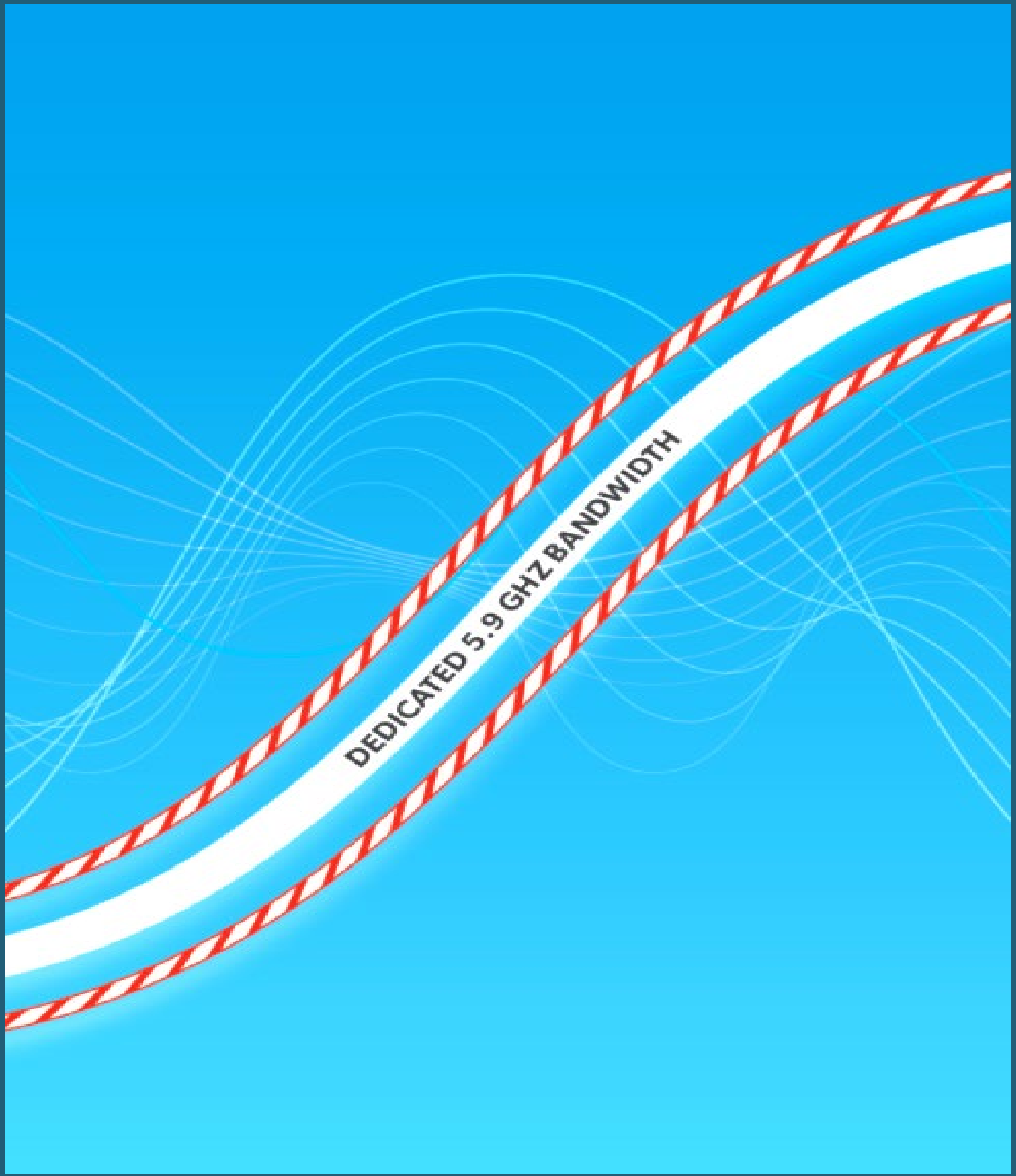
USDOT Vehicle-to-Everything (V2X) Research
- selected projects & programs-

Presented at
NHTSA Research Day
November, 2019
Washington DC

Motivation for V2X!

Agenda

- Spectrum Research
- Connected Vehicle Pilots Update
- V2X Deployment Activity
- Sensor Based Misbehavior Detection
- CARMA Research
- V2X Commercial Vehicle Research at FMCSA



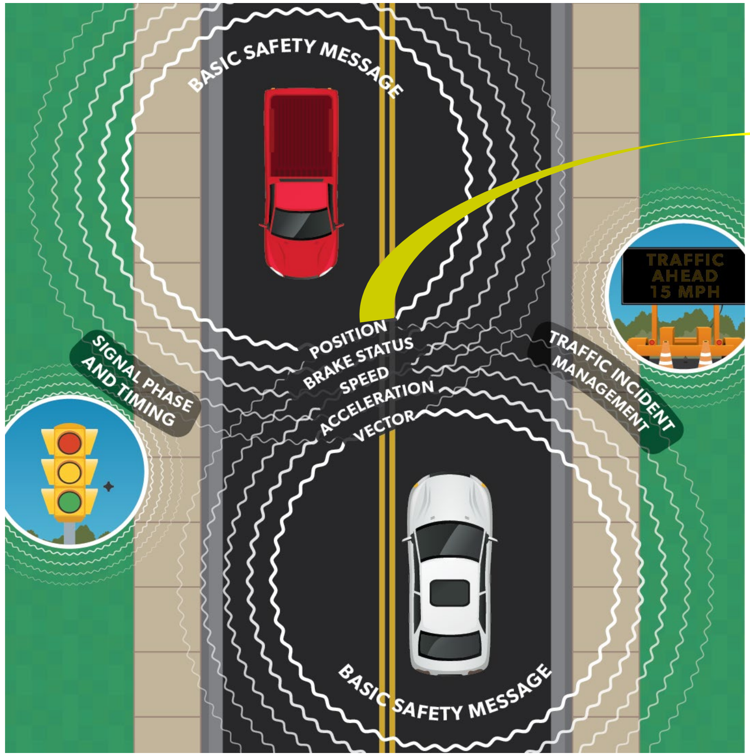
5.9 GHz Transportation Safety Band Testing

Criticality of Spectrum Availability With No Interference

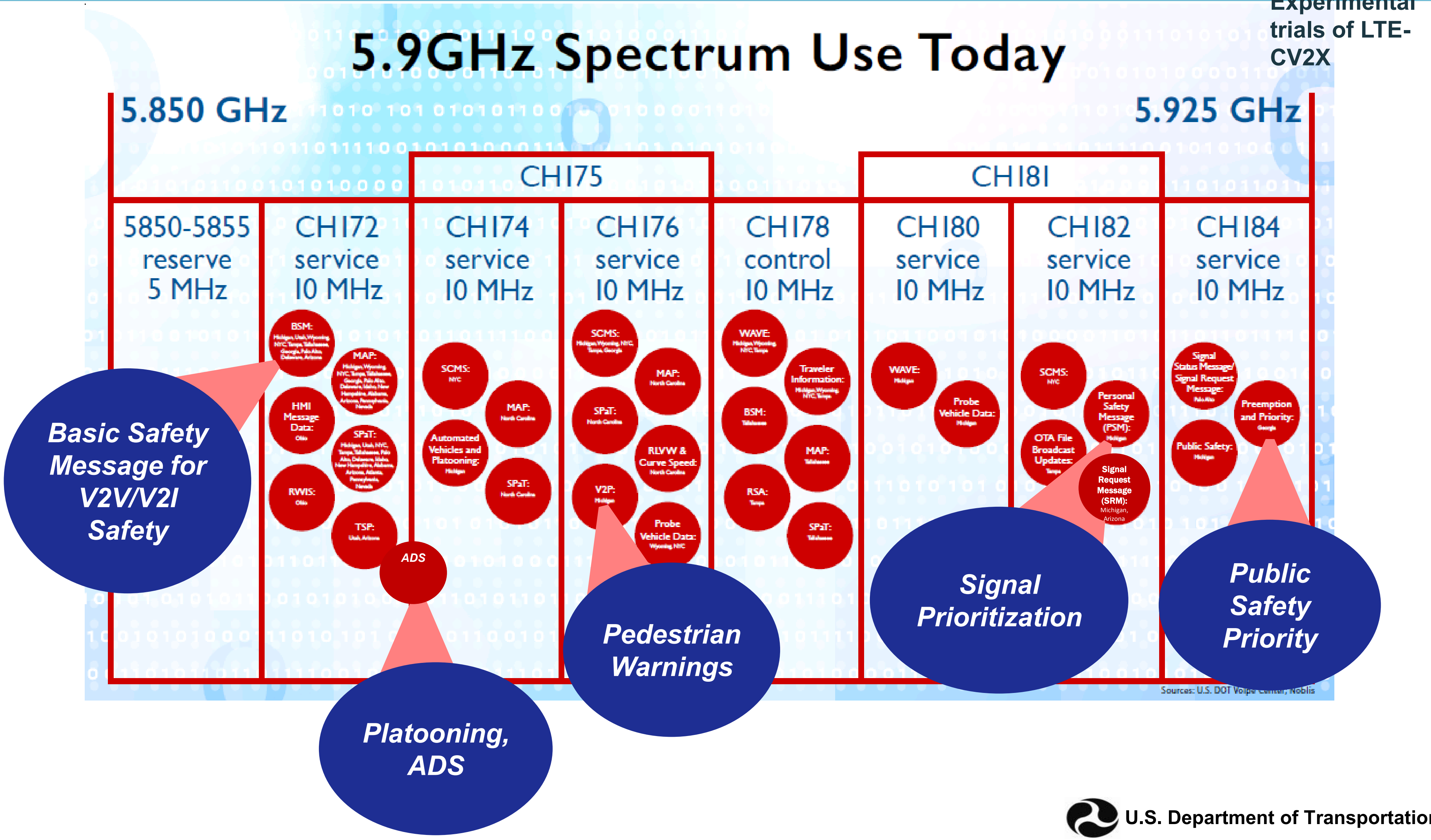
- **The "Safety Band" allocation is critical for transportation safety** → supports the vision of advancing toward a fully connected and automated transportation system.

- **The band plan is tailored to meet transportation needs** → sharing the band could compromise the speed at which V2V/V2x information is received, putting lives at risk.

