimize signal timing

⬅ **BSM** *Message*

Vehicle Information
Location
Heading
Speed
Path History
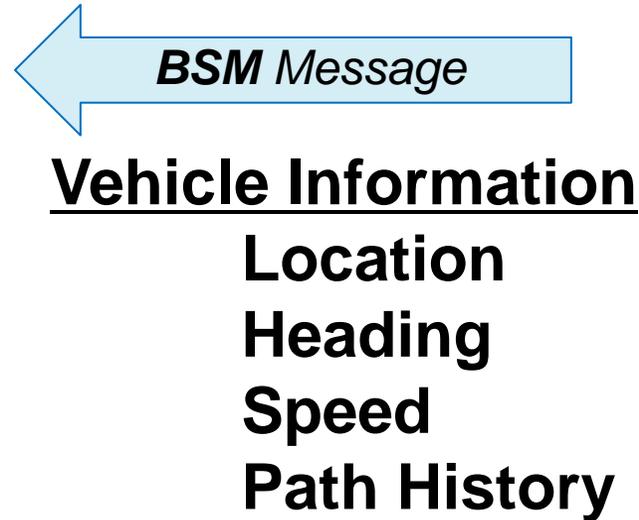
- *Security Mechanism establishes a "trusted environment"*
  Messages can be signed, authenticated and encrypted as necessary

U.S. Department of Transportation

INFRASTRUCTURE-TO-VEHICLE (I2V)
HOW IT WORKS

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

➢ **Vehicles** receive the data –
➢ Determine immediate infrastructure issues
➢ Alert driver   **Red Light Violation Warning (**RLVW)

→ **Other Messages:**
Priority request//Status (SRM/SSM)
Pedestrian (Personal) Safety message (PSM)

Traveler Information Message - in-vehicle messages
Location Correction (RTCM)
Vehicle Event Message

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DSRC
Dedicated Short Range Communications

Public Safety V2V Applications Channel (Dedicated)

Control Channel

Emergency Vehicles

Service Channel
Download Application software and operational parameters

Service Channel
Uploading Mobility, operations, & performance logs

Ch 172   Ch 174   Ch 176   Ch 178   Ch 180   Ch 182   Ch 184

10 MHz   Optional 20 MHz

5.850   5.855   5.860   5.865   5.870   5.875   5.880   5.885   5.890   5.895   5.900   5.905   5.910   5.915   5.920   5.925

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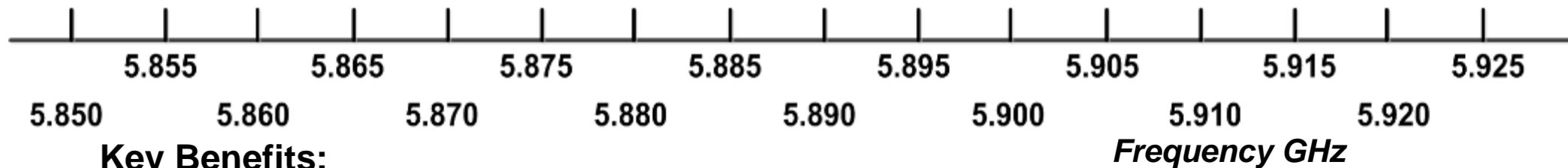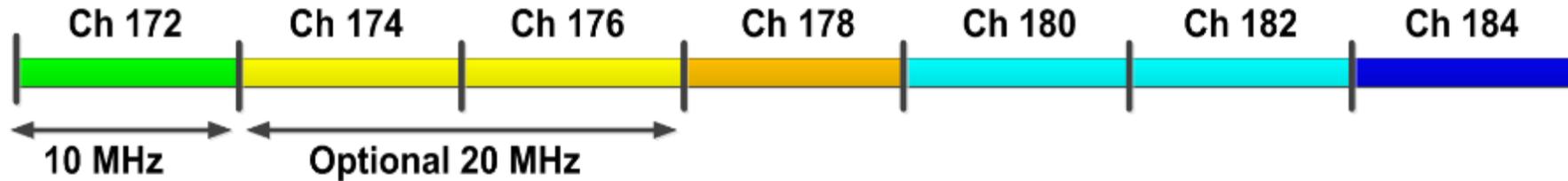
Key Benefits:
- 802.11p technology similar to 802.11a
- Low latency communication (<< 50ms)
- High data transfer rates (3 – 27 Mbps)
- Typically 300M and 360 °
- Up to 1000 M for emergency vehicles

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New York City

Project Overview

Photo Courtesy: MTA New York City Transit
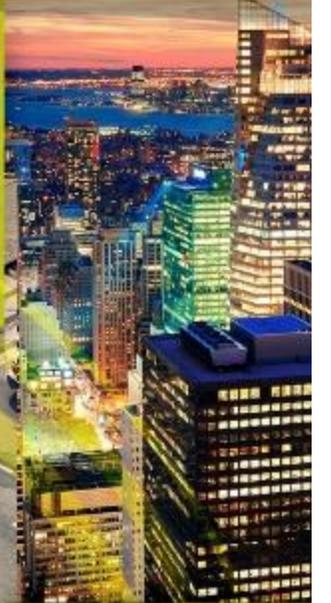
- New York City is aggressively pursuing "Vision Zero"

**"Traffic Death and Injury on City streets**

is not acceptable"

Vision Zero Goal : to eliminate traffic deaths by 2024

NYC will evaluate

- ▫ *Safety Benefits*

- ▫ *Challenges*
  *Of implementing **Connected Vehicle** technology with a significant number of vehicles in the **dense urban environment.***

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Smartphone/Personal DSRC App.

