

CONNECTED VEHICLE PILOT Deployment Program



HOW TO BRING CONNECTED VEHICLES TO YOUR TOWN



Program Manager: Kate Hartman

WHAT TO EXPECT IN THIS SESSION



- Summarize progress-to-date in the Connected Vehicle Pilot Deployment Program
- Discuss anticipated benefits of each pilot site
- Share challenges and lessons learned by the deployers' first-hand experience
- Preview critical milestones and next steps in preparation for an operational phase starting in May 2018



NYCDOT



Tampa (THEA)



WYDOT



USDOT



SESSION AGENDA



- Introduction and CV Pilots Overview

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

- New York City DOT Pilot Deployment

Robert Rausch, Vice President, TransCore

- Wyoming DOT Pilot Deployment

Ali Ragan, Project Manager, Wyoming Department Of Transportation

- Tampa (THEA) Pilot Deployment

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

- Q&A



CV PILOT DEPLOYMENT PROGRAM GOALS



THE THREE PILOT SITES



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



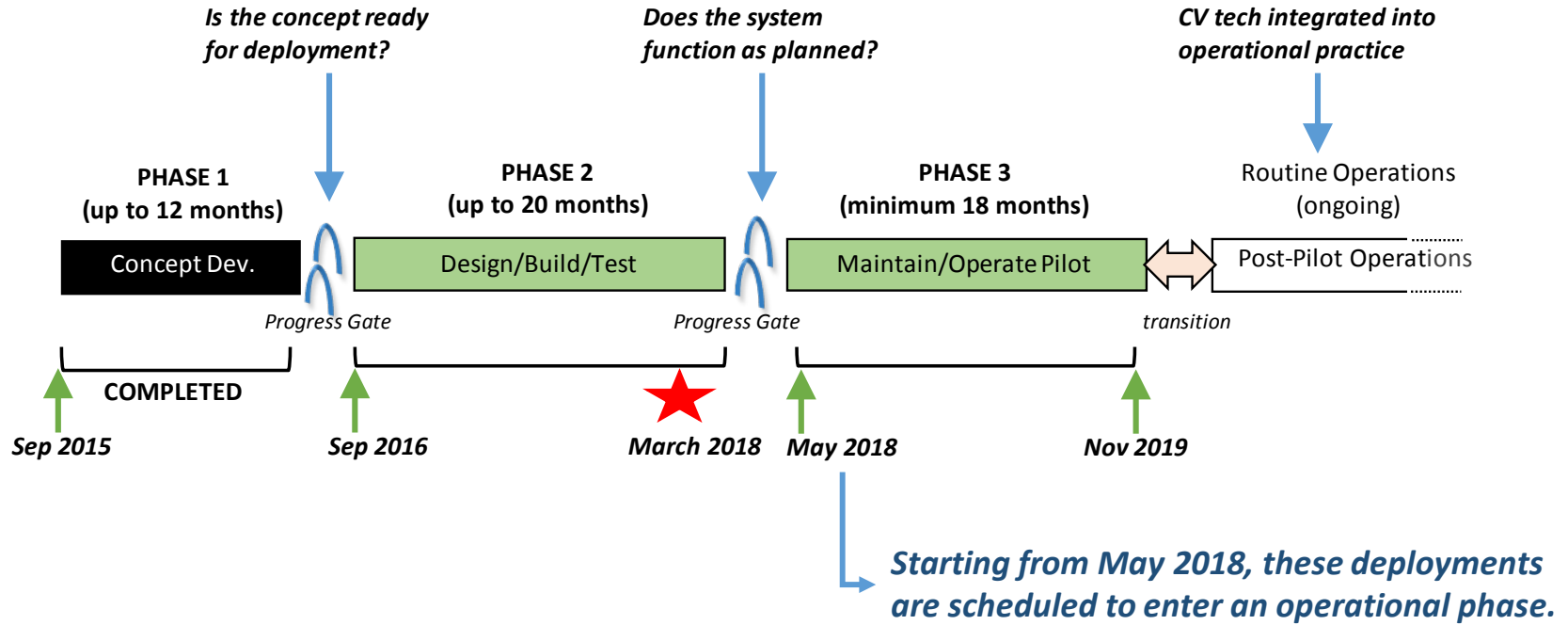
- Improve safety and mobility of travelers in New York City through connected vehicle technologies.
- Vehicle to vehicle (V2V) technology installed in up to 8,000 vehicles in Midtown Manhattan, and vehicle to infrastructure (V2I) technology installed along high-accident rate arterials in Manhattan and Central Brooklyn.