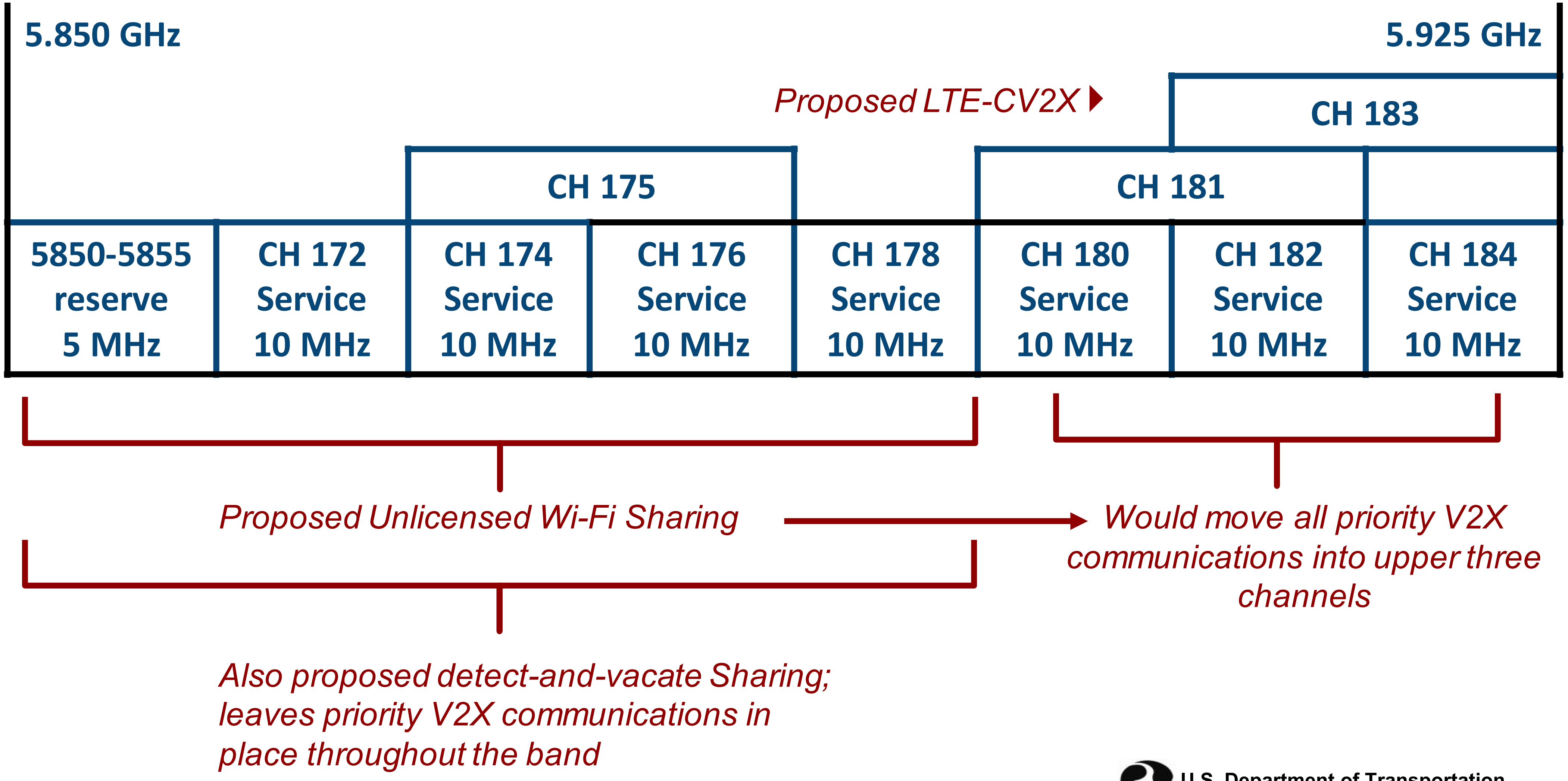
- **Over 37,000 deaths on our Nation's roads every year** → it is critical that efforts to free up additional spectrum do not come at the expense of saving lives.



5.9 GHz Safety Band In Use Today



Safety Band Research and Test Program



Phase 2 DSRC-UNII Sharing Testing Plan

Can DSRC continue to provide safety-critical messages in the **presence of unlicensed national information infrastructure (UNII-4) devices?**

Assess three types of interference:

- Interference at DSRC receiver that leads to corrupted or no messages received
- Interference at DSRC transmitter that suppresses message transmission
- Adjacent/n-adjacent channel interference

Can UNII-4 devices effectively share the Safety Band with DSRC by mitigating potential interference to DSRC operations using the proposed sharing techniques?

- Re-channelization
- Detect & Vacate

Test Metrics

Performance indicators

- Packet Error Rate (PER)
- Data Throughput
- Network Latency or Delay
- Packet Delay Variation (aka, “Jitter”)

Specific to Re-Channelization of the Band for DSRC & Unlicensed Wi-Fi

- **Detection Threshold:** Point at which the probability of detecting DSRC signal is equal to or greater than target percentage (90th percentile).
- **(Received) Packet Completion Rate (PCR):** Ratio of the number of successfully received DSRC packets to number of transmitted DSRC packets.
- **(Transmitted) Packet Completion Rate (PCR):** Ratio of the number of DSRC packets placed in the transmit queue to number of successfully transmitted DSRC packets.
- **Inter Arrival Time (of Received Packets) (IAT):** Time between two successive received DSRC packets.
- **Inter Departure Time (of Transmitted Packets) (IDT):** Time between two successive DSRC transmitted packets.

Test Metrics

Specific to Detect & Vacate with DSRC & Unlicensed Wi-Fi

- **Detection Threshold** at which point probability of detecting DSRC preamble is equal to or greater than certain percentage (90th percentile).
- **Channel-Move Time** or the time between detection of DSRC preamble and start of IEEE 802.11 transmission in a backup channel.
- **(Received) Packet Completion Rate (PCR):** The ratio of the number of successfully received packets to number of transmitted packets.
- **(Transmitted) Packet Completion Rate (PCR):** The ratio of the number of packets placed in transmit queue to the number of successfully transmitted packets.
- **Inter Arrival Time (of Received Packets) (IAT):** The time between two successive received packets.
- **Inter Departure Time (of Transmitted Packets) (IDT):** The time between two successive transmitted packets.

TEST PROCEDURE OVERVIEW

Adjacent Channel with DSRC in Upper Band

- UNII-4 in 20MHz, 40MHz, 80MHz, 160MHz channels
- DSRC in 10MHz channel (Ch 180)

N-Adjacent Channel with DSRC in Upper Band

- UNII-4 in 20MHz, 40MHz, 80MHz, 160MHz channels
- DSRC in 10MHz channels

Adjacent Channel with DSRC in Lower Band

- UNII-4 in 20MHz and 40MHz channels
- DSRC in 20MHz channel

N-Adjacent Channel with DSRC in Lower Band

- UNII-4 in 20MHz and 40MHz channels
- DSRC in 20MHz channel

USDOT's LTE-CV2X Testing Framework

- **Operations and Safety Performance tests** to assess LTE-CV2X capability to support crash-imminent V2V/V2I safety applications
- **Interference tests** to identify whether there is interference and the magnitude and impacts:
  - LTE-CV2X with DSRC
  - LTE-CV2X and unlicensed Wi-Fi above the band
  - Sensitivity of LTE-CV2X technology to other/existing forms of interference?
- **Scalability tests** to measure the consistency of performance as increasing numbers of LTE-CV2X devices are added
- **Interoperability tests** at the chipset, radio, applications levels for interoperability among different device vendors and chipset manufacturers. Can all makes and models "hear and understand" one another?
- **System Dynamics and Congestion testing** to assess how LTE-CV2X technology performs in complex, highly dynamic and congested transportation scenarios with varying conditions as well as a range of environmental effects
- **Validation tests** to ensure that the laboratory, field testing and industry simulation and test results are able to be validated.

US DOT's Testing Progress & 5G Efforts

DSRC-UNII-4 Sharing Testing with Phase 2 has begun:

- First rechannelization devices in testing
- Working to gain access to additional rechannelization devices + detect-and-vacate devices

