STANDARDS ITS TRAINING

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U.S. Department of Transportation

Office of the Assistant Secretary for
Research and Technology

Welcome

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www.pcb.its.dot.gov

MODULE 11:

Transit and the Connected Vehicle Environment/Emerging Technologies, Applications, and Future Platforms

Updated 2020

Instructor

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President

RK Patel Associates, Inc.

Learning Objectives

- Describe the connected vehicle (CV) environment
- Identify potential communications technologies that may be used in a transit CV environment
- Review the standards that support the transit CV environment
- Describe transit CV applications
- Identify the challenges and approaches to the successful deployment of transit CV applications

Learning Objective 1

Describe the Connected Vehicle (CV) Environment

Connected Vehicle (CV) Environment

CV Environment

CV Environment Consists of:

- V2X (V to Everything…)
  - Vehicle to Vehicle (V2V)
  - Vehicle to Infrastructure (V2I)
  - Vehicle to Pedestrian (V2P)

CV Communications:

- Wireless
- Mixture of:
  - Short-range communications-open
  - Remote communications, e.g. devices to Traffic Management Center (TMC)

- **Safety/Mobility Applications**

Connected Vehicle (CV) Environment

Transportation Challenges addressed by CV

- 6.45 million+ crashes (2018)
  - 7040 transit crashes

36,550 fatalities in 2018
  - 6283 pedestrians (17%)

- Reduce crashes by 20-80%

6 billion+ wasted hours (2018)

- Reduce congestion by 15-42%
- Improve mobility of those with disabilities
- Support automated driving