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



CV PILOT DEPLOYMENT SCHEDULE





Robert Rausch

NYCDOT Pilot Deployment



ANOTHER “TOOL” TO IMPROVE SAFETY



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

CV is being added to other changes: 25 MPH, Bicycle, SBS, PED Plazas

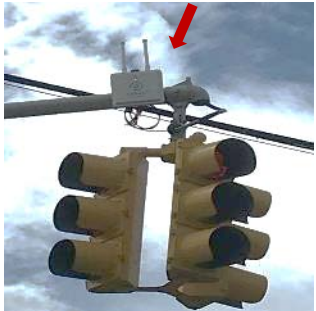
NYC Pilot will evaluate Safety benefits of CV technology

- *Reduce crashes*
- *Reduce pedestrian Injuries*
- *Use CV Technology to assist the visually impaired*
- *Address CV deployment challenges*
 - *Dense urban environment*
 - *Large number of vehicles & different vehicle types*

} Expect mobility
Improvements



THE CONNECTED VEHICLE TECHNOLOGY (CV)



Roadside Unit



Traffic Controller

MAP Message

Intersection Geometrics

- Stop Bar
- Lanes
- Permitted Movements

SPaT Message

Signal Phase & Timing

- Start time for:
Green, Yellow, Red
Walk, Don't Walk

TIM Message

Traveler Information

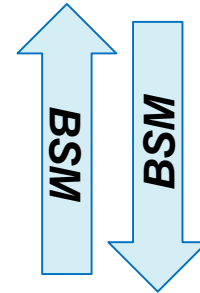
- Speed Limits & Zones
- Work Zones & Detours
- Curve and Roadway Conditions

BSM Message

Vehicle Information

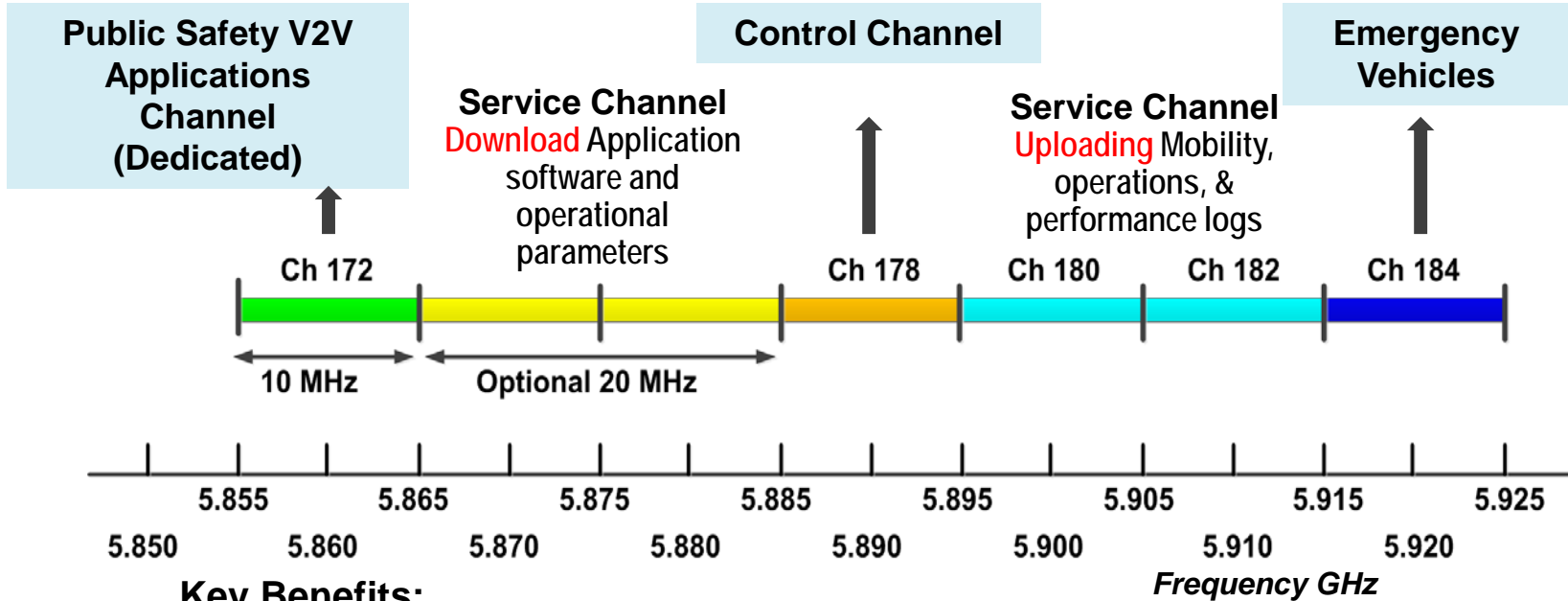
- Location
- Heading
- Speed
- Path History

*Supports:
V2I Safety
Applications*



**Supports:
V2V Safety
Applications**





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



CV → Security and Privacy – By Design



- Supported by a **Security Credential Management System – SCMS**
 - ^a Authentication of messages (signed by a ***certified*** originator)
 - ^a Encryption of Messages (where needed)
 - ^a Rotating security certificates ~ 60 per week
 - ^a Changing identifiers - 5 min 2 KM
 - MAC Address, Temporary ID's, message counters
 - ^a Misbehavior Detection – “detection of bad actors”
 - ^a Certificate Revocation List Distribution
 - List Bad Actors and compromised devices
 - ^a Special Service Permissions for privileged Vehicles
 - Emergency Vehicles, Transit Vehicles, Freight