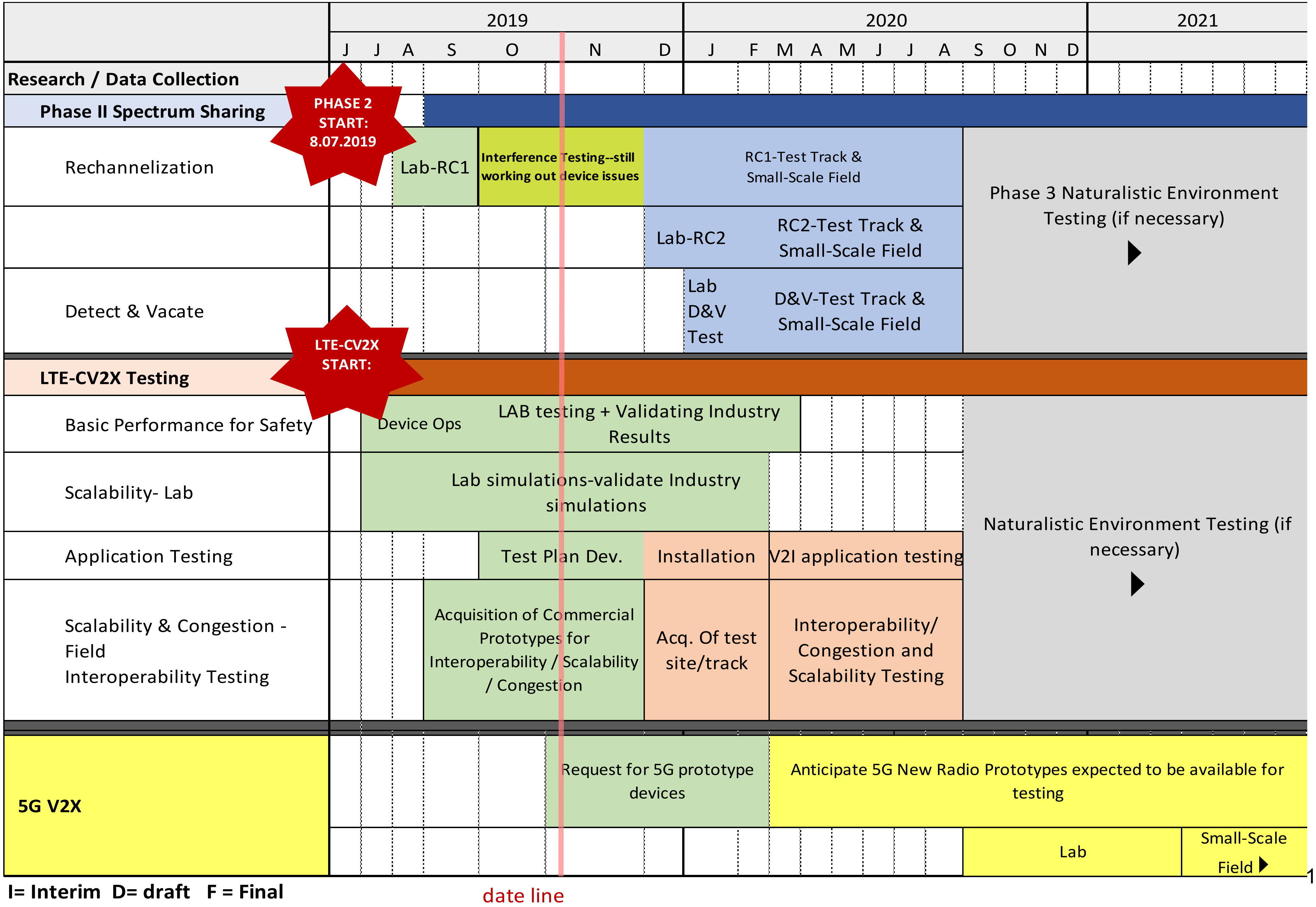
LTE-CV2X Testing has begun

- First devices received in Summer 2019 and set-up for testing at end of August.
- Testing on operability and interference underway
- Working with development platforms; receiving commercial-prototypes and will add them to the testing

5G:

- Monitoring of transportation use cases and device specifications
- Seeking to acquire 5G prototypes (appear to be available in Asia for testing as of this past Fall)
- Assessing 5G's security to meet transportation needs

Test Schedule



I= Interim D= draft F = Final

For More Information

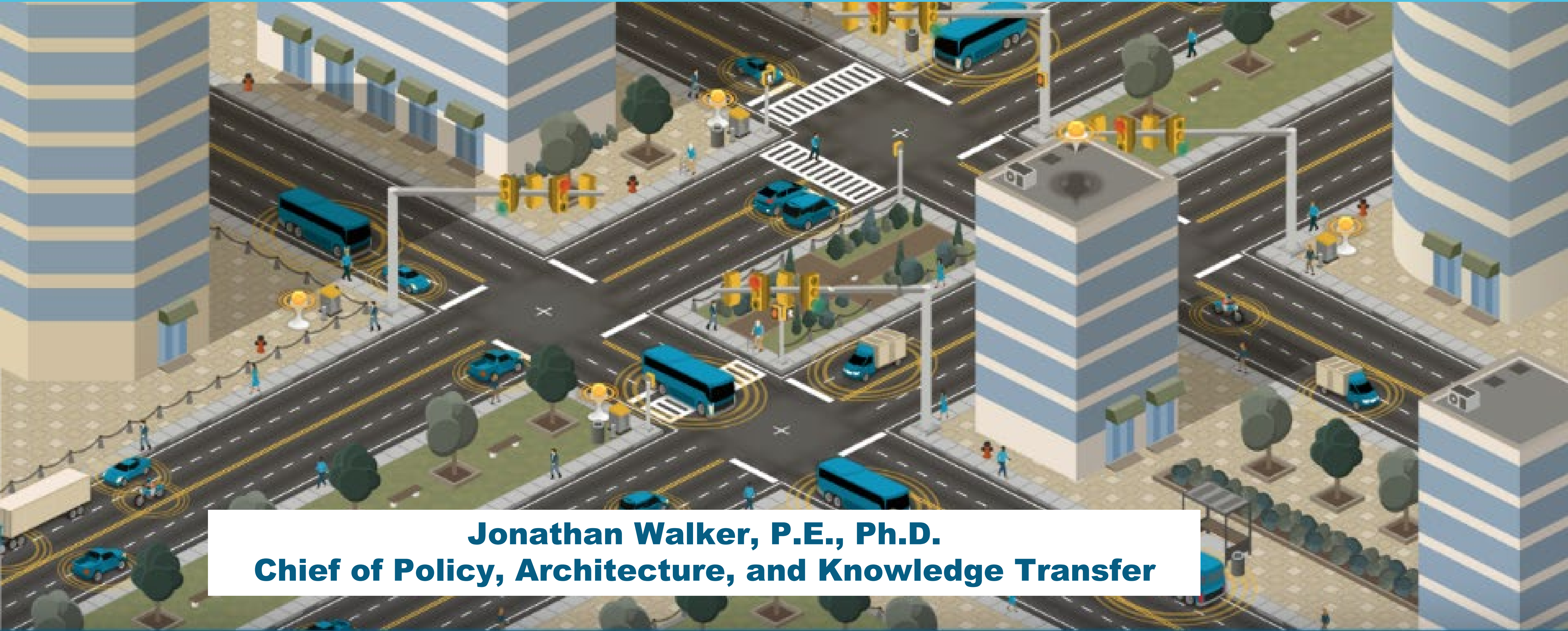
For Information:

- https://www.transportation.gov/content/safety-band
- https://www.its.dot.gov

Contacts for Testing New Communications Technologies

- Jim Arnold, USDOT Spectrum Engineer; James.A.Arnold@dot.gov
- Jonathan Walker, Division Chief, Knowledge Transfer and Policy, ITS Joint Program Office; Jonathan.B.Walker@dot.gov

CONNECTED VEHICLE PILOT
Deployment Program



Jonathan Walker, P.E., Ph.D.
Chief of Policy, Architecture, and Knowledge Transfer