ASD Safety Device

Bus/Transit **ASD**

ASD Commercial Vehicle Warning Device

DSRC

Security Management System

Internet

CV Support Systems

NYC Traffic Management Center

Traffic Control System

NYCWiN

CV Roadside Unit **(RSU)**

Traffic Signal Controller

ASD: Aftermarket Safety Device

15
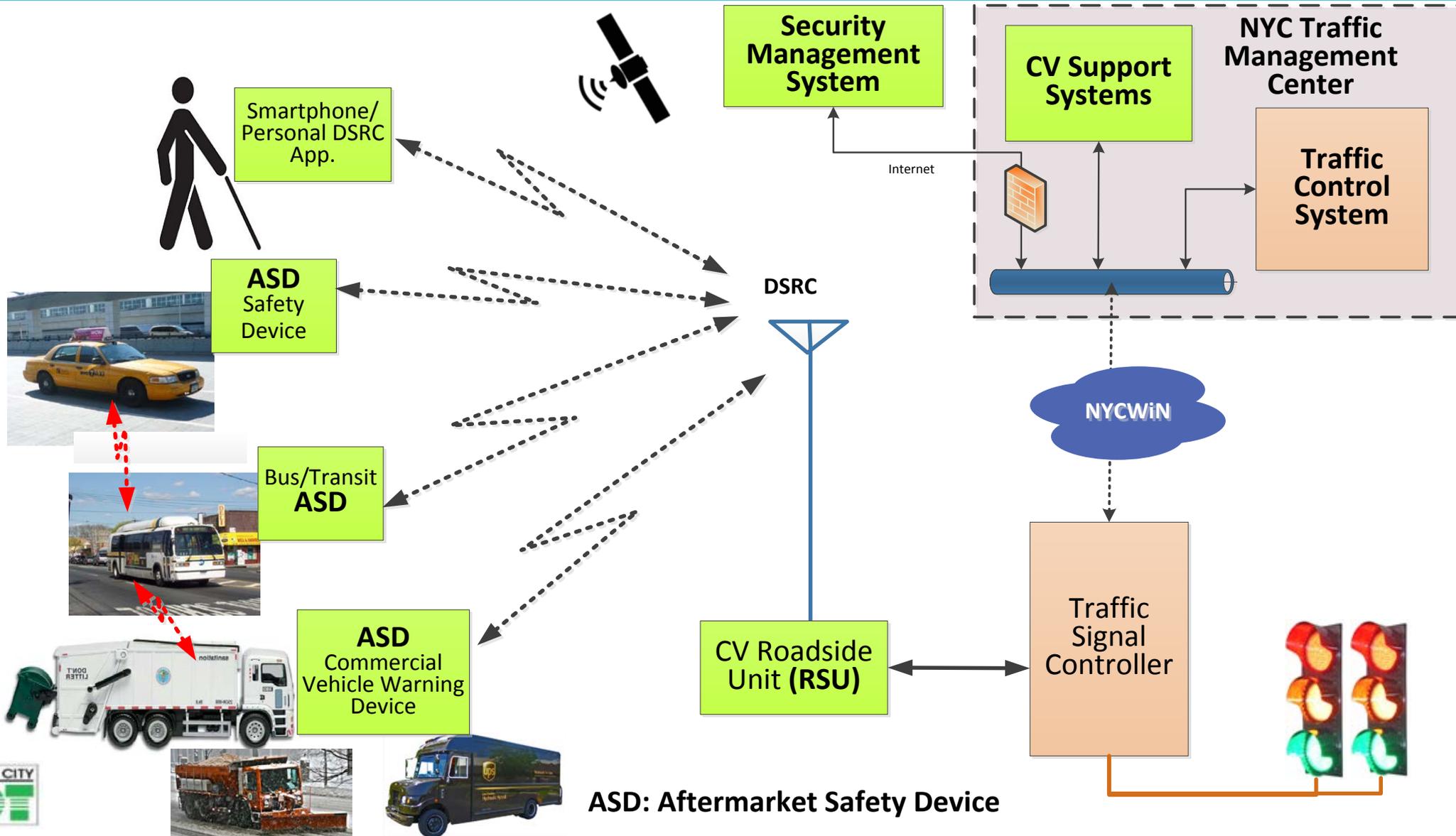
CV Deployment Equipment - Vehicles

- 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

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

Pedestrian Trials

- Pedestrian **PIDs**
  - Visually Impaired
- PED in Crosswalk

NEW YORK CITY
DOT

CV Deployment Equipment – Infrastructure

- Roadside Units (**RSU**) at ~350 Locations
  - ~200 Manhattan Ave
  - ~ 80 Manhattan Cross
  - ~ 30 on Flatbush Ave
  - ~ 8 on FDR
  - ~ 36 Support locations (airports, river crossings, terminal facilities)
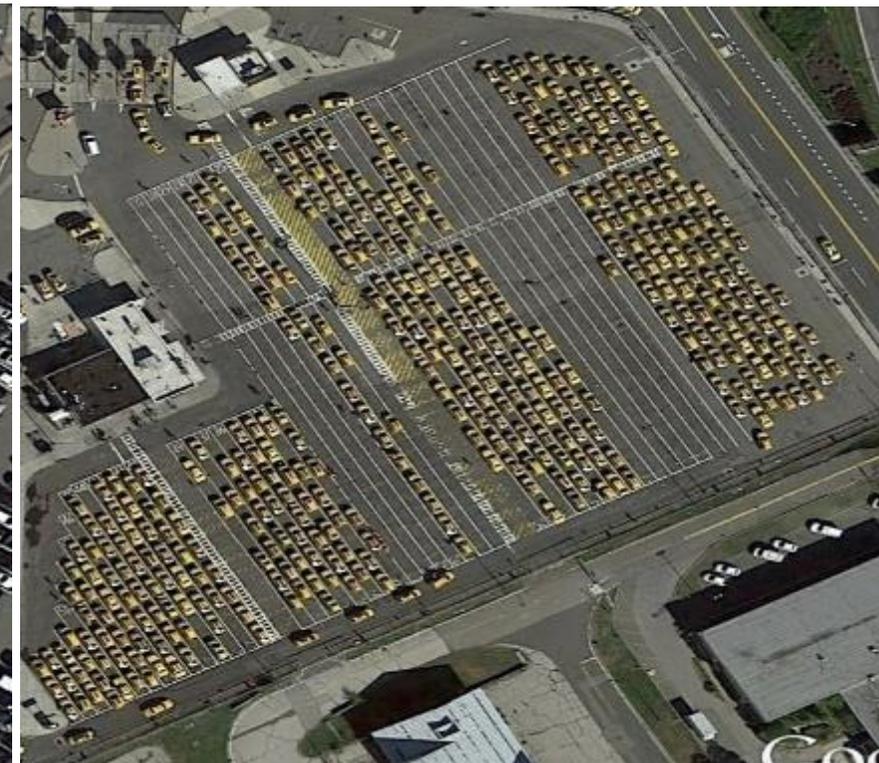
Locations (Manhattan, Brooklyn)

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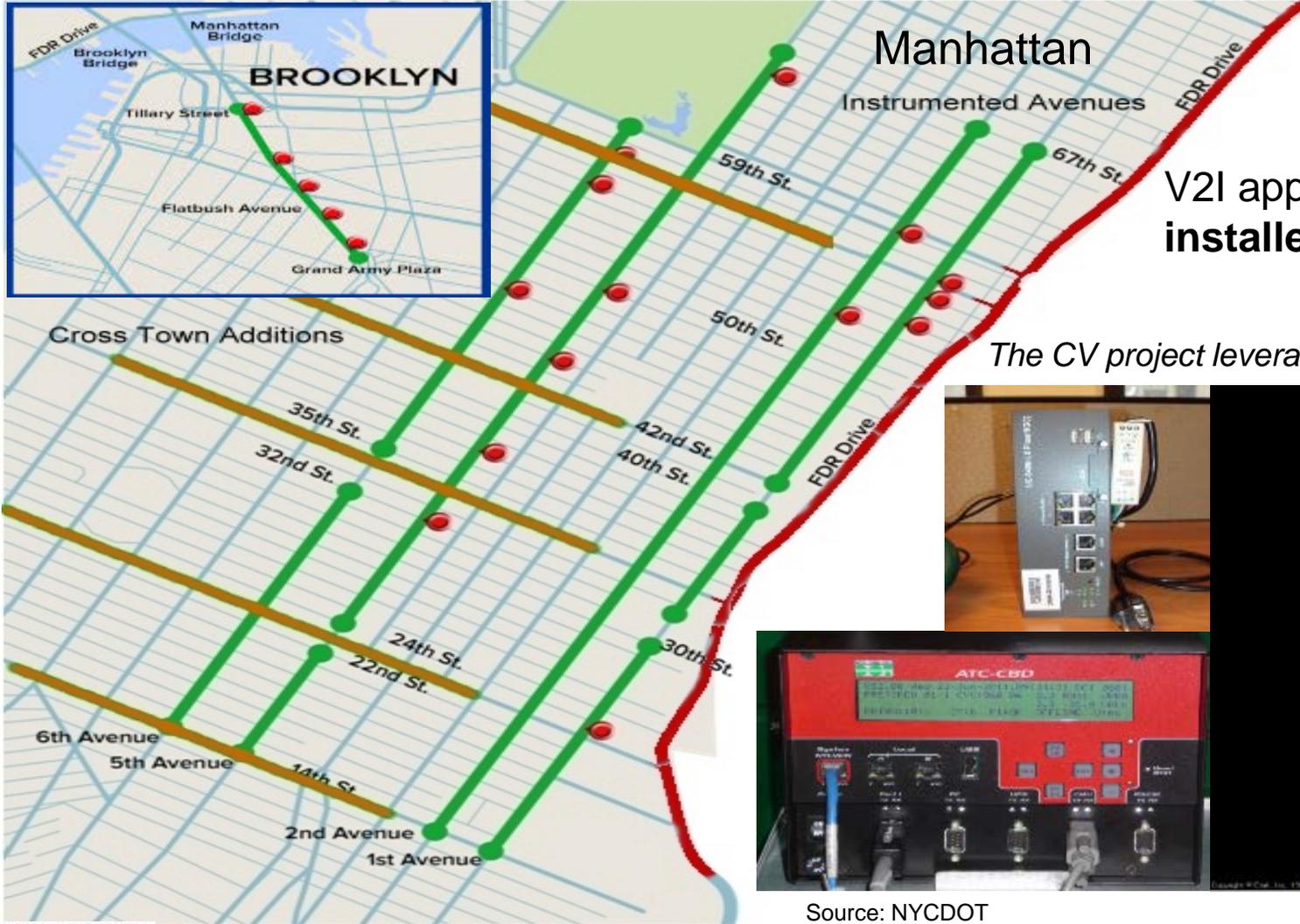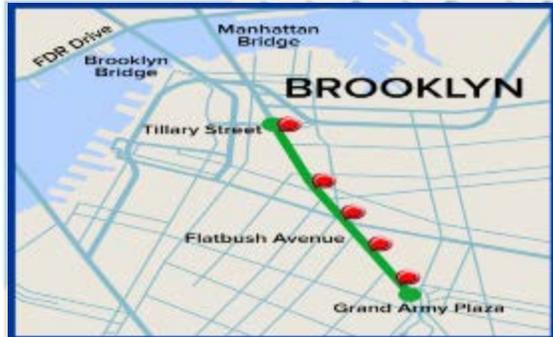
V2V applications work **wherever** equipped vehicles encounter one another.