Total Emissions-
6,457 million metric tons of CO_2 equivalent

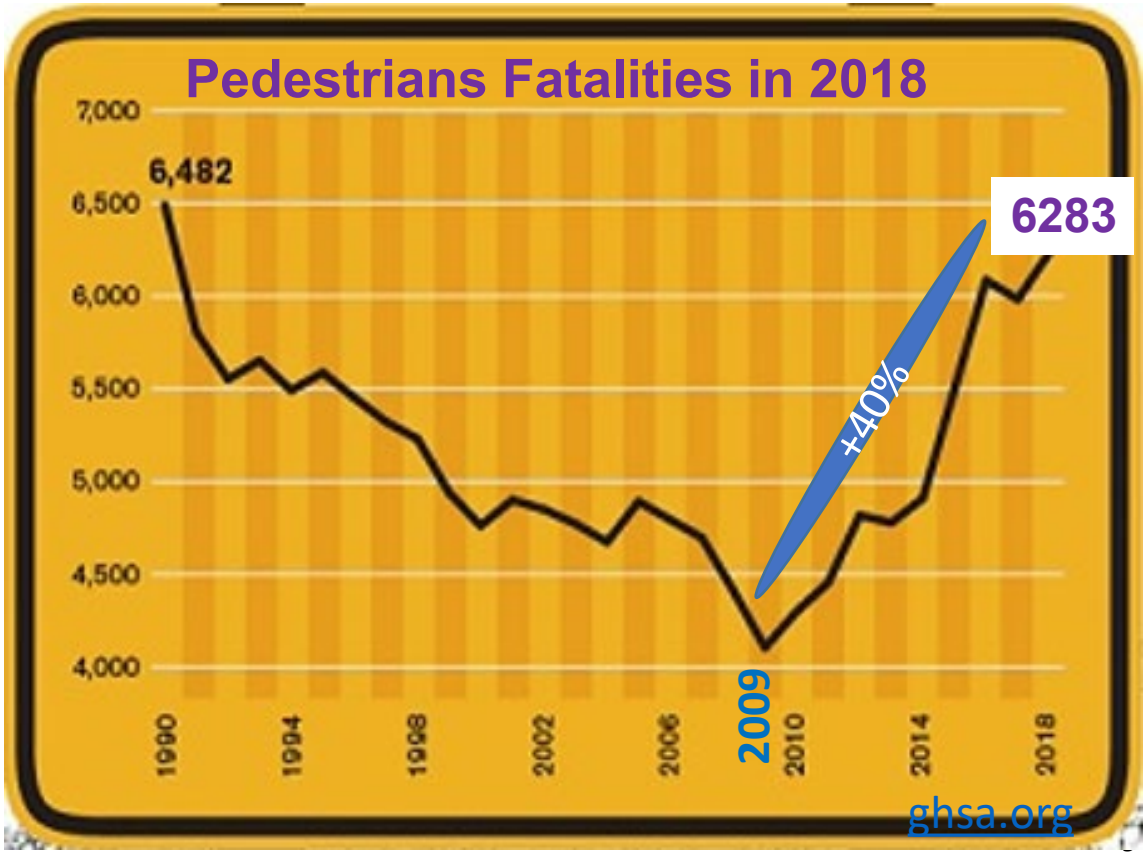
- Reduce pollution by ~10%

Connected Vehicle (CV) Environment

Vehicle-to-Pedestrian (V2P) Safety Challenges

- Transit vehicles operating in environments with non-transit vehicles and pedestrians pose a unique challenge, e.g., turning movements

Source: NYCDOT



Areas of Applications-Transit Examples

SUPPLEMENT

V2I Safety

- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

Agency Data

- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies
- Work Zone Traveler Information

Environment

- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority
- Connected Eco-Driving
- Wireless Inductive/Resonance Charging
- Eco-Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Traveler Information
- Eco-Ramp Metering
- Low Emissions Zone Management
- AFV Charging / Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
- Eco-ICM Decision Support System

Road Weather

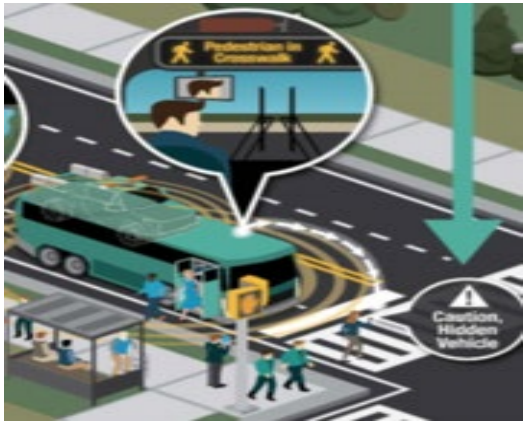
- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

Mobility

- Advanced Traveler Information System
- Intelligent Traffic Signal System (I-SIG)
- Signal Priority (transit, freight) — TSP
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Dynamic Speed Harmonization (SPD-HARM)
- Queue Warning (Q-WARN) — PCW
- Cooperative Adaptive Cruise Control (CACC)
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
- Emergency Communications and Evacuation (EVAC)
- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (T-DISP)
- Dynamic Ridesharing (D-RIDE)
- Freight-Specific Dynamic Travel Planning and Performance — VTRW
- Drayage Optimization

Smart Roadside

- Wireless Inspection
- Smart Truck Parking



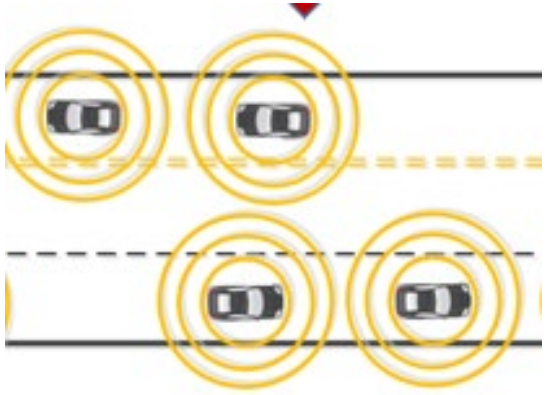
Connected Vehicle (CV) Environment

What has Changed (different)?