CV Pilot Deployment Program Goals

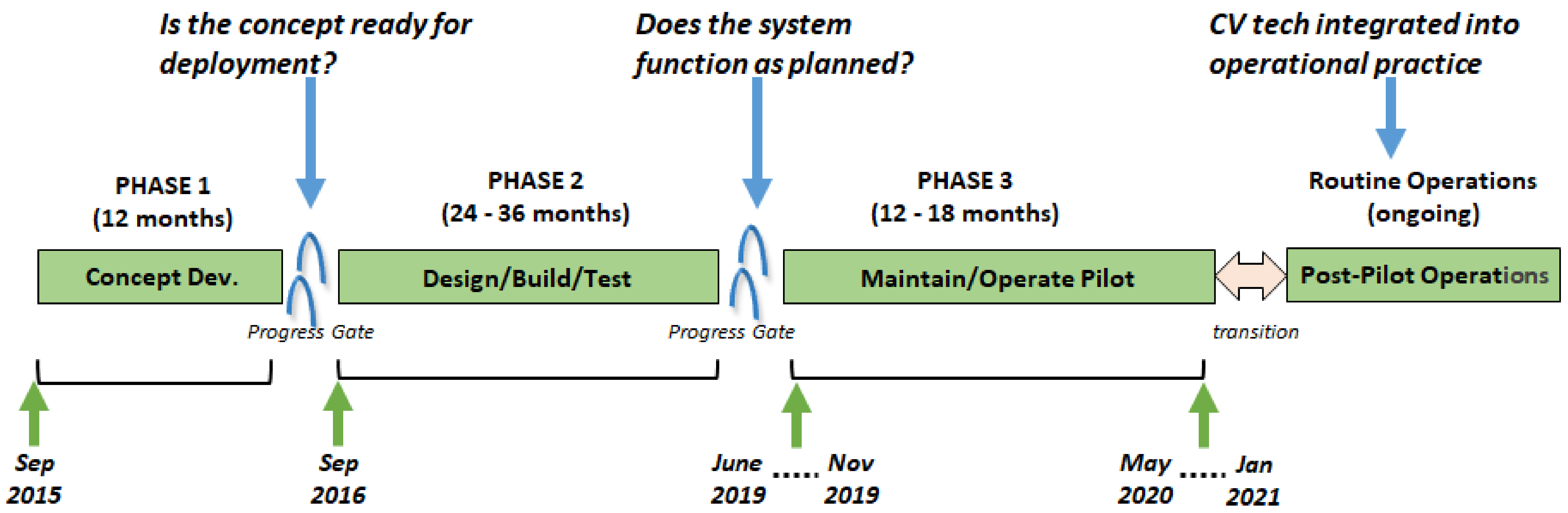
The Three Pilot Sites

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

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

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

CV Pilot Deployment Schedule



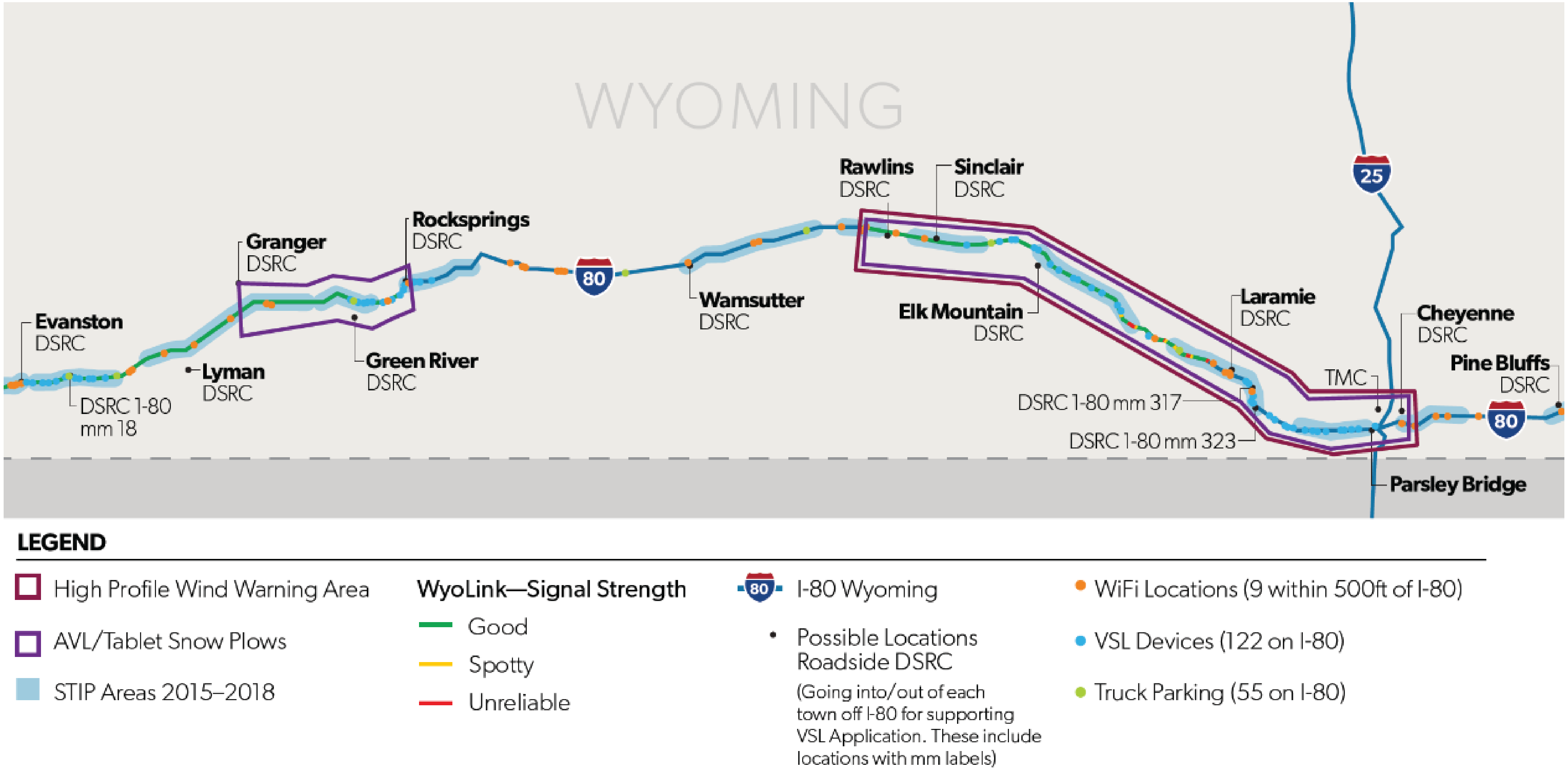
Last updated: October 2019

Wyoming DOT

WYDOT Pilot Deployment Overview

- Wyoming Department of Transportation (WYDOT) Transportation Challenges
  - I-80 in WY is one of the busiest freight corridors in the region
    - More than 32 million tons of freight per year.
    - Truck volume is 30-55% of the total traffic on an annual basis—can be as much as 70% on a seasonal basis.
  - Difficult environment and terrain
    - Elevations above 6,000 feet across the entire corridor.
- WYDOT Pilot Approaches
  - Equip fleet vehicles that frequently travel the I-80 corridor to transmit BSMs, collect vehicle and road condition data and provide it remotely to the WYDOT TMCs.
  - Share road weather data with freight carriers who will transmit to their trucks using existing in-vehicle systems (such as 511).

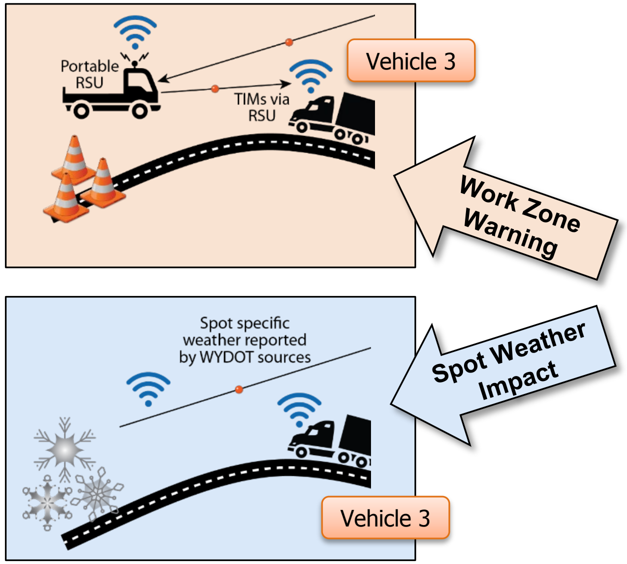
WYDOT Pilot Deployment Location

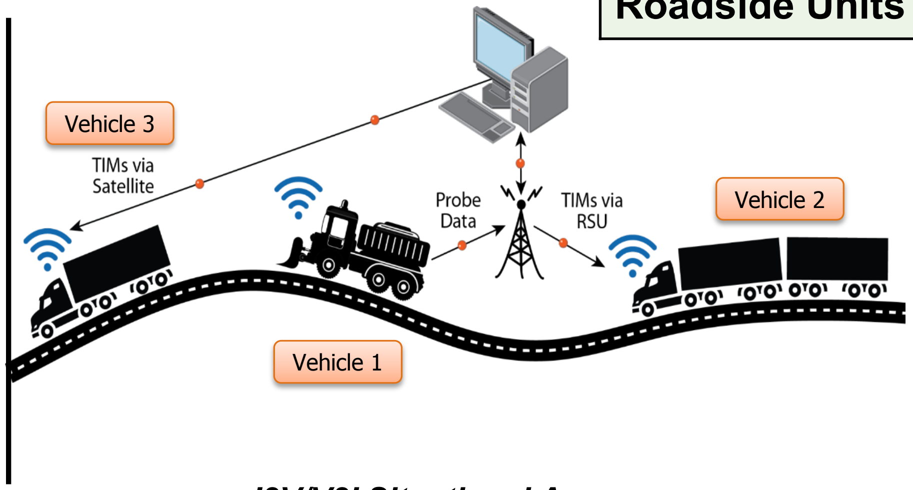


WYDOT Pilot CV Applications and Devices

Category	WYDOT – CV Application
V2V Safety	Forward Collision Warning (FCW)
V2I/I2V Safety	Situational Awareness
	Work Zone Warnings (WZW)
	Spot Weather Impact Warning (SWIW)
V2I and V2V Safety	Distress Notification (DN)

WYDOT – Devices	Planned Number
WYDOT Maintenance Fleet Subsystem On-Board Unit (OBU)	90
Integrated Commercial Truck Subsystem OBU	25
Retrofit Vehicle Subsystem OBU	255
WYDOT Highway Patrol	35
Total Equipped Vehicles	**405**
Roadside Units (RSU) along I-80	**75**





I2V/V2I Situational Awareness

Tampa Hillsborough Expressway Authority

THEA Pilot Deployment Overview

- Tampa Hillsborough Expressway Authority (THEA) Transportation Challenges
  - Significant delay at the REL morning commute endpoint intersection resulting in and caused by rear-end crashes and red light running collisions.
  - Potential wrong way entry at the end of the REL.
- THEA Pilot Approaches
  - Deploy CV applications to relieve congestion, reduce collisions, and prevent wrong way entry at the REL exit.
  - Use CV technology to enhance pedestrian safety, speed bus operations and reduce conflicts between street cars, pedestrians and passenger cars in downtown Tampa.

[Connected Vehicle Pilot Deployment Program]

THEA Pilot Deployment Location

RUSH HOUR COLLISION AVOIDANCE

WRONG WAY ENTRY PREVENTION

PEDESTRIAN SAFETY (TWIGGS ST.)

TRAFFIC FLOW OPTIMIZATION (MERIDIAN AVE)

TRAFFIC FLOW OPTIMIZATION (FLORIDA AVE.)

BUS PRIORITY

STREETCAR SAFETY

THEA Pilot CV Applications and Devices

Category	Tampa (THEA) – CV Application
V2I Safety	End of Ramp Deceleration Warning (ERDW)
	Wrong Way Entry (WWE)
	Pedestrian Collision Warning (PCW)
V2V Safety	Emergency Electronic Brake Lights (EEBL)
	Forward Collision Warning (FCW)
	Intersection Movement Assist (IMA)
	Vehicle Turning Right in Front of a Transit Vehicle (VTRFTV)
Mobility	Intelligent Traffic Signal System (I-SIG)
	Transit Signal Priority (TSP)

Tampa (THEA) – Devices	Planned Number
Vehicle Equipped with On-Board Unit (OBU)	1,200
HART Transit Bus Equipped with OBU	10
TECO Line Streetcar Equipped with OBU	8
Total Equipped Vehicles	**1,218**
Roadside Units (RSU) at Downtown Intersections	**44**

Electronic Brake Lamp Warning

Exit Ramp Deceleration Warning

New York City DOT

NYC Pilot Deployment Overview

- New York City Department of Transportation (NYCDOT) Transportation Challenges
  - Achieve Vision Zero goals to eliminate traffic deaths by 2024.
  - Improve safety and mobility of travelers in New York City through connected vehicle technologies.

- NYCDOT Pilot Approaches
  - Equip vehicles that frequently travel in Midtown Manhattan and Central Brooklyn and Install V2I technology at high-accident rate arterials.
  - Evaluate the safety benefits and challenges of implementing CV technology with a significant number of vehicles in the dense urban environment.