} Protects against tracking



CONNECTED VEHICLE HISTORY



- More than 10 years
 - Proof of Concept - ended 2008
 - Safety Pilot (Ann Arbor MI)
 - 2700 vehicles – “BSM broadcast”
no applications
 - ~70 vehicles OEM integrated,
 - ~300 vehicles After Market Devices
 - ~25 Roadside devices
 - Many other small trials, tests, demonstrations
 - 1-25 intersections
 - 10-25 vehicles

Our Stakeholders



SAFETY APPLICATIONS – PROVIDE DRIVER ALERTS



Vehicle-to-Vehicle (V2V) Safety Applications

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

Other Applications

- Intersection Navigation - Visually Impaired
- Pedestrian in Crosswalk Warning
- Travel time data for Traffic Signal Control

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 information)



NY Goes “All-In”



- Up to 8,000 **fleet vehicles** with **Aftermarket Safety Devices (ASDs)**:
 - ~5,900 Taxis (Yellow Cabs)
 - ~ 700 MTA Buses
 - ~ 1000 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 Applications

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

~350 Roadside Units (**RSU**)

- ~310 Intersections
- ~ 40 Support locations
(airports, river crossings,
terminal facilities)



LOCATIONS (MANHATTAN, FLATBUSH AVE. - BROOKLYN)



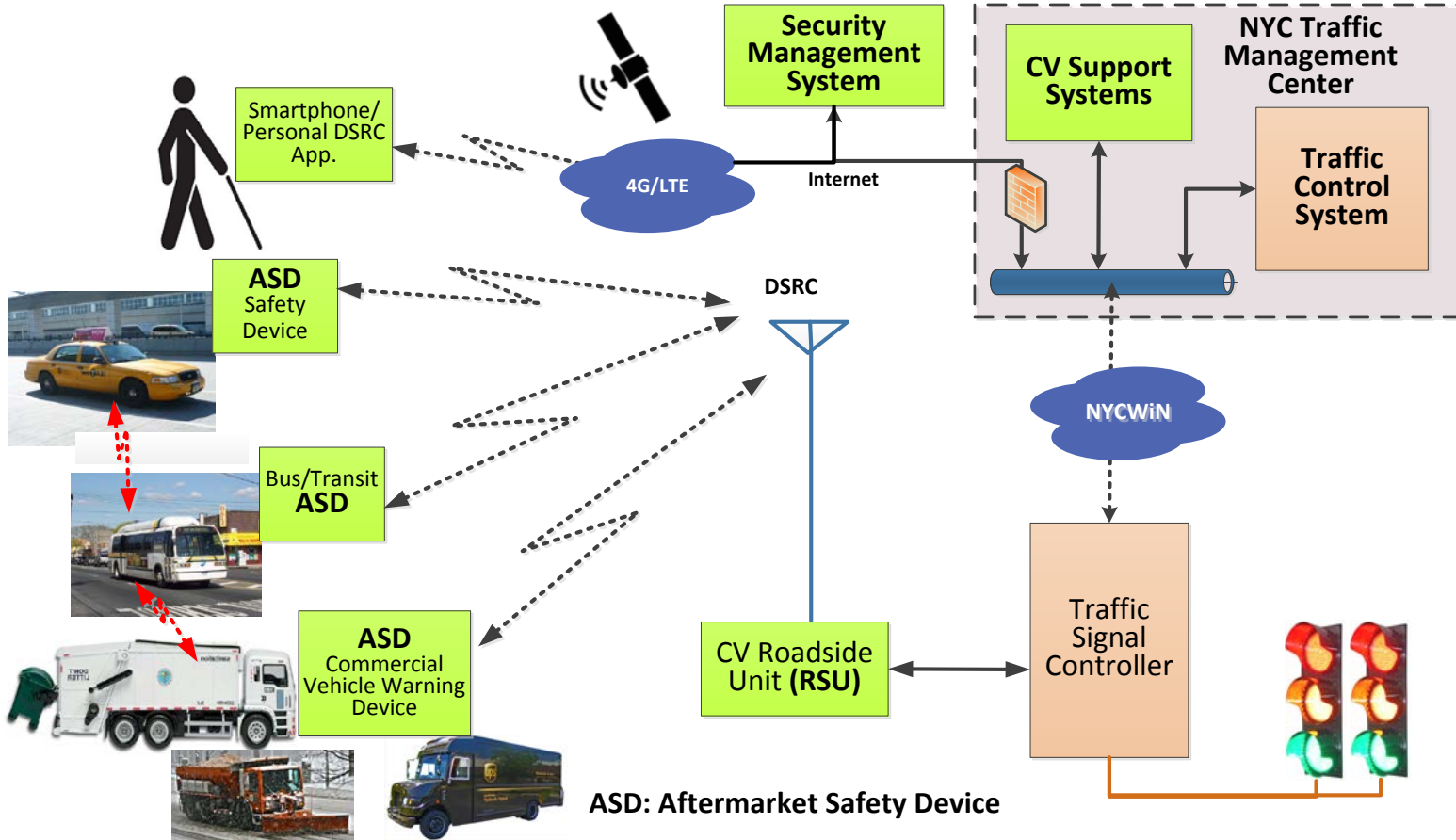
V2I applications work where **infrastructure is installed** (along highlighted streets).