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

*The CV project leverages the City's transportation investments*

Source: NYCDOT

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

  - Multi Channel DSRC support
  - Security Management Features

GPS
DSRC **(2 channel)**

Vehicle CAN of J Bus

After Market Safety Device (ASD)

Power

Left

Speakers

Right

MIC

Alerts, warnings & driver information

Verifies Proper Operation

Source: NYCDOT

NEW YORK CITY DOT
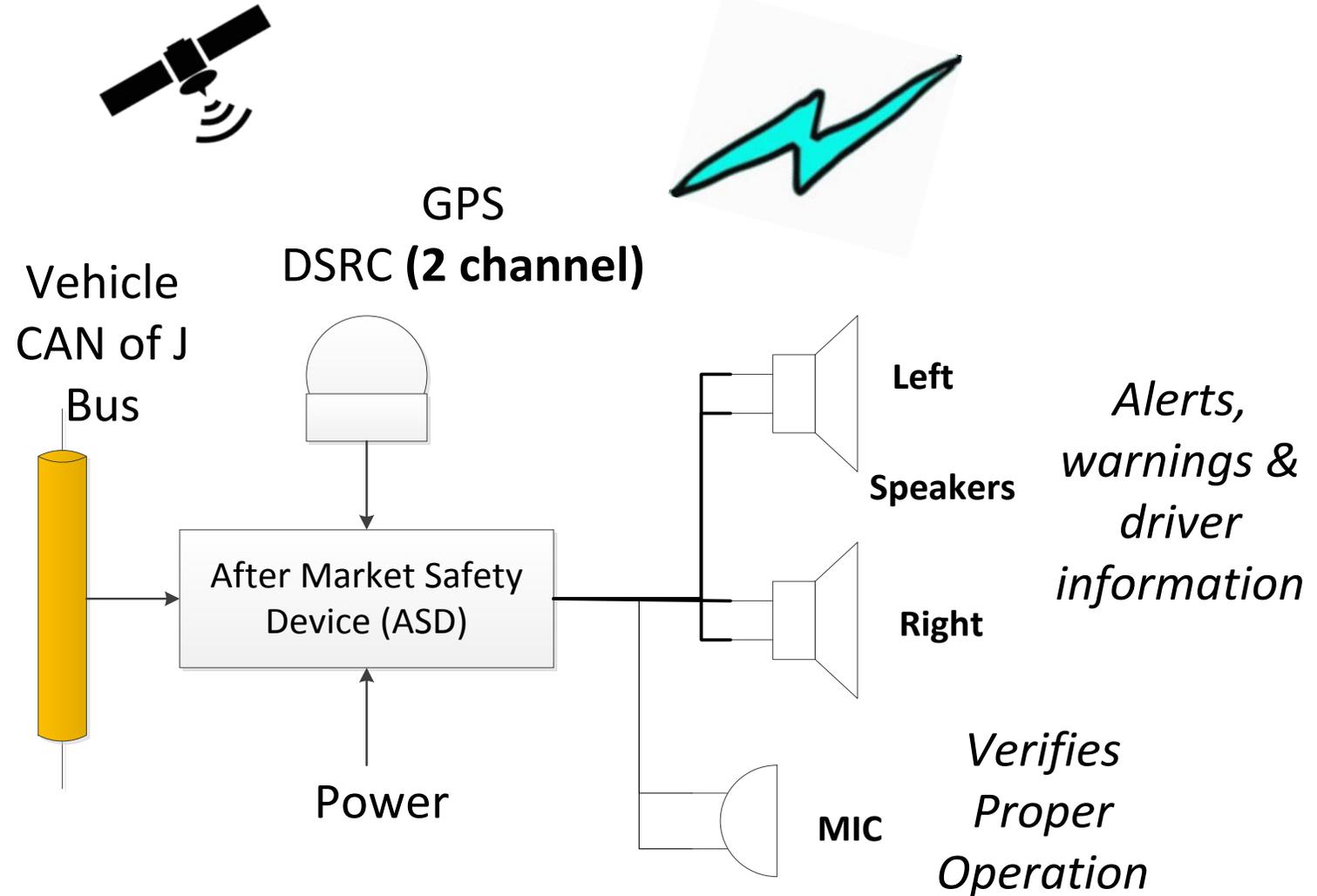
Vehicle-to-Vehicle (V2V) Safety Applications

- 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***

NEW YORK CITY DOT

U.S. Department of Transportation

Vehicle-to-Infrastructure (V2I) Safety Applications

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

Tailored for New York City
- Modified from the generic versions

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

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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*   *To Evaluate the*
- *Event History Up Load*   *EVTCOLLECT*   *benefits*

- Focus on "proven" **Safety Applications - Prior 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
- **Leverage existing** standards, infrastructure, and knowledge base
- Advance the state of the art:
  - Develop operations and maintenance applications
  - Develop data collection applications [for benefits analysis]
  - Develop benefit evaluation applications

- **Stakeholder privacy** concerns – while still collecting meaningful statistics

- Stakeholder requirements to avoid **distracting "cockpit"** displays

- **Density** of Roadside **DSRC** Transponders   *DSRC – Nominal 300M - Channel Assignments & Xmit Power*
  - ~76 M for short blocks
  - ~200 M for the long blocks (between avenues)

- **Location Accuracy** – Urban Canyons *(both relative V2V and absolute V2I)*
  - Tests, trials, and consideration of alternative sources

- **Bandwidth limitations** of our wireless backhaul – *it is IPV4 only*

- Ongoing **maintenance and support** (in-vehicle and infrastructure) of the large scale deployment (8,000+ Vehicles and >350 RSUs)

- Security for all applications & DSRC Over-the-air (OTA) certificate distribution
- OTA [DSRC] data collection – bandwidth limited
- OTA [DSRC] software updates
- OTA [DSRC] parameter management

ONLY DSRC Communications!

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Safety Needs (ConOps)

Safety applications

Developed Questions for Evaluation

Performance Measurement Metrics ~47

Reduce Vehicle to Vehicle Crashes

V2V & V2I Safety Applications for Crash Avoidance

- Does number of crashes decrease?
- Does number and severity of red light violations decrease?
- Does number of bus / right turn vehicle crashes decrease?
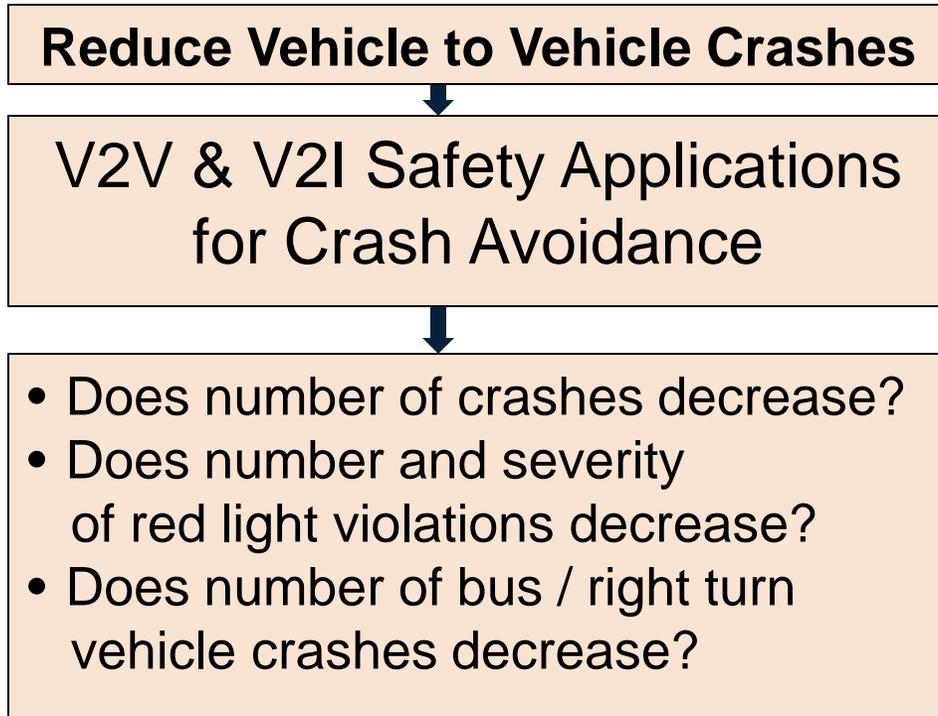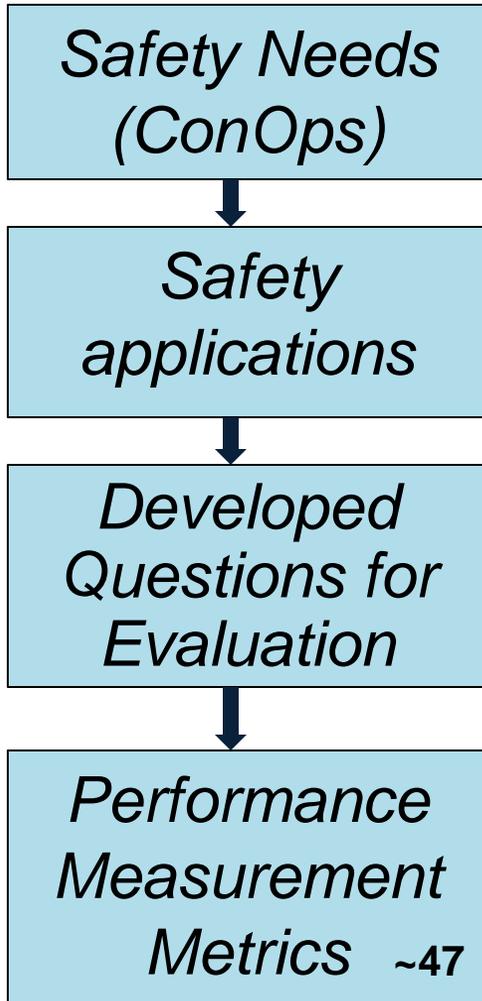
- Fatality crash counts
- Injury crash counts
- Property damage only crash counts
- Time to Collision
- Red light violation counts
- Red light violation crash counts
- Driver actions and/or impact of actions when they receive alerts
- Bus & right turn related crash counts
- Number of warnings generated
- Right-turning related conflicts