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

NYCDOT Pilot Deployment Location

LEGEND: ● Indicates at least one fatality (2012–2014) ——— Connected Vehicle Roads

NYC Pilot CV Applications and Devices

Category	NYCDOT – CV Application
V2I/I2V Safety	Speed Compliance
	Curve Speed Compliance
	Speed Compliance/Work Zone
	Red Light Violation Warning
	Oversize Vehicle Compliance
	Emergency Communications and Evacuation Information
V2V Safety	Forward Crash Warning (FCW)
	Emergency Electronics Brake Lights (EEBL)
	Blind Spot Warning (BSW)
	Lane Change Warning/Assist (LCA)
	Intersection Movement Assist (IMA)
	Vehicle Turning Right in Front of Bus Warning
V2I/I2V Pedestrian	Pedestrian in Signalized Crosswalk
	Mobile Accessible Pedestrian Signal System (PED-SIG)
Mobility	Intelligent Traffic Signal System (I-SIGCVDATA)

NYCDOT – Devices	Planned Number
Taxi Equipped with Aftermarket Safety Device (ASD)	3,200
DCAS Fleet Equipped with ASD	3,200
MTA Fleet Equipped with ASD	700
NYCDOT Fleet Equipped with ASD	700
DSNY Fleet Equipped with ASD	170
Total Equipped Vehicles	**8,000**
Roadside Units (RSU) at Manhattan and Brooklyn Intersections and FDR Drive	**400**
Vulnerable Road User (Pedestrians/Bicyclists) Device	**100**
PED Detection System	**10**

*MTA: Metropolitan Transportation Authority; DSNY: City of New York Department of Sanitation; * In addition, 600 spare ASDs will be purchased.*

Photo Source: MTA New York City Transit

Photo Source: NYCDOT

CV Device Deployment Status (as of November 2019)

Wyoming Pilot (WYDOT)	Complete	Target
WYDOT Maintenance Fleet Subsystem On-Board Unit (OBU)	32	90
Integrated Commercial Truck Subsystem OBU	0	25
Retrofit Vehicle Subsystem OBU	20	255
WYDOT Highway Patrol	0	35
Total Equipped Vehicles	**52**	**405**
Roadside Units (RSU) along I-80	**75**	**75**

Tampa Pilot (THEA)	Complete	Target
Vehicle Equipped with On-Board Unit (OBU)	831	1,080
HART Transit Bus Equipped with OBU	10	10
TECO Line Streetcar Equipped with OBU	8	8
Total Equipped Vehicles	**849**	**1,100**
Roadside Units (RSU) at Downtown Intersections	**44**	**44**

New York City Pilot (NYCDOT)	Complete	Target
Taxi Equipped with Aftermarket Safety Device (ASD)	1	Up to 2,000
DCAS Fleet Equipped with ASD	1	Up to 5,000
MTA Fleet Equipped with ASD	10	700
OCME Fleet Equipped with ASD	4	TBD
NYCDOT Fleet Equipped with ASD	660	1,000
Total Equipped Vehicles	**676**	**~ 8,000**
Roadside Units (RSU) at Manhattan and Brooklyn Intersections and FDR Drive	**280**	**400**
Vulnerable Road User (Pedestrians/Bicyclists) Device	**0**	**100**
PED Detection System	**9**	**10**

- *DSNY: City of New York Department of Sanitation; MTA: Metropolitan Transportation Authority; OCME: New York City Office of Chief Medical Examiner.*
- *In addition, 600 spare ASDs will be purchased.*

PILOT SITES

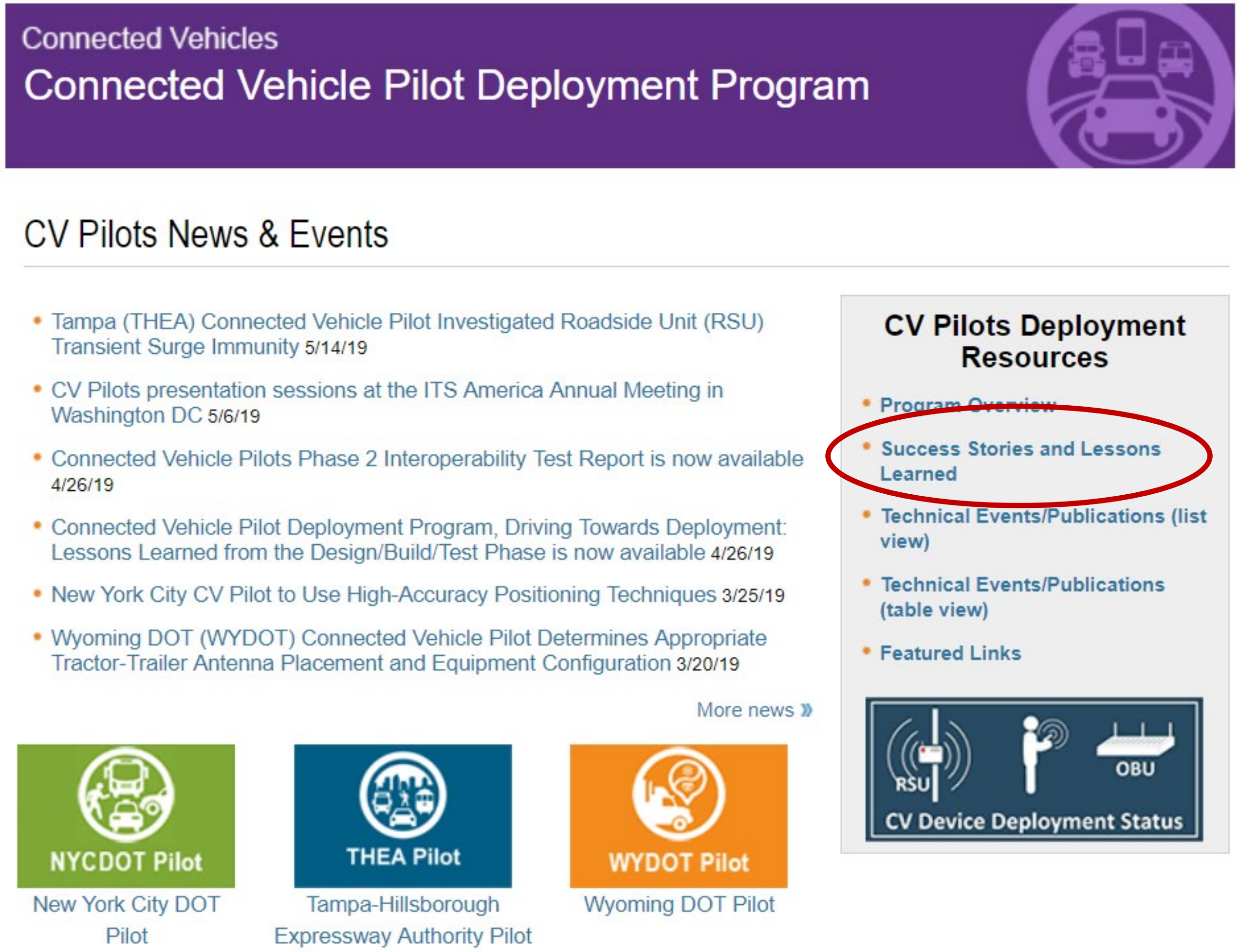
WYDOT

NYCDOT

Tampa (THEA)

We Document Deployment Experiences

- https://www.its.dot.gov/pilots/index.htm



- Success Stories
  - Keeping Stakeholders and the Public Informed
  - Bringing Local Agencies to Work Together
  - Promoting Interoperability
  - Providing Open Source CV Applications and Sharing Data
  - Accelerating Collaboration and CV Deployment
- Lessons Learned
  - Driving Towards Deployment: Lessons Learned from the Design/Build/Test Phase
  - Connected Vehicle Pilot Deployment Program Phase 1 Lessons Learned
  - Interoperability Testing amongst the three Connected Vehicle Pilots
  - NYC Pilot's demonstration at the ITS-NY Annual Meeting and Technology Exhibition
  - Integrating and Testing Large Disparate Systems

Stay Connected

Contact for CV Pilots Program/Site AORs:

- Kate Hartman, Program Manager, Wyoming DOT Site AOR; Kate.Hartman@dot.gov
- Jonathan Walker, NYCDOT Site AOR; Jonathan.b.Walker@dot.gov
- Govind Vadakpat, Tampa (THEA) Site AOR; G.Vadakpat@dot.gov
- Walter During, Evaluation COR, Walter.During@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://wydotcvp.wyoroad.info/

NYCDOT

Tampa (THEA)

WYDOT

V2X Deployment Activity in the United States

John Harding
FHWA Office of Operations

Uses of the 5.9 GHz band: Connected Vehicle Deployment Locations – Planned and Operational

- Planned Projects
- Operational Projects

Source: Volpe, the National Transportation Systems Center (USDOT). May 2019.
The project information and data contained on this map was gathered from publicly available materials and is subject to change.

	#Projects	#Devices*	#Infrastructure
Planned	35	3,266	802
Operational**	52	15,435	6,086
Total	87	18,701	6,888

*Includes aftermarket devices **Includes devices in phased deployments

Intelligent Transportation Systems Joint Program Office (ITS JPO)

Sensor Based Misbehavior Detection Analysis, Simulation, and Proof-of-Concept Testing

NHTSA's Research Portfolio Meeting

November, 2019

Background

- For V2X applications to be effective, messages exchanged directly between entities must be trusted.
- To enable trusted messaging, USDOT, working with industry partners, built and demonstrated a prototype messaging security system based on public key infrastructure (PKI) principals.
- Trust is achieved by attaching certificates to each message that have been issued and signed by a trusted third-party called a certificate authority.
- Messages with valid certificates, encryption and signatures allow receiving entities to verify the authenticity and integrity of the message—namely, that it
  - was generated from a trusted source, and,
  - the message was not altered in any way during transmission
- **BUT…..**

More Background

- **Certificate-based security processes cannot guard against erroneous data contained within the message**—whether errors are purposeful (malicious intent) or a consequence of defective vehicle systems.
- **Today's Solution—misbehavior detection, reporting and revocation…**
  1) "Observer" vehicles indirectly infer potential anomalies locally,
  2) Observer vehicles report incidents to a "global" misbehavior detection authority,
  3) "Big data" techniques used to determine if a particular vehicle is "misbehaving",
  4) Misbehaving vehicles are placed on a Certificate Revocation List (CRL) which is sent out to all vehicles so that messages from such vehicles can be identified by receiving vehicles
- **Problems with today's solution**
  - Need to break privacy to affect global misbehavior detection
  - Need multiple corroborating Misbehavior Reports
  - Excessive delay in processing and disseminating the CRL
- **Alternative Solution**: **Sensor Based Misbehavior Detection (SBMD)**

What is SMBD?

- Sensors on-board the vehicle (radar, camera, lidar) are used to position other vehicles relative to host vehicle—and create projected GPS coordinates for observed vehicles.
- Projected GPS coordinates can be compared with the GPS coordinates contained in the BSMs of observed vehicles to detect anomalies (or misbehavior).
- Observer vehicles send out **“Error Notifications Messages” (ENMs)** containing the temporary ID of misbehaving vehicle(s) to other vehicles in proximity.
- Vehicles may receive confirmatory ENMs from multiple observer vehicles for a particular vehicle in the vicinity—and adjust their confidence in BSMs from that vehicle accordingly.