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

The CV project leverages the City's transportation investments



OVERALL PROJECT CONCEPT



CHALLENGES WITH THE DENSE URBAN ENVIRONMENT



CHALLENGES - 1



▪ **Location Accuracy**

- Initial Testing 6th Ave – GPS was not good enough – Urban Canyons
- Solutions
 - ^a Multiple Mechanisms for maintain location accuracy
 - RSU triangulation
 - Inertial Navigation
 - Map Matching
 - Tethered to the host vehicle

▪ Stakeholder fears of **loss of privacy**

- Data collection – combined with Police Records through subpoena
- Solutions
 - ^a Limited data collection (no personal information)
 - ^a Encryption and automatic log “destruction”
 - ^a Obfuscation, normalization, aggregation



CHALLENGES - 2



- **Limitations of the backhaul network**
 - NYC is all wireless – Costs driven by usage
 - Solutions
 - ^a Edge computing – convert **data** to **Information** @ RSU
 - ^a Limited data collection – enough to prove benefits
 - ^a O&M data to manage operational state (RF Levels, uptime, errors, etc.)

- **Security** – CV requires a trusted environment
 - Solutions
 - ^a Upgraded communications security TMC<->RSU & TMC<->Controller
 - ^a Upgraded security practices @ TMC systems, login, & physical access
 - ^a Upgraded links to all external systems
 - ^a Updated security software for existing traffic controllers



CHALLENGES - 3



- Availability of **DSRC** for cellphone: PED applications
 - SPaT/MAP critical for the PED navigation for the visually impaired
 - Solutions
 - ^a Modified PED application to use cellular service (4G/LTE)
 - ^a Modified Traffic Controller: transmit SPaT *information* to PED servers
 - ^a Modified TMC systems: transmit MAP *information* to PED servers
 - ^a Adapted application to “work” with cellular network

- Need scalable approach: **tune, update, and add applications** -- **DSRC**
 - Support for incremental deployment and updates to software
 - Solution
 - ^a Developed a common approach to over-the-air (OTA) updates
 - ^a Uses simultaneous broadcast – to hundreds of ASDs
 - ^a Efficient utilization of bandwidth



CHALLENGES - 4



■ Human Interface

- CV applications provide warnings and alerts

□ Solution

^a After Market Devices –
NYC using **audio only**

^a Optimizing alerts using
tones, words, and combinations



BRINGING CV TECHNOLOGY TO YOUR CITY



■ USDOT launched 3 pilots to “find” and solve the challenges

^a **NYC:** Urban Density – affects applications (tuning), location technology, DSRC propagation, backhaul requirements & limitations, & data collection. → ***Lessons Learned!***

^a Standards being updated from *Lessons Learned*

^a Security elements are being deployed for the first time discovering issues to be resolved and - - - -

→ ***Security Is Crucial To CV Deployment***

Pilot lessons will serve as a foundation for future deployment!



BRINGING CV TECHNOLOGY TO YOUR CITY



- The USDOT is continuing to develop **tools** and **software**
 - Optimizing the applications
 - Certification programs being developed - interoperability
 - Optimizing installation procedures – easier and cheaper!
- **To be ready**
- Upgrade your controllers and backhaul
 - Examine and upgrade your networks, IT environment, and security practices
 - Program your projects – budgetary estimates are more accurate now!





Ali Ragan

Wyoming DOT Pilot Deployment



A PROBLEM WORTH SOLVING



A PROBLEM WORTH SOLVING



IN 1 YEAR PERIOD ALONE



700
COMMERCIAL
VEHICLE
ACCIDENTS



906
NON-COMMERCIAL
VEHICLE
ACCIDENTS



1,552
HOURS
ROAD
CLOSURES

1600+ CRASHES IN 1 YEAR



18
FATALITIES



271
INJURIES



1,317
PROPERTY
DAMAGE

MEETING A REAL NEED



EN-ROUTE HAZARD AWARENESS

Using Dedicated Short Range Communication (DSRC) capability between vehicles and roadside infrastructure to provide new applications to support driver awareness.