Data collection:
Everything that "occurred" immediately before and after the alert

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- **Turn-key ASD and RSU equipment procurement**

- Multiple stage delivery
  - Prototypes install/test Hardware/software/DSRC
  - Award to 2 ASD Bidders (~1/2 each) and 1 RSU Bidder
  - Production delivery after proof of prototypes

- **Concept: Verify the hardware & software platform early**
  - **Use OTA updates (firmware, parameters) to expand the applications**

- The limiting factor – Installation time for 8000 vehicles!

- Expect Bid to be out in March 2017!

**Stakeholders
Fleet Owners and Users**

Project Team

WHERE ARE WE NOW ?

- Phase 2 – 20 Month Deployment
  - Started September 1, 2016
  - Official Kick Off September 23, 2016
  - Twenty (20) Months *(14 left!)*
    - *Developing architecture, data management pan, detailed designs, procurement documents, etc.*
  - Phase 3 Evaluation
    - Starts April 2018

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

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Connected Vehicle Pilot in Wyoming – Managing a Busy Freight Corridor under all Weather Conditions

Wyoming DOT

**Ali Ragan, Wyoming Department of Transportation**
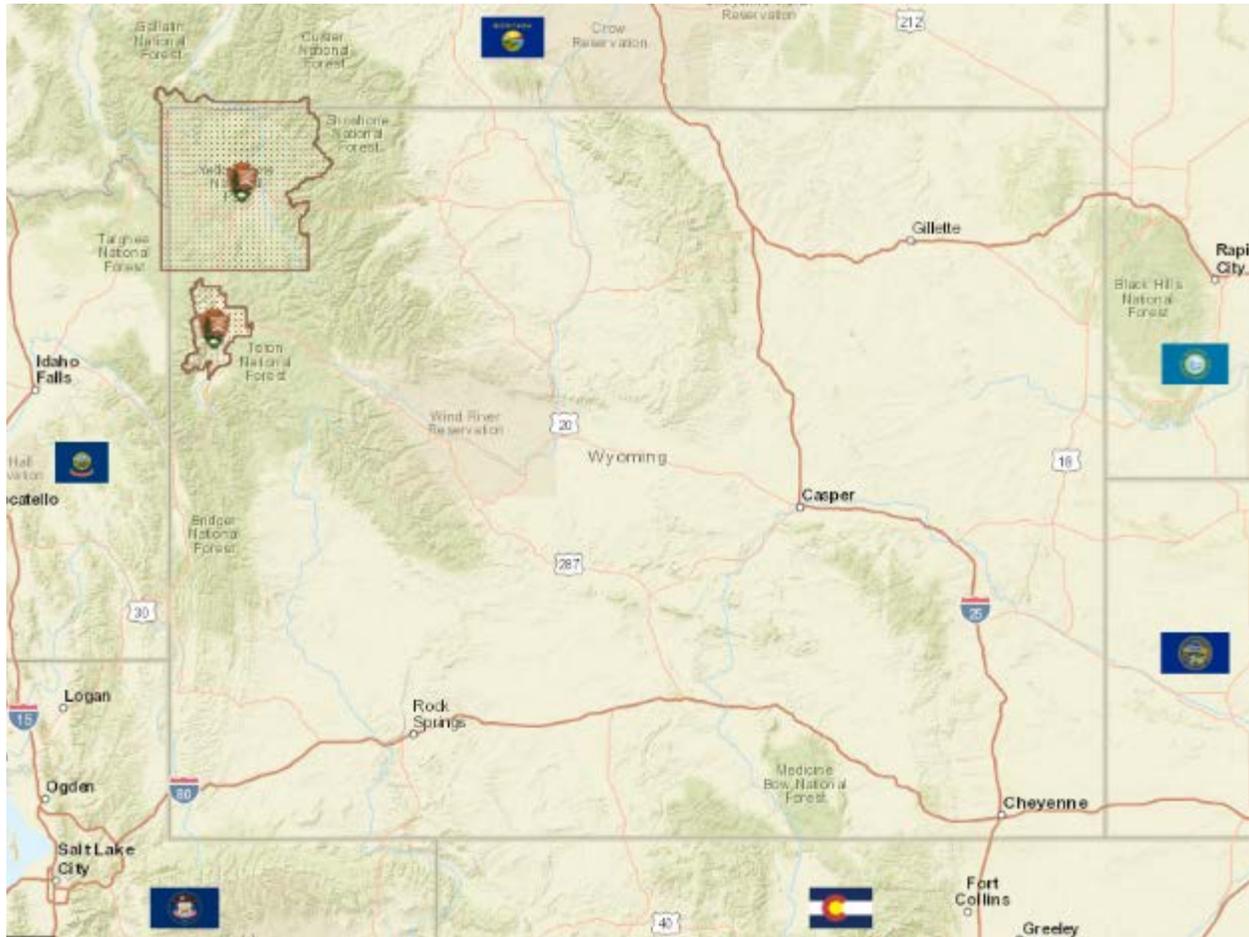
Environmental Overview

- Project area: 402 miles from the border with Utah to the border with Nebraska
- Entire elevation higher than 6,000 feet; highest point 8,640 feet
  - Donner Pass, Calif.: 7,057 feet
  - Parley Summit, Utah: 7,120 feet

U.S. Department of Transportation

Wyoming's I-80 Corridor

Heavy Freight Traffic

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

Severe Weather Conditions

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)