Advantages and Challenges

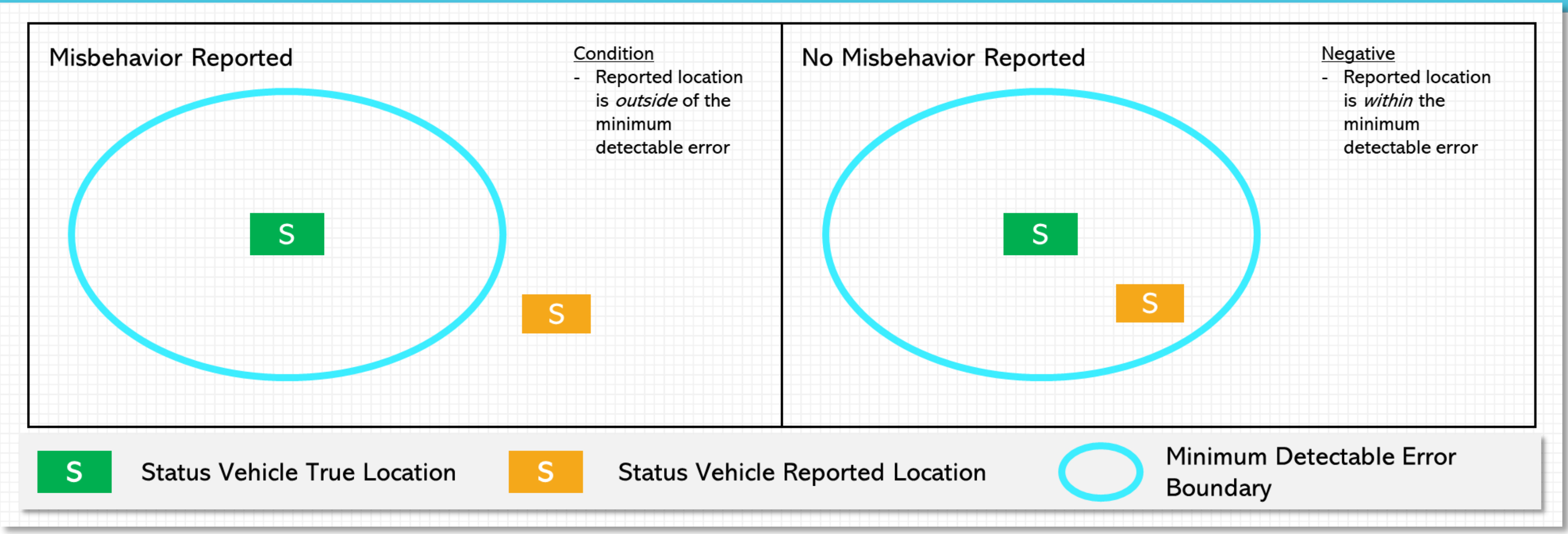
- **Advantages**
  - No need to break privacy
  - No delays in identifying misbehaving vehicles
  - Can compliment existing misbehavior detection methods by also sending ENMs to a Global misbehavior detection entity
- **Challenges**
  - Too many ENMs can cause congestion and/or increase bandwidth (spectrum) requirements
  - Cumulative errors in GPS positioning, heading, and perception sensors system accuracy could lead to false positives and/or negatives.

Project Activities

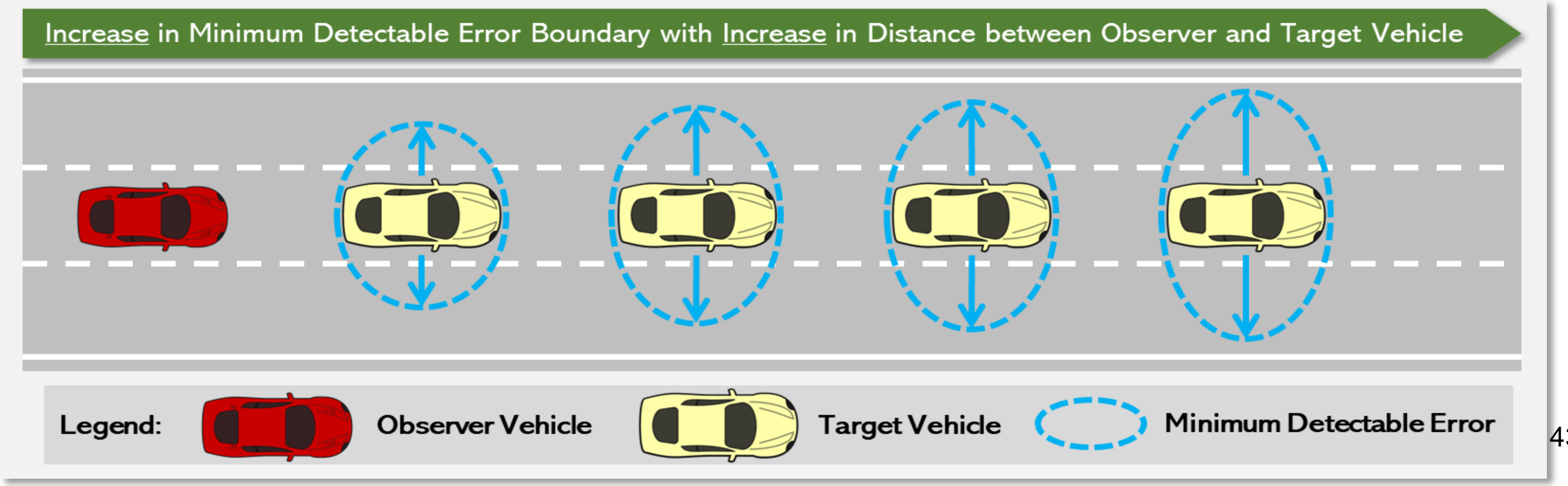
- **Characterize Vehicle Sensor Systems**
  - Accuracy and coverage for given sensor types
  - Various vehicle sensor system configurations
- **Simulate traffic conditions and misbehavior activity**
  - Determine probabilities of “seeing” a misbehaving vehicle
  - Identify conditions when some vehicles can help neighbors with early detection of misbehaving vehicle(s)
- **How Bad Do the Anomalies Need to Be in Order to be Detected**
  - Develop an understanding of the variations and error profiles of a vehicle’s own position and its capability to accurately determine the position of the misbehaver.
- **Model strategies for broadcasting Error Notification Messages**
  - Frequency
  - Duration
  - Distance (or location) from incident detection

Minimum Detectable Error

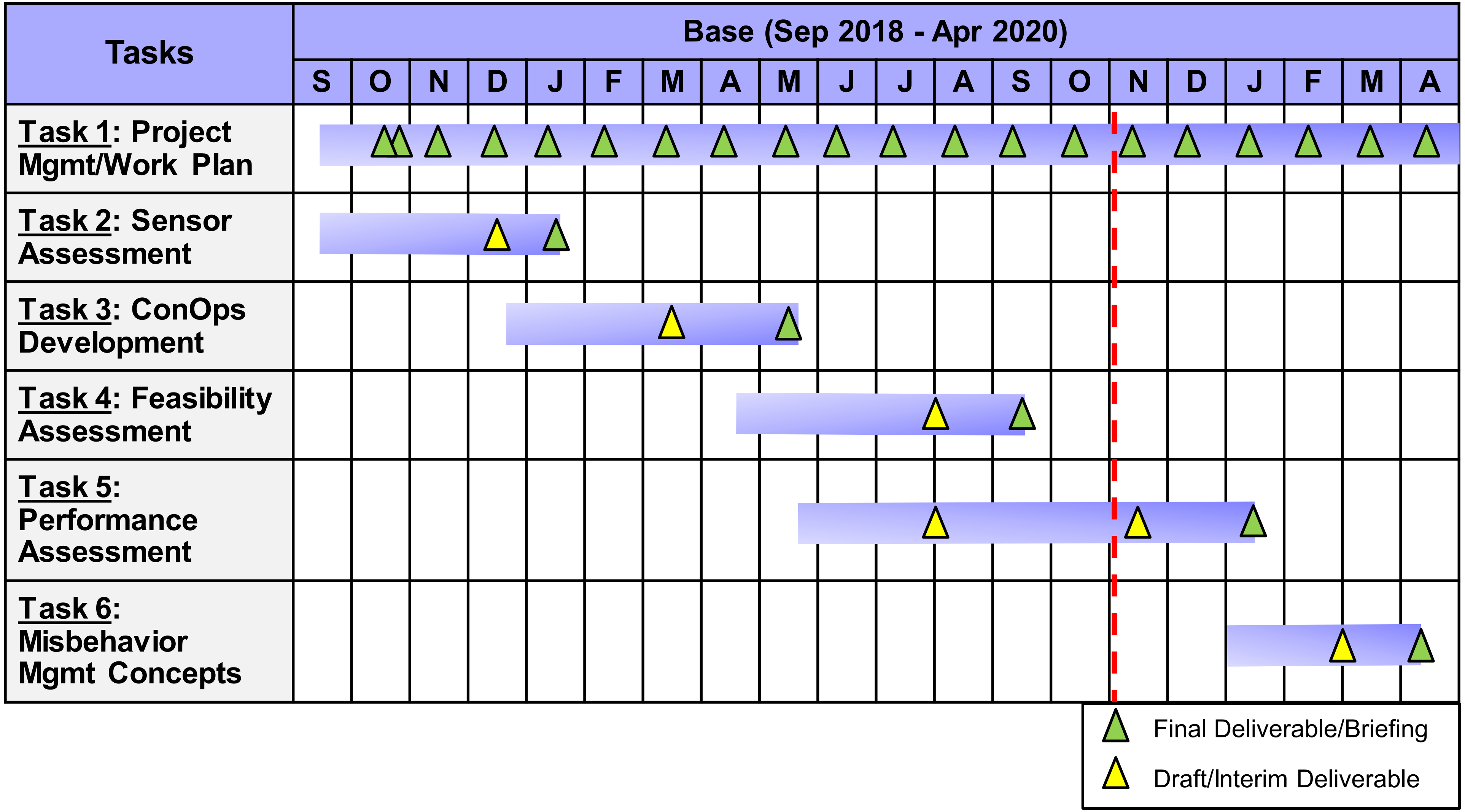
Sensor-based Misbehavior Detection Classification: Misbehavior only detected if outside the Minimum Detectable Error boundary



Increase in Minimum Detectable Error boundary with Increase in Distance Between Observer and Status Vehicle



Project Schedule



Source: FHWA.