VEHICLE TO VEHICLE

- Forward collision warning
- Distress notification

VEHICLE TO INFRASTRUCTURE

- Alerts and advisories
- Road weather warnings
- Work zone warnings

STAKEHOLDER INVOLVEMENT



- The most critical component for our project success is stakeholder buy-in:

Validate our understanding of the problem

Shape the solution

Engage participation



Image source: WYDOT

CASTING A WIDE NET



STRUCTURE FOR SUCCESS



- Support from state's technology group
- Agency-wide project
 - Support for the project came from the top, but we still worked to get buy in
 - The project scope required cooperation from many different departments; we needed buy-in and that involved sharing credit



Image source: WYDOT

USDOT RESOURCES



- Explanations of how connected vehicles work
 - UMTRI meeting: Seeing another deployment
 - Fact sheets and infographics
- Systems like SCMS, ODE, Pikalert
- Project oversight
 - Kept on track

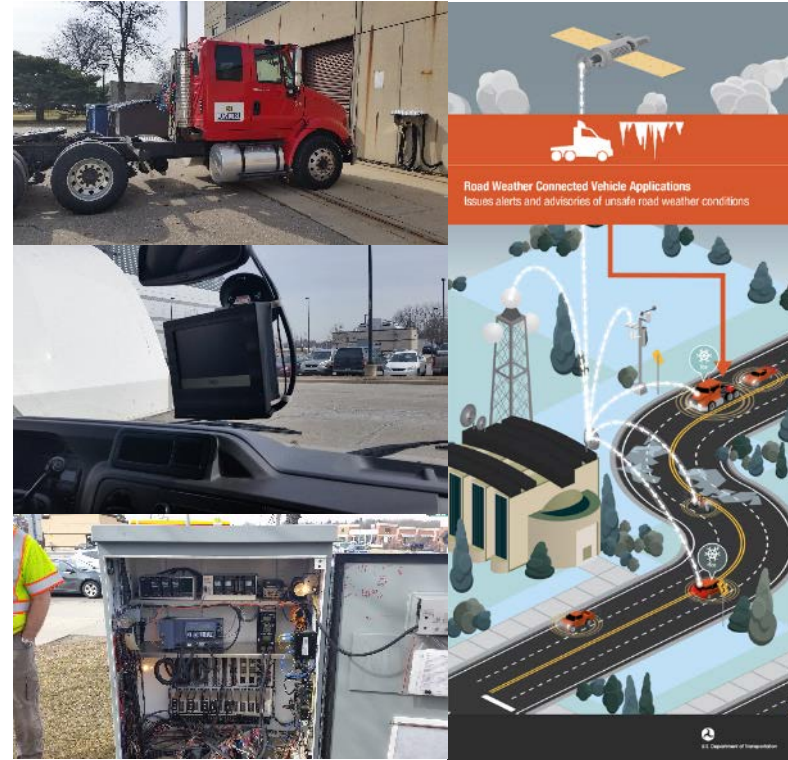


Image source: WYDOT
Infographic: USDOT



U.S. Department of Transportation

THREE CHALLENGES



Technology

Telecommunications

Security

THREE COMMUNITY NEEDS



Know your problems

Know your audience

Know your capabilities



Bob Frey

Tampa (THEA) Pilot Deployment





THEA CV PILOT

South by Southwest: HOW TO BRING CONNECTED VEHICLES TO YOUR TOWN

Walk. Ride. Drive. *Smarter.*



Why CV? Change = Opportunity

"Innovation is the process of turning ideas into a manufactural and marketable form."
— Watts Humprey



- History of Innovation
 - First Reversible Elevated Lanes
 - First full All Electronic Toll Road in Florida
 - First to use image based tolling in Florida
 - First to operate an AET Reversible Express Lane in the US
- Supportive State Legislators
- Visionary Executive Director
- Supportive Board of Directors
- Innovative Partners: CUTR, FDOT, City of Tampa, Hillsborough County

AT THEA, WE SEE NEW TECHNOLOGY AS AN OPPORTUNITY. AGENCIES TAKING PART IN ITS DEVELOPMENT WILL BE THE FIRST TO REALIZE THE SAFETY, OPERATIONAL AND FINANCIAL REWARDS.

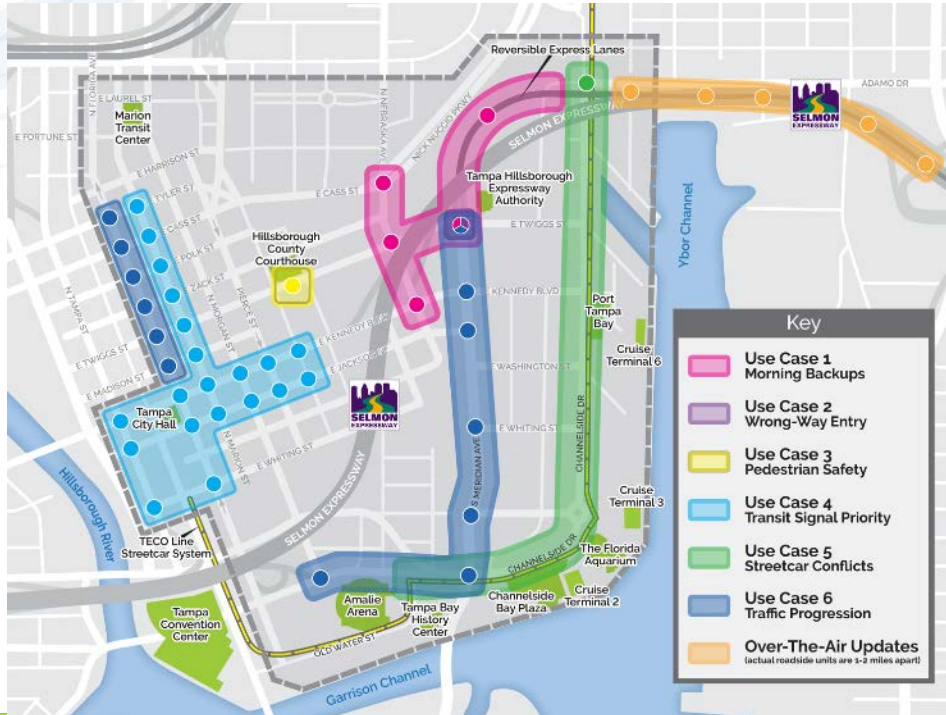
CAN A LOCAL AGENCY LEAD CHANGE? ALL AGENCIES CAN CONTRIBUTE TO GOOD TRANSPORTATION