WYDOT | CONNECTED VEHICLE PILOT
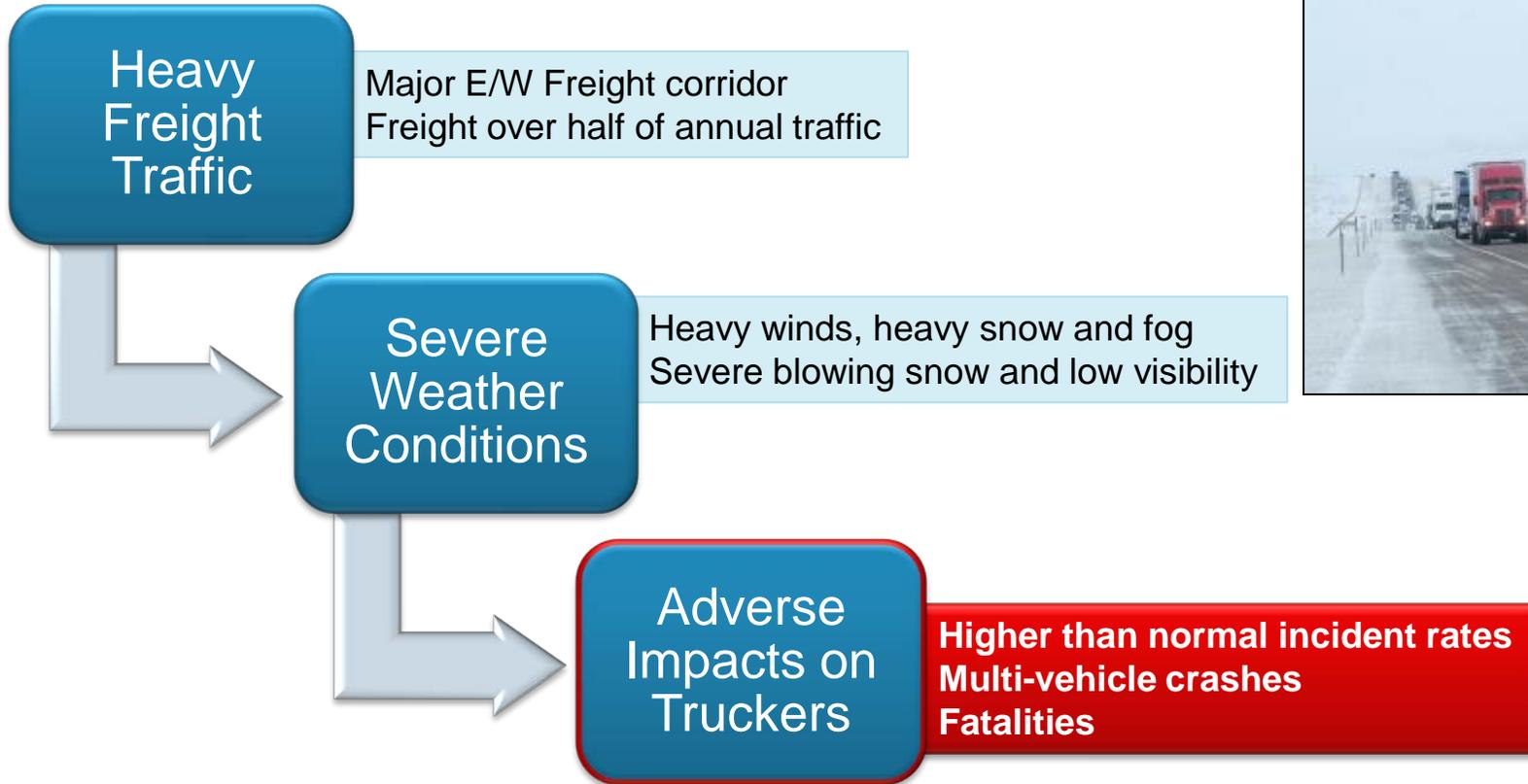
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Wyoming's I-80 Corridor

What's Been Done?

Variable Speed Limits

Closures to Light, High Profile-Vehicles when wind gusts top 60 mph

More efficient road condition updating

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33

Interstate 80 Incidents
10/01/15 - 09/30/16

Fatal (9)

Westbound: 6 (Weather Present: 1)   Eastbound: 3 (Weather Present: 0)

Injury (115)

Westbound: 66 (Weather Present: 16)   Eastbound: 49 (Weather Present: 21)

Property Damage Only (576)

Westbound: 297 (Weather Present: 140)   Eastbound: 279 (Weather Present: 125)

Westbound total: 369   Eastbound total: 331
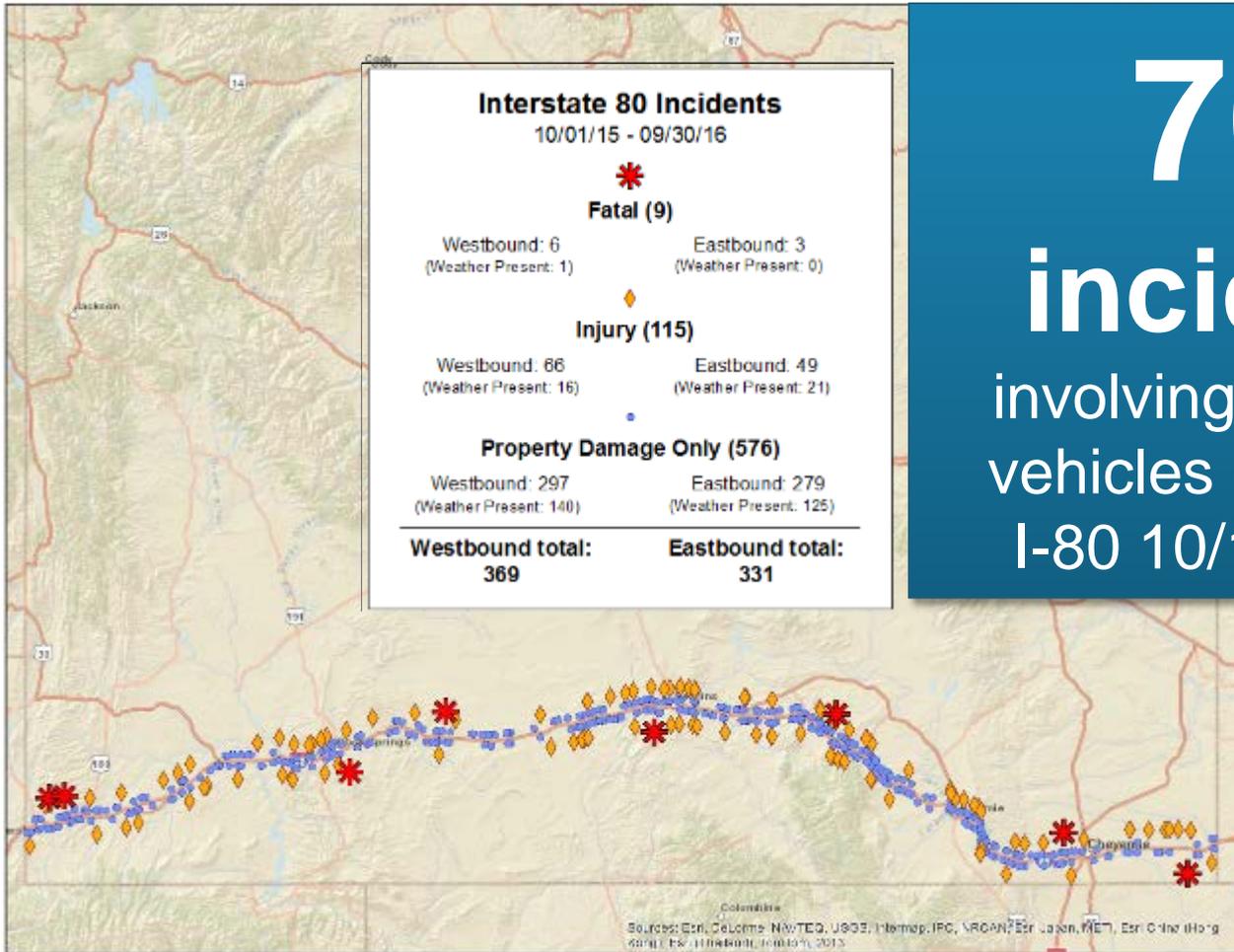
700 incidents

involving commercial vehicles occurred on I-80 10/15 to 09/16

1,600+ crashes
1,923 vehicles
$865.3M
Societal Impact

WYDOT | CONNECTED VEHICLE PILOT

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I-80 Users Need Actionable Road Weather Information