Driving Innovation℠

CARMA℠

Govind Vadakpat, Ph.D., P.E.,PTOE,
Highway Research Engineer
Federal Highway Administration (FHWA) Office of Operations Research and Development (R&D)

SAXTON LABORATORY

2019
Mobility Report

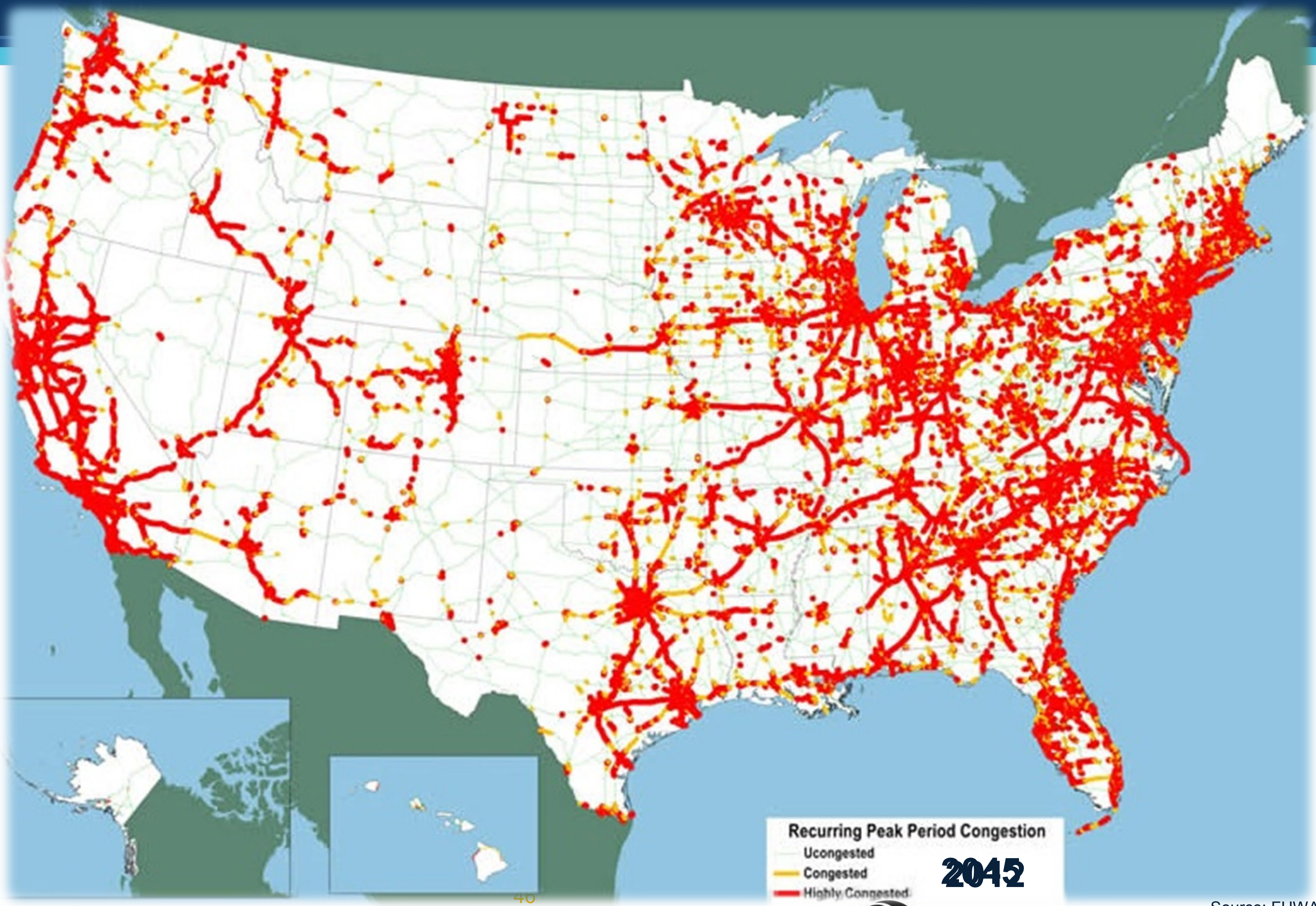
In 2017, the Cost of Congestion increased to **$166 billion**.

The wasted time increased to **8.8 billion hours** of extra travel time.

Wasted fuel equaled **3.3 billion gallons**.

U.S. Department of Transportation
Federal Highway Administration

Traffic Congestion Statistics in the United States



Peak-Period Congestion on the National Highway System

U.S. Department of Transportation

Source: FHWA.

Cooperative Automation

COOPERATIVE AUTOMATION FOCUSES ON **AUTOMATED VEHICLES WORKING TOGETHER AND WITH ROADWAY INFRASTRUCTURE** TO INCREASE SAFETY AND IMPROVE EFFICENCY.

Source: FHWA.

Reduce fuel consumption at intersections by 20 percent.

Source: FHWA.

Double capacity of existing lanes.


Source: FHWA.

Fuel savings of 10 percent.

Cooperative Automation and CARMA[SM]

Icon source: FHWA.

CARMA, an FHWA initiative, achieves the benefits of cooperative automation through collaboration using open source tools.

Source: FHWA and Creative Commons.

OBJECTIVES

Source: FHWA.

CARMA 2

5
Cooperative Driving Features

24
Days at Aberdeen Test Center (ATC)

22,000
Miles of closed track testing

42,000
Lines of code

Source: FHWA.

CARMA℠ 3

UNITED STATES DEPARTMENT OF TRANSPORTATION (USDOT) MULTIMODAL PARTNERSHIP

CARMA℠

Federal Highway Administration
Office of Operations
Office of Operations R&D
Office of Safety R&D

Federal Motor Carrier Safety Administration (FMCSA)
Technology Division
Research Division

Maritime Administration (MARAD)
Office of Ports & Waterways Planning

Intelligent Transportation Systems Joint Program Office
Vehicle Safety and Automation
Data Program

Volpe National Transportation Systems Center
Advanced Vehicle Technology Division

Source: FHWA and Port Houston.

TSMO – Transportation Systems Management and Operations

4 Automated Cars

6 Use Cases

FHWA

1

Freeway Basic Travel

2

Traffic Incident Management

3

Work Zones

4

Weather

5

Intersections

6

Arterial Management

4 Automated Trucks

4 Use Cases

FMCSA

1

Truck Platooning

2

Roadside Inspection / Enforcement

3

Work Zones

MARAD

1

Port Drayage

Source: FHWA and MARAD.

CARMA 3

FHWA Automated Research Vehicles

- Utilize industry's AV technology.
- Are based on existing AV Open Source Software.

CARMA Platform[SM]

- Adds V2X communications.
- Enables AVs to cooperate.
- Facilitates participation and collaboration.

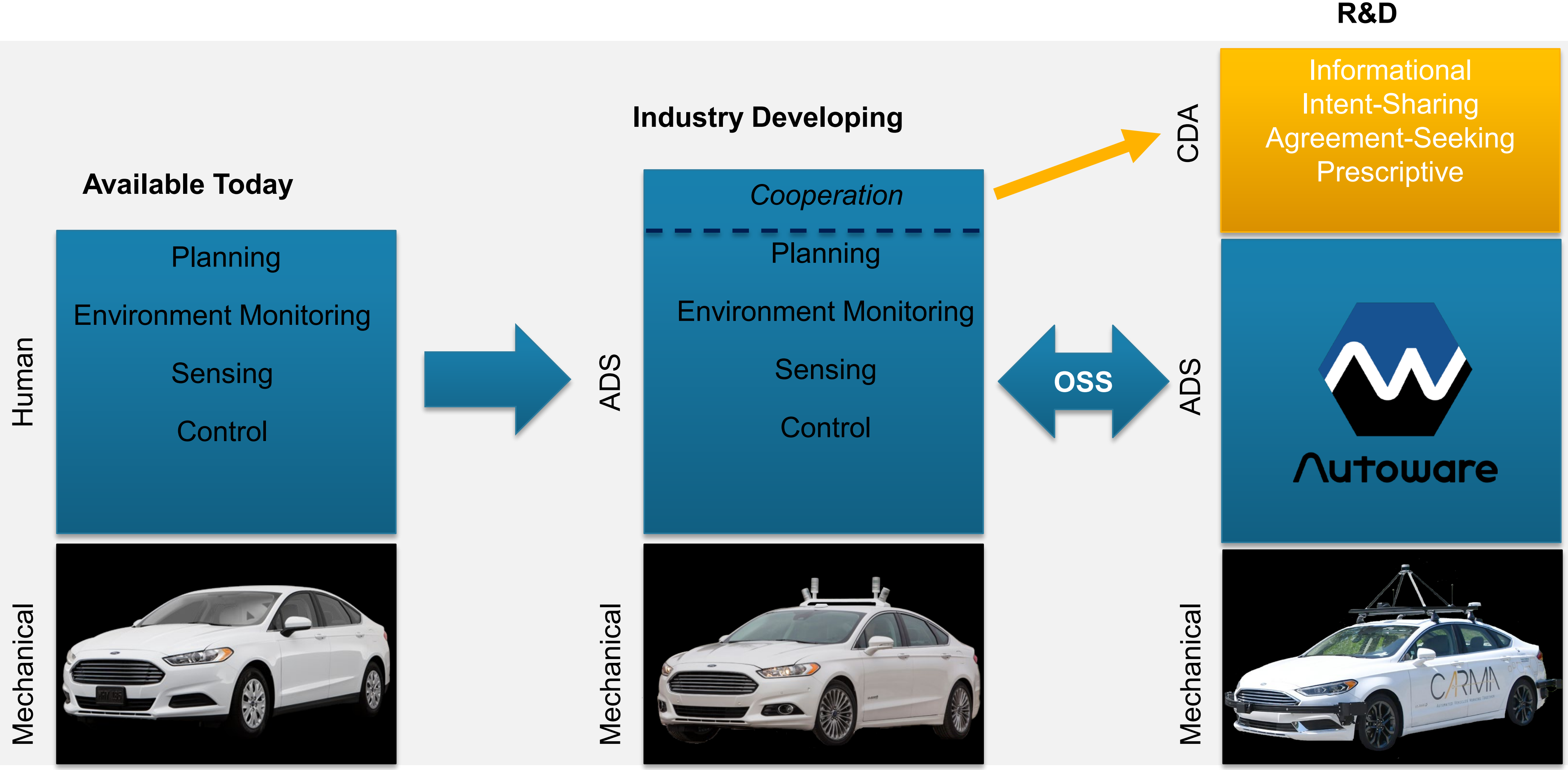
Four Automated Cars

Four Automated Trucks

Source: FHWA.