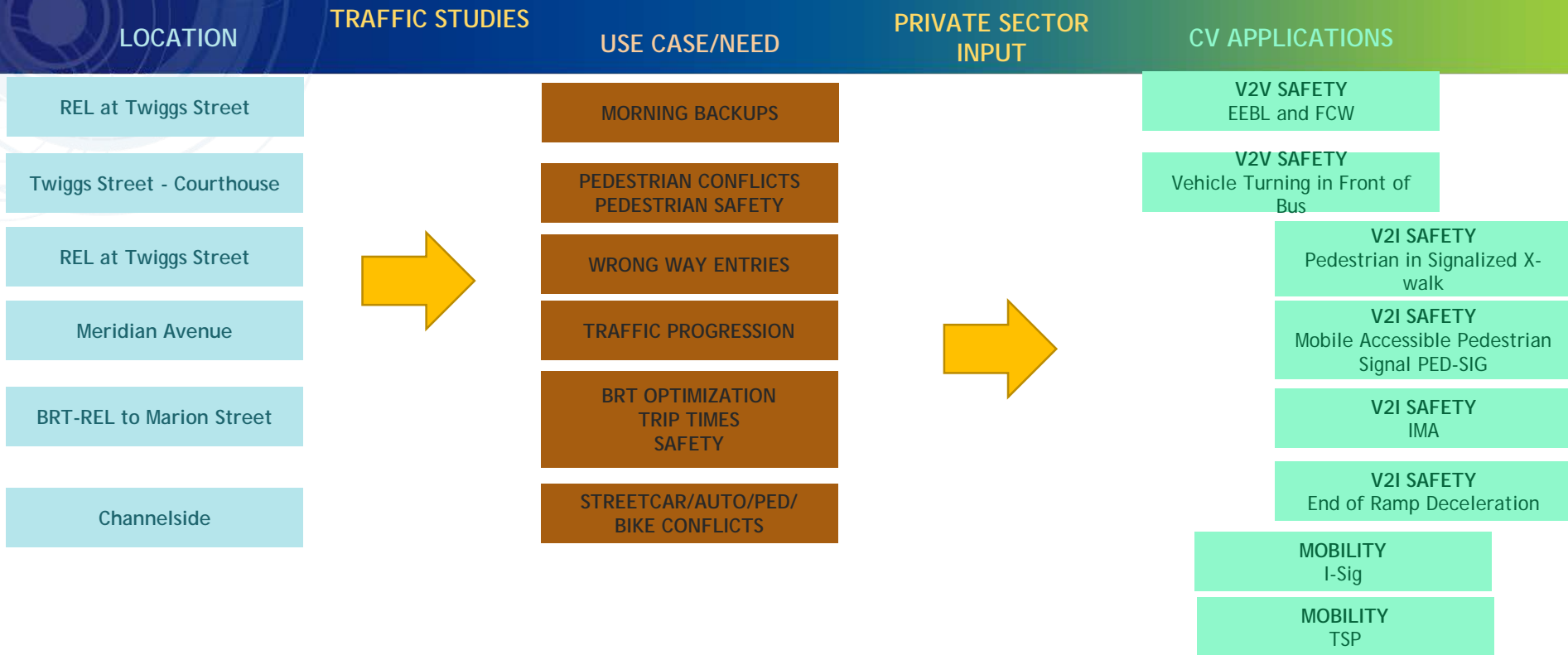
- “Contract for CUTR study “Tampa Bay: An Automated Vehicle Catalyst?” (THEA Board action 6/24/13)
- THEA worked with FDOT to co-host first AV/CV Summit in Florida & supporting State initiatives
- Joined the USDOT Affiliated Test Bed Program
- Participating in FDOT’s Statewide initiative by being on working group, bring local and tolling perspective
- Actively marketed Test Bed
 - Audi was the first to test in Florida on facility the week of July 21, 2014
- USDOT CV Pilot
 - THEA lead the Tampa CV Pilot and paid all local matches to bring this technology to Tampa.
 - Created a public/private partnership team on US DOT Pilot Deployment

THEA AND OTHER LOCAL AGENCIES CAN LEAD INITIATIVES AND DEMONSTRATIONS THAT BENEFIT CUSTOMERS, CONSISTENT WITH NATIONAL AND STATEWIDE INITIATIVES.