The need for actionable information is growing

March 2017

800

65,869

Estimated Firms Subscribed to WYDOT's CVOP

Downloads of WYDOT 511 App*

150

0

Sept 2015
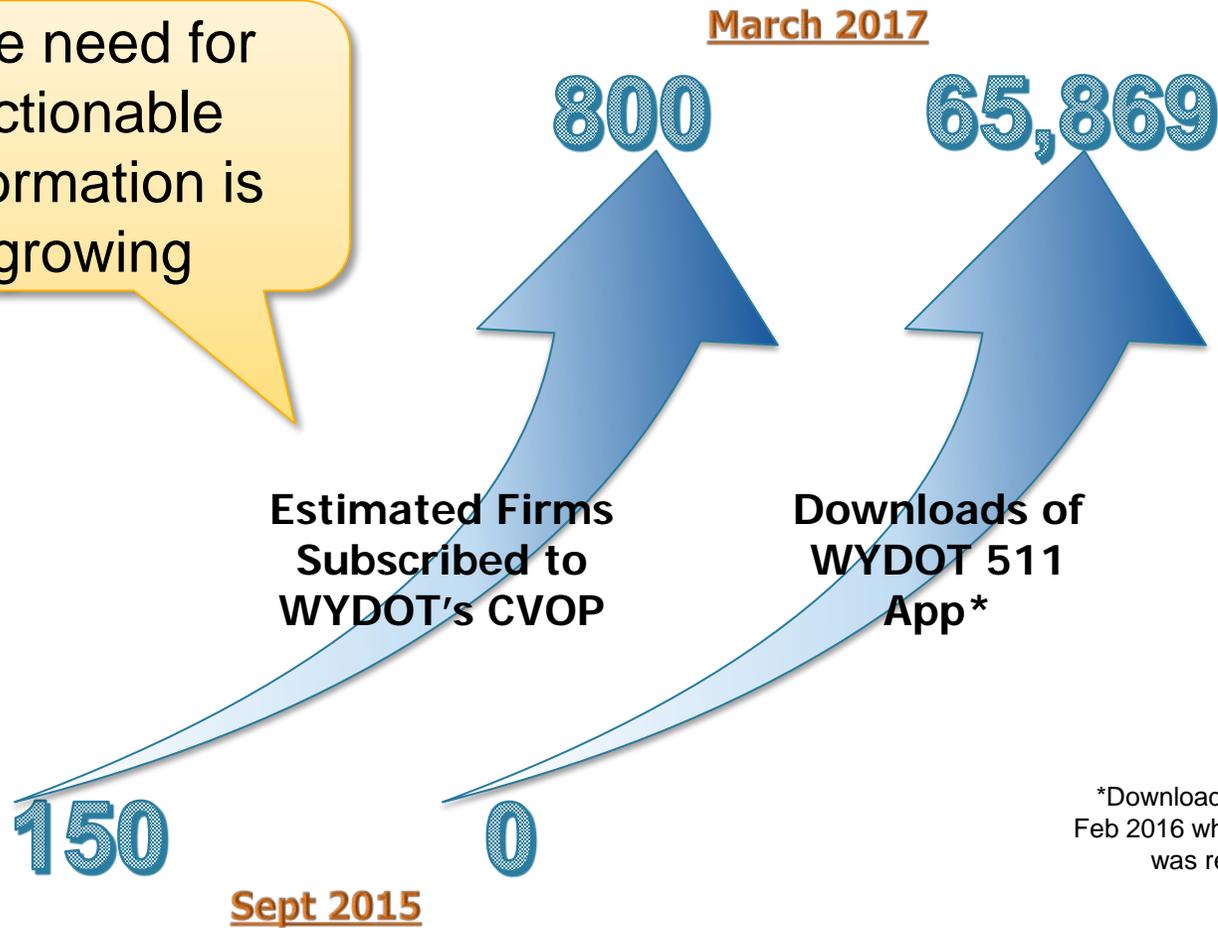
*Downloads since Feb 2016 when app was released

WYDOT's Commercial Vehicle Operator Portal (CVOP

CVOP Users by Location

302 out of 1330 users did not provide location information.

Five states not represented:
Connecticut
Hawaii
Maryland
Rhode Island
Vermont

User Count
1 - 6
7 - 13
14 - 23
21 - 45
46 - 188

WYDOT | CONNECTED VEHICLE PILOT

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35
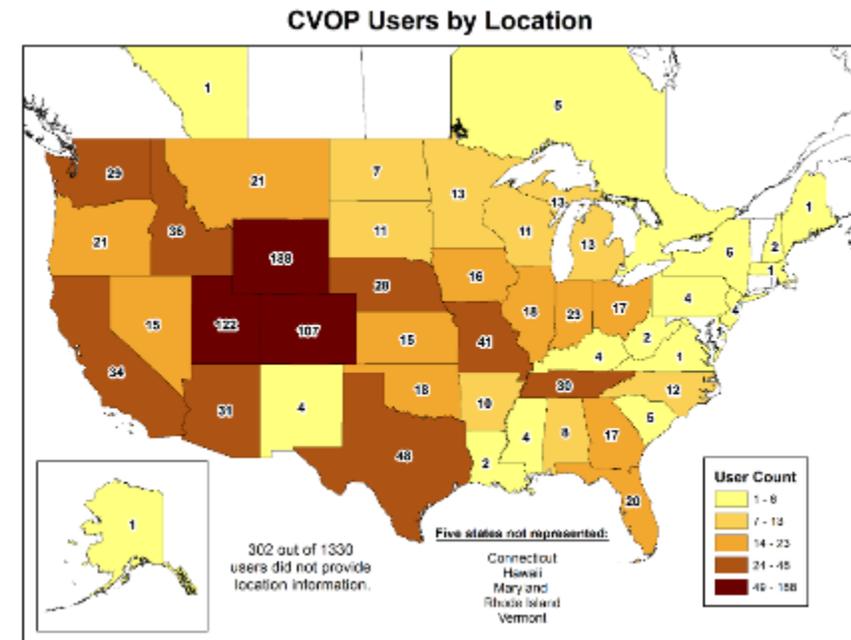
Pilot Objectives

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

WYDOT | CONNECTED VEHICLE PILOT

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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

WYDOT's CV Pilot System

Vehicle System

Wyoming CV System

Roadside Infrastructure

Back office system

External Interfaces
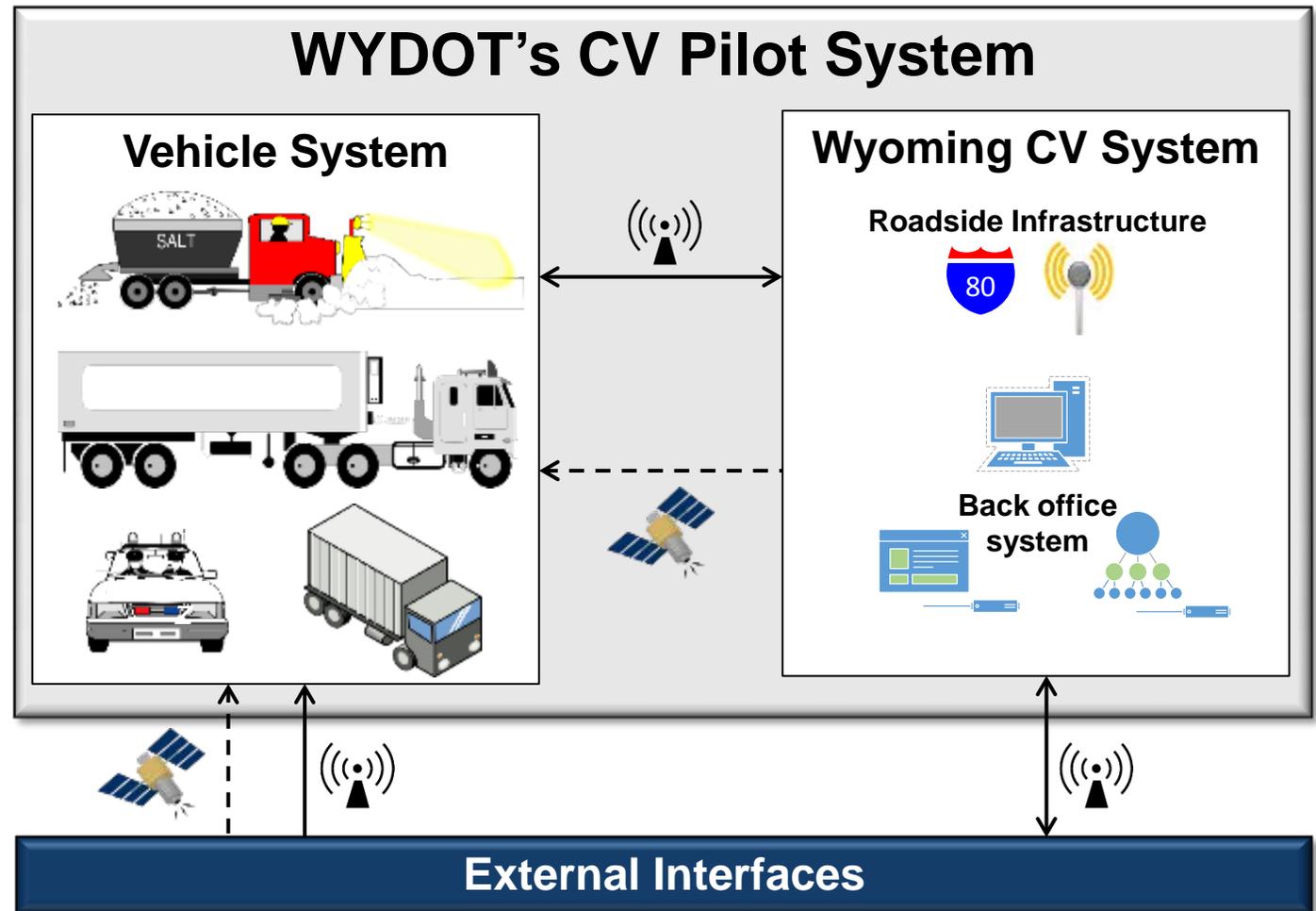
WYDOT | CONNECTED VEHICLE PILOT

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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)

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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)