- Internal vehicle-based sensor data (speed, size, position...) not sufficient for reliable hazard detection-prediction

- "Connected vehicle" sensor data broadcasted **externally** to other vehicles in the vicinity, for issuing application-driven warning-alert

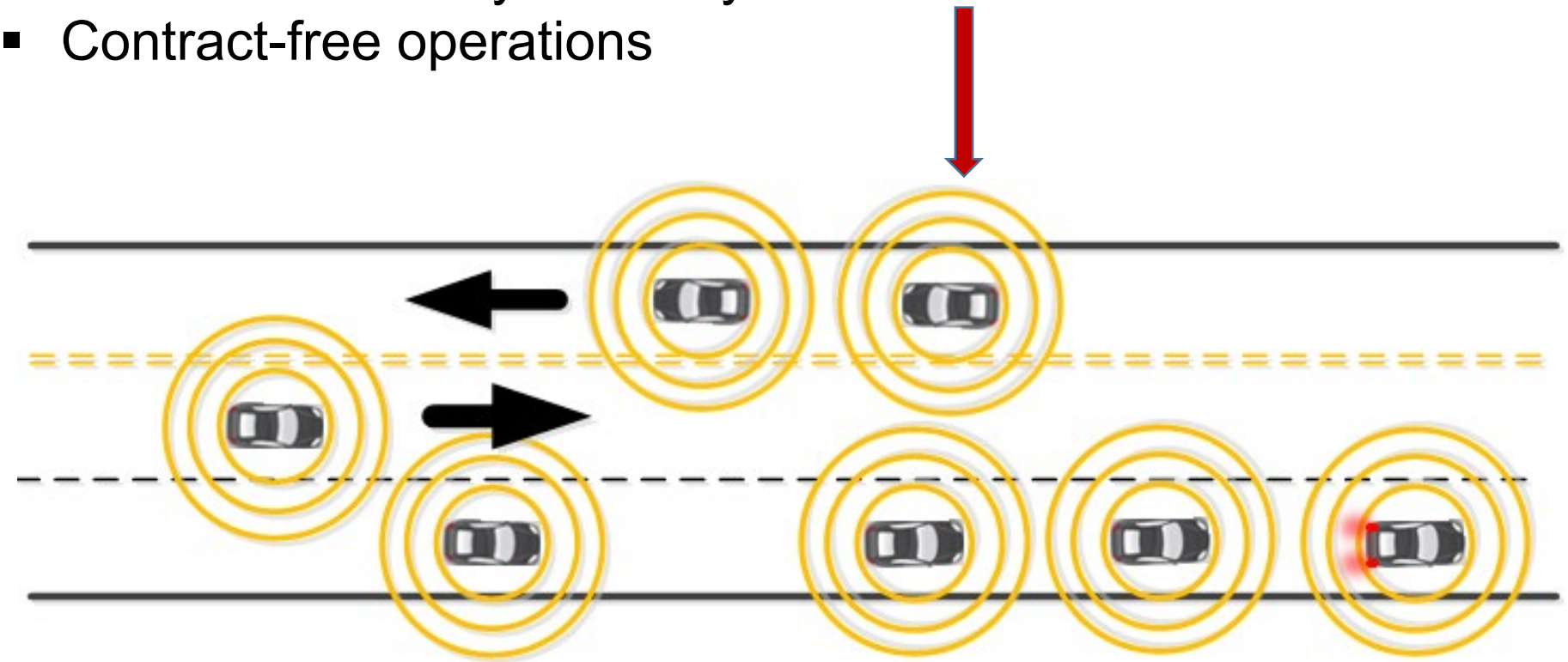
Cooperative ITS (C-ITS)



Connected Vehicle (CV) Environment

Ad-Hoc Roadside Wireless Connectivity has Arrived

- Vehicles/devices access and “contact” each other
- Act and behave-dynamically as “**nodes**”
- Contract-free operations