THEA PILOT DEPLOYMENT OVERVIEW



SOLVING REAL PROBLEMS: PILOT DEPLOYMENT ISSUES AND APPLICATIONS RELATIONSHIPS



MORNING BACKUP



Forward Collision
Warning (FCW)

Emergency
Electronic Brake
Light (EEBL)

End of Ramp
Deceleration
Warning (ERDW)

Intelligent Signal
Systems (I-SIG)



WRONG WAY DRIVERS



Wrong-way
Entry

Intersection
Movement Assist
(IMA)

MAP

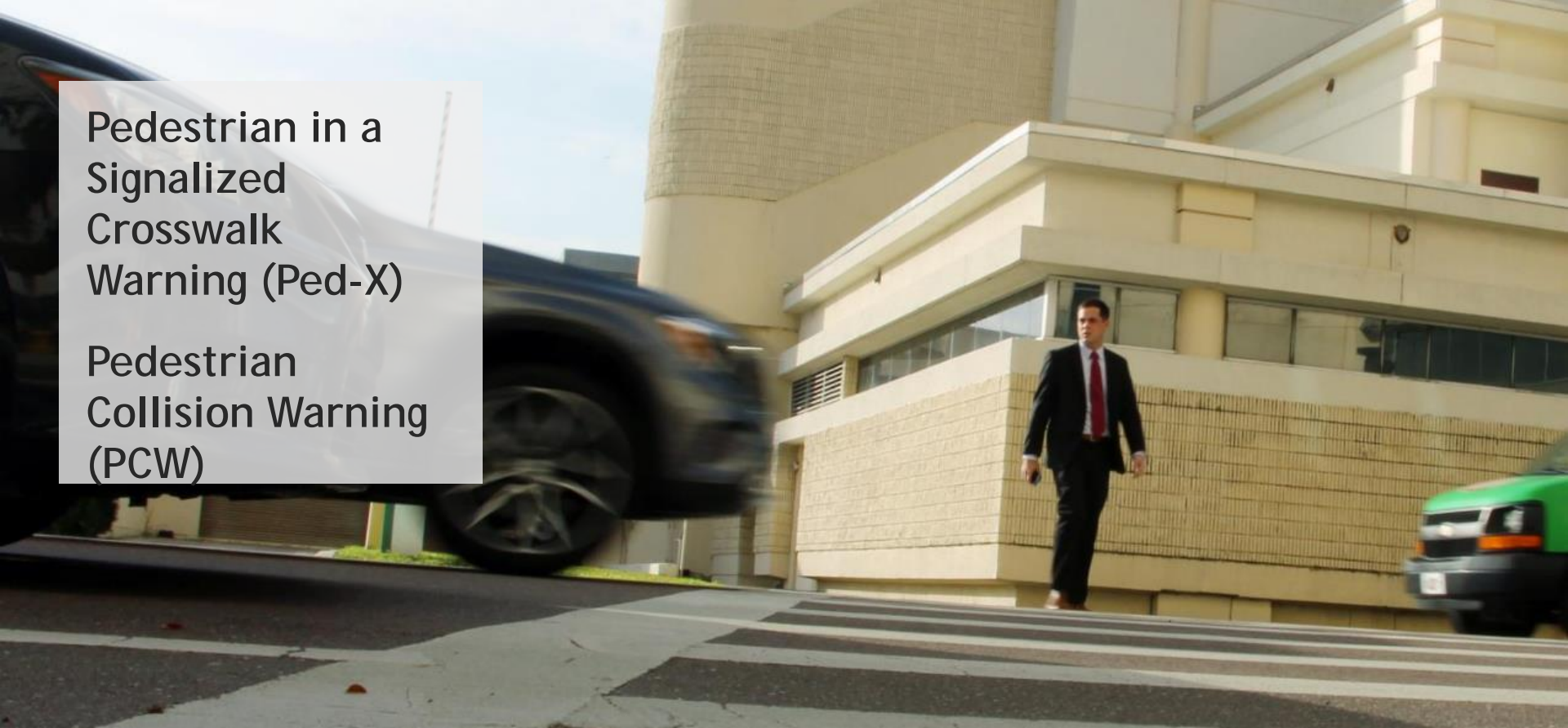
Signal Phasing
and Timing
(SPaT)

PEDESTRIAN SAFETY



Pedestrian in a
Signalized
Crosswalk
Warning (Ped-X)

Pedestrian
Collision Warning
(PCW)



TRANSIT SIGNAL PRIORITY



I-SIG

Transit Signal
Priority (TSP)

IMA

Pedestrian
Transit
Movement
Warning (PTMW)

STREETCAR CONFLICTS



Vehicle Turning
Right in Front of
Transit Vehicle
(VTRFTV)

PTMW



TRAFFIC PROGRESSION



Probe Data
Enabled Traffic
Monitoring
(PDETM)

Pedestrian Mobility
(PED-SIG)

I-SIG

IMA

PARTICIPANTS



1,600

Privately Owned
Vehicles

500+

Pedestrian
Smartphones
(Android devices only)

9

TECO Line
Streetcar

10

Hillsborough Area
Regional Transit
(HART) buses

INFRASTRUCTURE



Source: Siemens

IN VEHICLE USER INTERFACE



Safety warnings integrated into the rear-view mirror, visual (with auditory alert) examples shown below.