WYDOT | CONNECTED VEHICLE PILOT

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CV Pilot Partnership
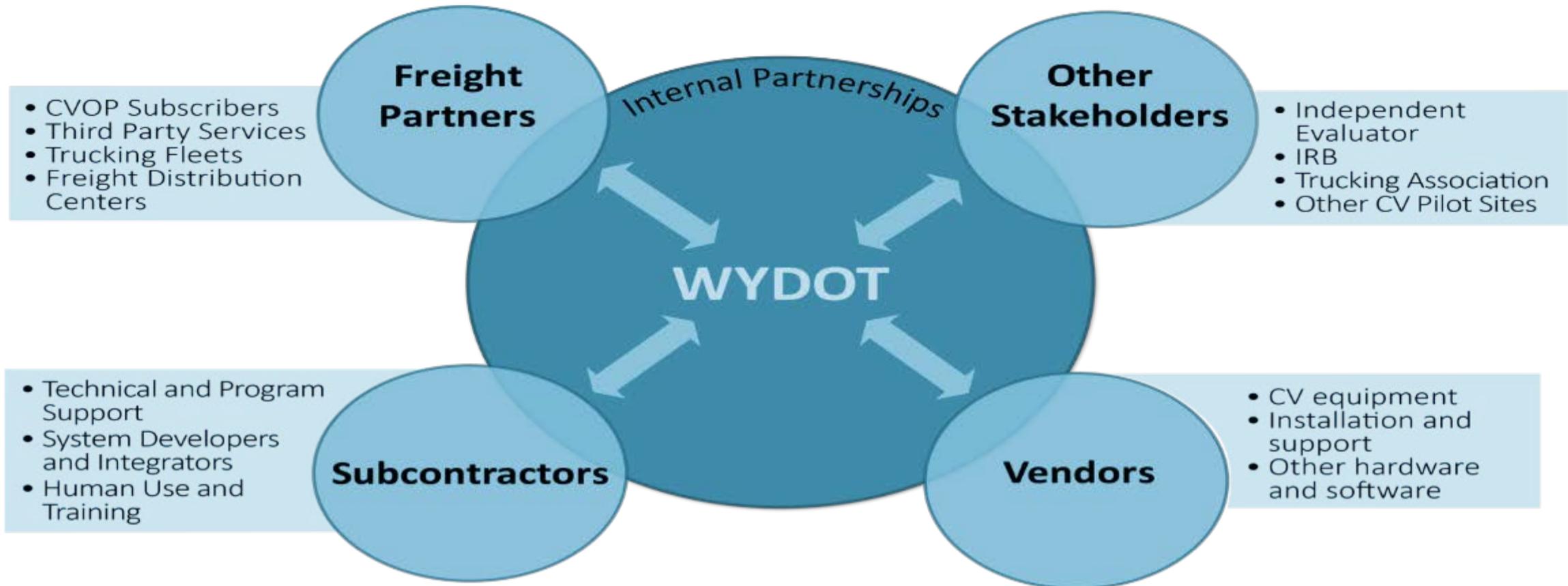
Next Steps and Activities

- Third-party data feed Spring 2017

- Install roadside equipment and in-vehicle systems on WYDOT fleets Spring/Summer 2017

- System operation and testing Winter 2017/2018

- Install equipment on private vehicles Springs/Summer 2018

- System operation Winter 2018/2019

WYDOT | CONNECTED VEHICLE PILOT

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Connected Vehicle Pilot in Tampa, Florida – Managing Safety and Mobility Impacts in Integrated Expressway/ Surface Street Networks

Tampa (THEA)
Tampa Hillsborough
Expressway Authority

Bob Frey, Tampa Hillsborough Expressway Authority

CV Applications to be Deployed

Application	Description	Use Case
Curve Speed Warning	Alerts driver approaching curve with speed safety warning	1
Emergency Electronic Brake Light (EEBL)	Enables broadcast to surrounding vehicles of severe braking	1
Forward Collision Warning (FCW)	Warns driver of impending collision ahead in same lane	1,3
Intersection Movement Assist (IMA)	Indicates unsafe (i.e., wrong way) entry into an intersection	2
Pedestrian in a Signalized Crosswalk (PED-X)	Alerts vehicle to the presence of pedestrian in a crosswalk	2,4,6
Pedestrian Mobility (PED-SIG)	Gives pedestrians priority with signal phase and timing (PED-SIG)	2,4,6
Intelligent Traffic Signal System (I-SIG)	Adjusts signal timing for optimal flow along with PED-SIG and TSP	1,2,6
Vehicle Data for Traffic Operations (VDTO)	Uses vehicles as probes to detect potential incidents, (also called Probe-enabled Data Monitoring or PeDM)	6
Transit Signal Priority (TSP)	Allows transit vehicle to request and receive priority at a traffic signal	4
Vehicle Turning Right in Front of a Transit Vehicle (VTRFTV)	Alerts transit vehicle driver that a car is attempting to turn right in front of the transit vehicle	5
Red Light Violation Warning (RLVW)	Warns driver of potential of red light violation	2

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EQUIPMENT: BY THE NUMBERS

PHOTO: THEA
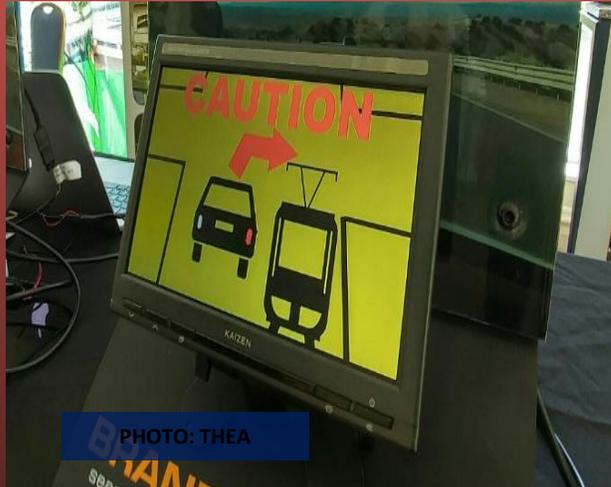
1,620

On-Board Units (OBUs)

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

PHOTO: NPR

500+

Pedestrian smartphones (Android devices only)

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)

CONNECTED VEHICLE PILOT TAMPA

Wrong-way Entry

Intelligent Signal System (I-SIG)

Intersection Movement Assist (IMA)