AV – Automated Vehicles
V2X – Vehicle-to-Everything

CARMA Platform℠ Integration with Open Souce ADS to Enable Cooperation



© Ford. © Ford. Source: FHWA.

ADS – Automated Driving Systems
CDA – Cooperative Driving Automation
OSS – Open-Source Software

CDA

Machine-to-machine (M2M) communication to enable cooperation.

SAE INTERNATIONAL
J3216

CARMA Platform[SM]

CDA

Autoware

Mechanical

Source: FHWA.

Informational
Informing other entities of the general state of the driving environment.

Intent-Sharing
Providing specific information about an entity’s future state or goals that could not be determined by a noncooperative entity.

Agreement-Seeking
Exchanging information to support coordinated planning of future actions that will achieve a goal.

Prescriptive
Using M2M communications for vehicle motion control in near real time.

OPEN SOURCE Collaboration Vision

ADVANCE COOPERATIVE AUTOMATION RESEARCH

USDOT
FHWA Lead Agency

PARTNERS

- Academia
- Industry
- Consultants
- State and Local Governments
- Federal Partners

Connectivity and Data Sharing

V2X HUB

Developing software applications for connected infrastructure on a Vehicle-to-Everything (V2X) platform.

CAV
CONNECTED AND AUTOMATED VEHICLES SUPPORT SERVICES

Providing technical support and equipment loans to Connected and Automated Vehicles (CAV) Support Services deployments throughout the United States.

Next Generation Transportation Management

Transportation Management Centers (TMC):

Collect and process freeway system data and fuse it with other operational and control data.

Produce and distribute information to stakeholders, other agencies, and the traveling public.

Monitor information and initiate control strategies to make changes in the freeway network.

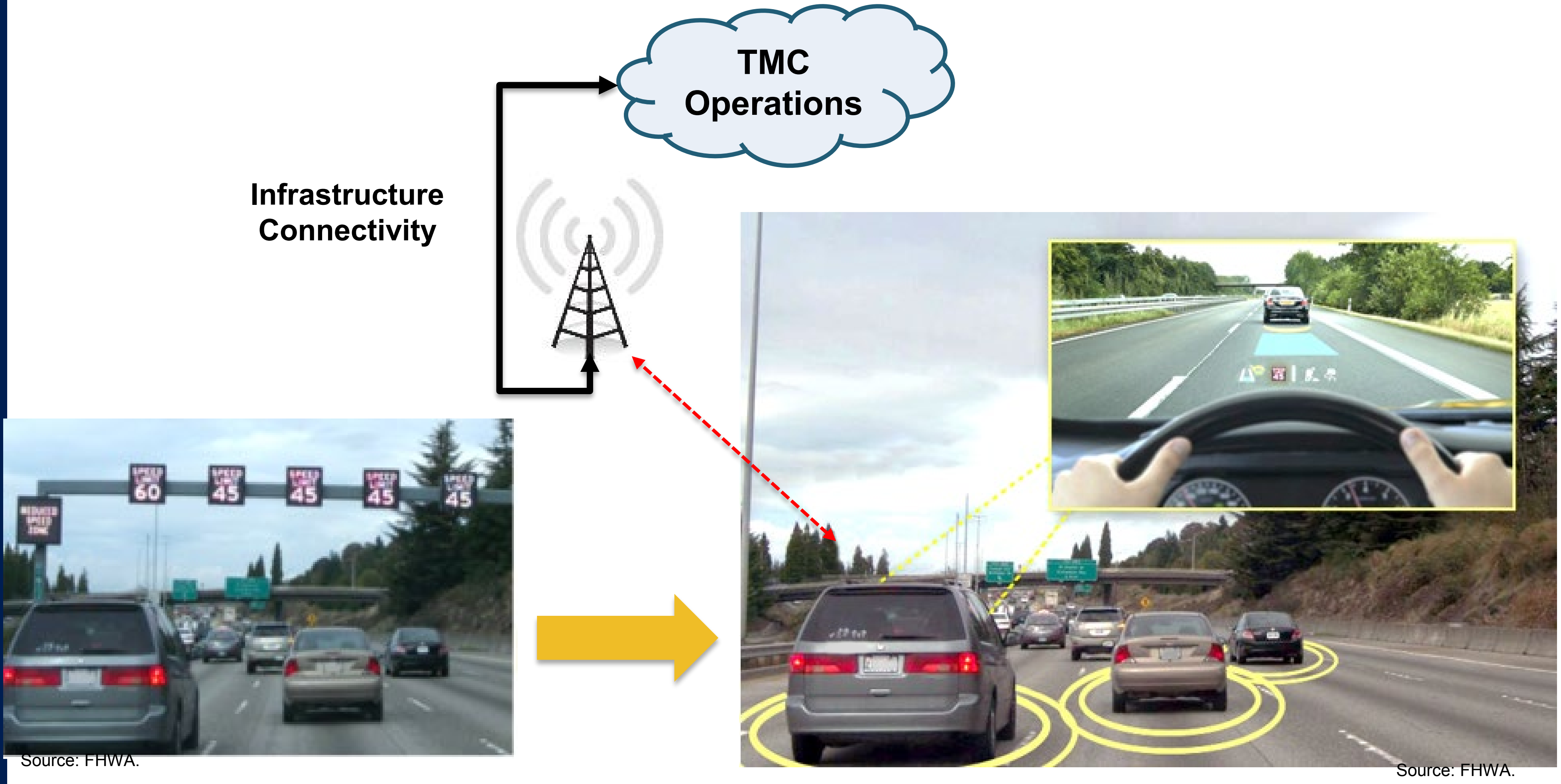
Use Artificial Intelligence (AI) instead of algorithms for incident detection.

Connectivity provides

New Use Cases for Transportation Systems Management and Operations (TSMO).

Connectivity

Important for Managing Our Transportation System



Today – Expensive Infrastructure

Tomorrow – Connectivity

Source: FHWA.

V2X Hub

Features:

- **Software platform is open source.**
- **CAV deployers can implement custom code.**
- **Hub is accessible across different organizations and disciplines.**
- **Program enables integration with existing systems.**

CAV Support Services

Knowledge and equipment provided to advance CAV deployments without additional costs for users.

No-cost equipment loans for CAV deployment sites to test equipment before purchasing.

Help desk to resolve software, equipment, configuration, testing, and security issues.

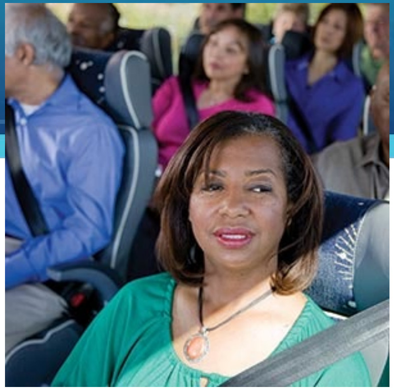
Contact: CAVSupportServices@dot.gov.

Contact us!

Govind Vadakpat, Ph.D., P.E., Highway Research Engineer
FHWA Office of Operations R&D
g.vadakpat@dot.gov

Source: FHWA.

U.S. Department of Transportation
Federal Highway Administration

Federal Motor Carrier Safety Administration

FMCSA

NHTSA Research Day

Nicole Michel
November 21, 2019


FMCSA's Role in Automated Commercial Motor Vehicles

FMCSA's Automated CMV Evaluation (ACE) Program will:

- **Conduct research** to inform safety equivalency decisions for waivers, exemptions, and pilot programs
- **Identify best practices** for industry's use of automated CMVs
- **Remove regulatory barriers** to the operation of automated CMVs
- **Promote safe operation** of automated CMVs

ACE Program Focus Areas

- Roadside Inspections of Automated Driving System (ADS)-equipped CMVs
- Automated CMV Technologies and Capabilities (e Platooning, Advanced Driver Assistance)
- In-service training with FMCSA field staff
- CMV Driver Readiness for Advanced Technologies
- CMV Cybersecurity

ACE Program Resources

- Four tractor-trailers equipped with hardware to enable Level 2/3 automation
- Autoware & CARMA software to enable automation
- To be used as research vehicles in FMCSA's automated CMV evaluation program

USDOT Cooperative Automation Solution

CARMA 3 APPROACH

Advancing Cooperative ADS research with FHWA and FMCSA fleet and partnerships

CARMA PLATFORM

Source: FHWA.

- Expand cooperative automation capabilities.
- Develop proofs of concept to support TSMO use cases.
- Collaborate with Infrastructure Owner-Operator (IOO)/Original Equipment Manufacturer (OEM) community.

Autoware PLATFORM

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- Leverage Autoware open-source software (OSS) development.
- Enable ADS level 2–3 capabilities.
- Engage ADS community.

COOPERATIVE ⟷ AUTOMATION

Five-Year Research, Testing, and Evaluation Timeline

2019

- Collaborate with the AV Industry through open-source AV Software (CARMA)
- Development of FMCSA's Automated Truck Safety Research Plan
- Design and Installation of hardware to equip three tractor-trailers with Level 2/3 automation capability

2020

- Verification testing and deliver of automated tractor-trailers
- Demonstration events with State Law Enforcement partners
- Development of individual test plans and test cases for future year testing

2021-2023

- Conduct test events to research inspection protocols, work-zone area safety, and emergency response situations
- Utilization of FMCSA's automated tractor-trailers for in-service training with FMCSA field staff at academies and training centers
- Joint testing with MARAD utilizing automated trucks in a port drayage setting

Contact Information

Nicole Michel

Automated CMV Evaluation
Program Manager

202-366-4354
Nicole.Michel@dot.gov