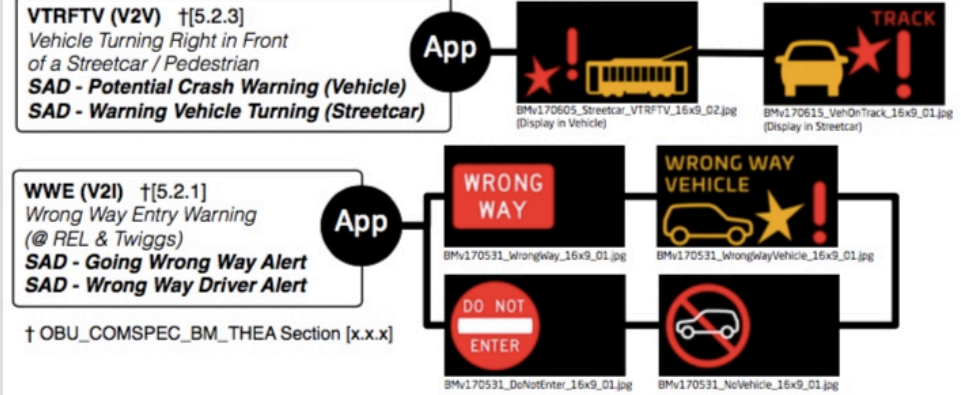
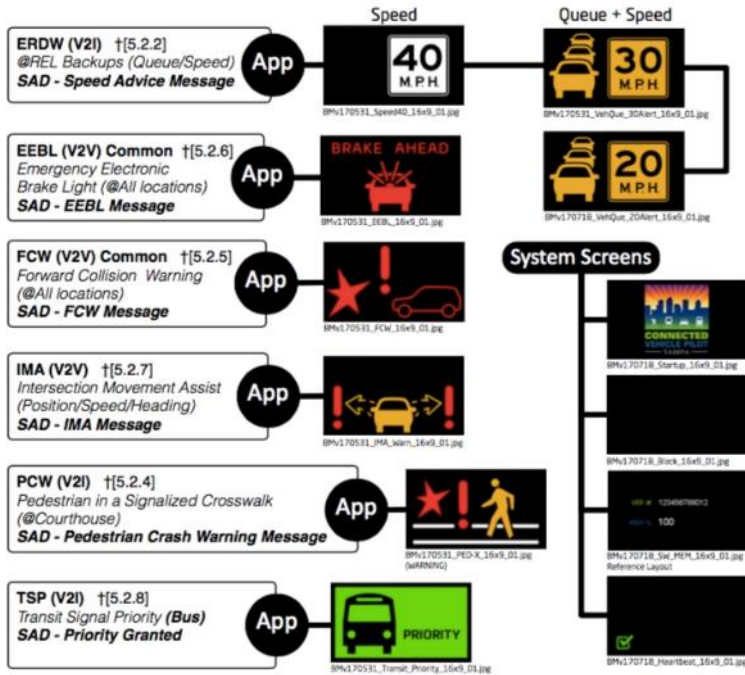
Electronic Brake Lamp Warning



Exit Ramp Deceleration Warning

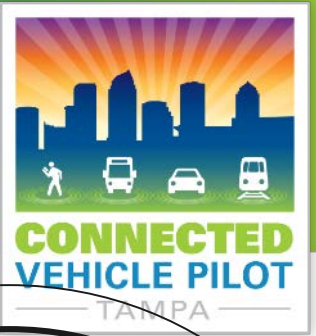
Source: Brand Motion and Global 5

IN VEHICLE SYSTEM – APP WARNING GRAPHICS



Source: Brand Motion

BENEFITS: CONNECTED VEHICLE COMMUNICATION



Vehicles have
360 degree
awareness of
surroundings

Communicate
with other
vehicles 10 times
per second

“Basic Safety
Messages”



EXAMPLE OF FRAMEWORK FOR SMART CITIES



- Mobility as a key outcome
- Four enabling technology suites
- Application layer on top of that foundation
- Framework for connecting people with opportunities
 - 4 systems
 - 4 districts
 - 4 outcomes
- CCTN ties it all together

TAMPA HILLSBOROUGH
EXPRESSWAY
AUTHORITY



U.S. Department of Transportation





Q&A



NYCDOT



Tampa (THEA)



WYDOT



USDOT



STAY CONNECTED



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- Govind Vadakpat, Tampa (THEA) Site AOR; G.Vadakpat@dot.gov

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://wydotcwp.wyroad.info/>



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