DO NOT ENTER

CLOSED
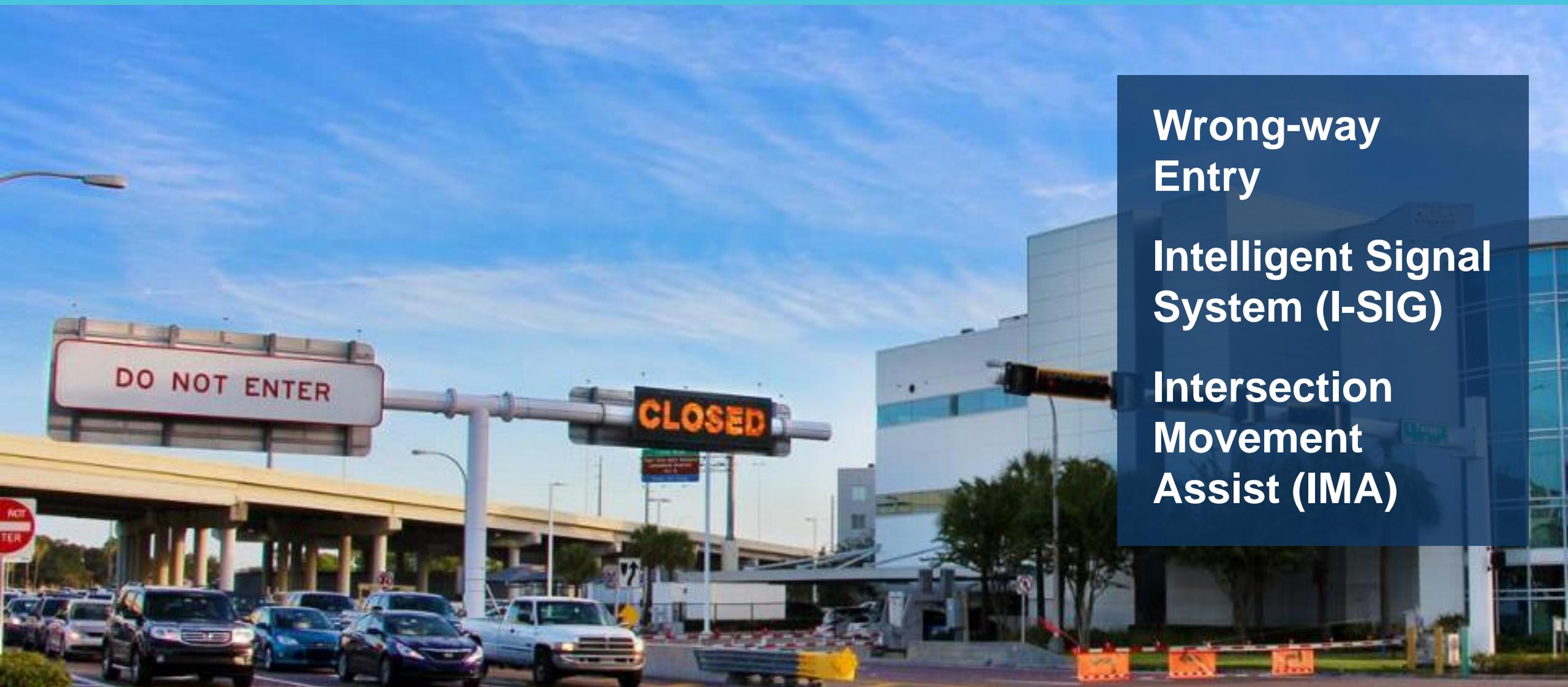
PEDESTRIAN SAFETY

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

STREETCAR CONFLICTS

Vehicle Turning Right in Front of Transit Vehicle (VTRFTV)

I-SIG

PED-SIG

PED-X

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

Probe Data Enabled Traffic Monitoring (PDETM)

I-SIG

IMA

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

City of Tampa Traffic Management Center provides info

Safety message sent

Traffic info

Siemens

THEA

Traffic info

Vehicle/ pedestrian info sent to RSU

THEA

Volpe Institute

THEA

THEA

THEA

Safety message displayed to commuter
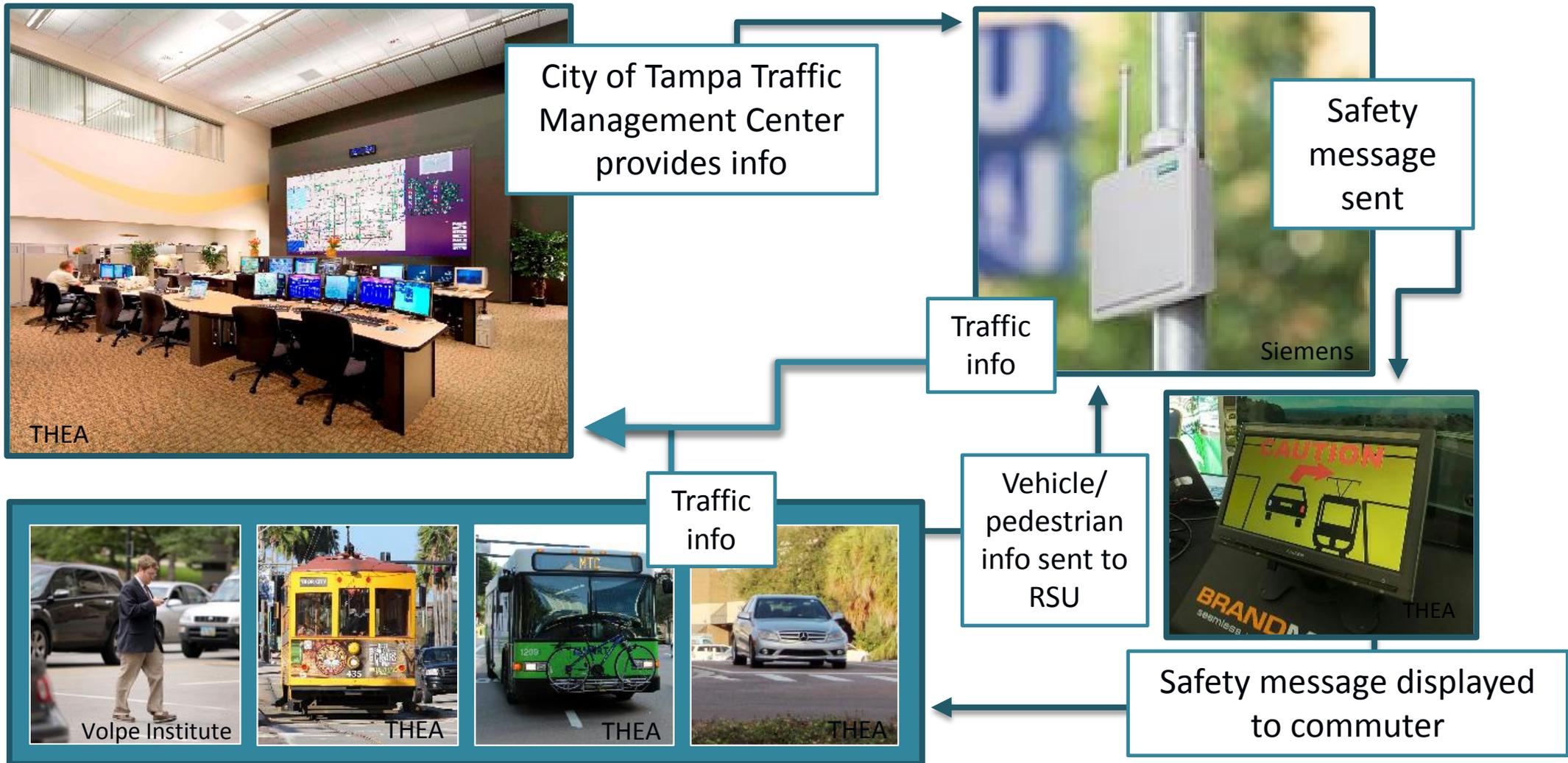
Source: Siemens

Mirror display uses sticker to depict location and concept of warning.
Actual image is still in development

Source: Brand Motion

- SAFETY: Connected vehicle technology could affect **more than 80% of vehicular crash scenarios** involving unimpaired drivers

- Improved mobility

- Reduce environmental impact

- Assist with toll interoperability

- Economic Impacts

  - Reduction in insurance rates

  - Realize fuel & maintenance savings – Inflation Fighter

  - Recoup productivity currently lost to long or erratic commutes
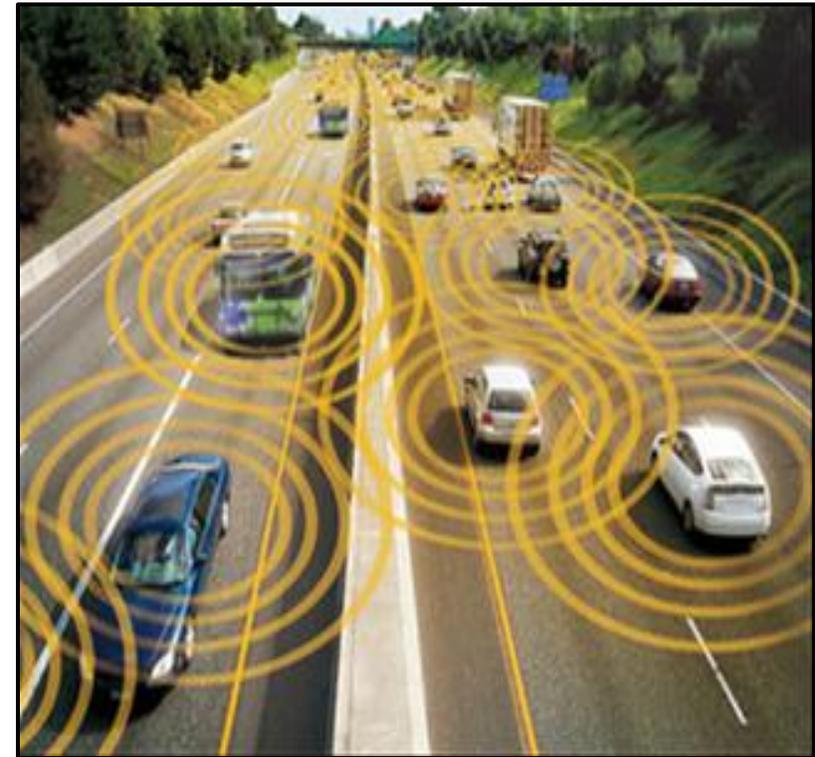
- Selmon East Capacity Improvements (Sample Project)
  - Additional lane in each direction for 16 miles   - $200 million
  - Selmon East Lane Harmonization
    - Bridge Improvements (3 Bridges)   - $75 million
    - Speed Harmonization   - $50 million

- Potential Savings - $75 million or 6-7 years delay of capacity improvements

- If nothing else,
  it is worth investigating…

U.S. Department of Transportation

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