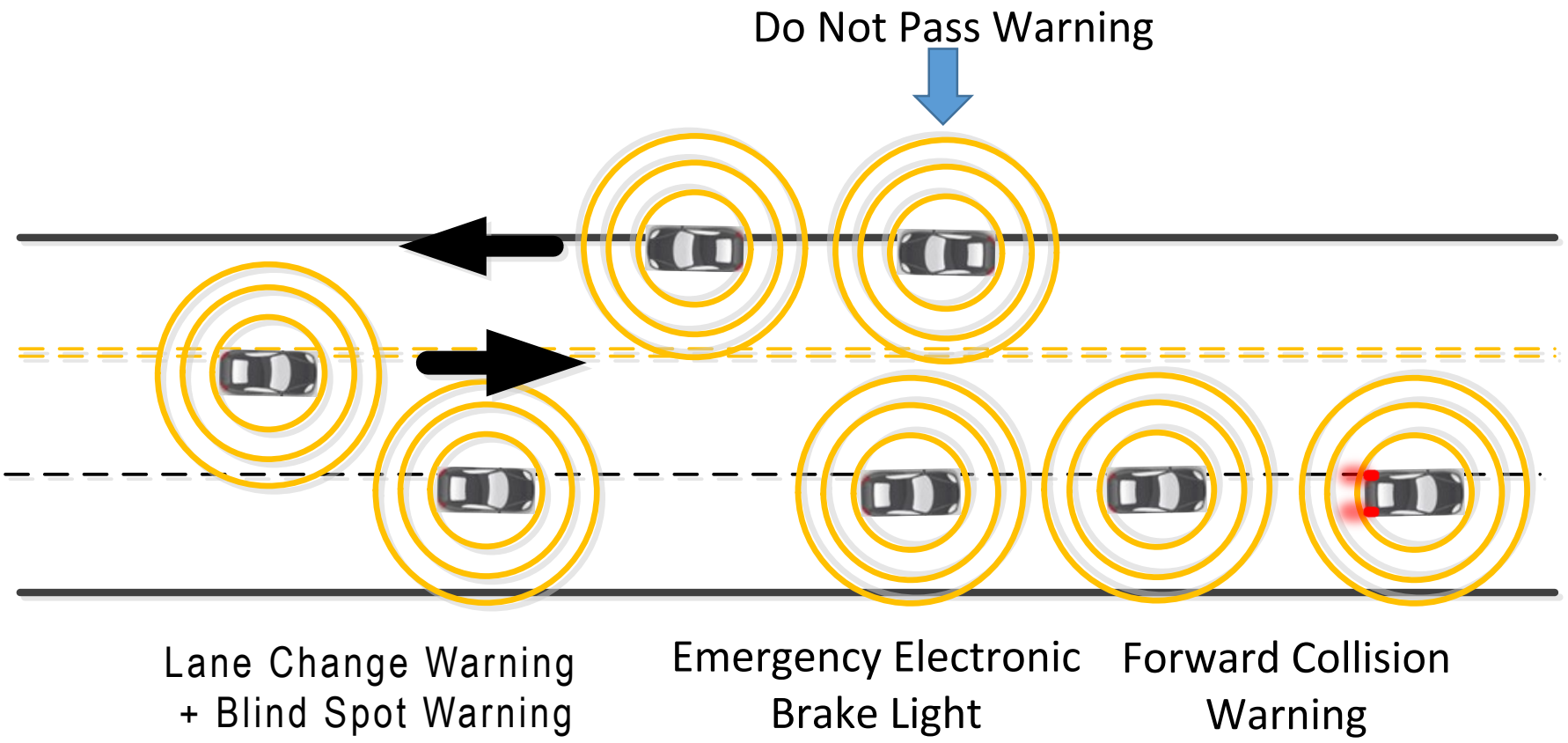


Basic Safety Message (BSM) Application

- Application-based short data packet
- Communicated to other vehicles 10 times per sec. or less
- Creates 360 degree awareness of surrounding

BSM conveyed data is used by vehicle-based **application** to determine if a collision threat exists

Illustrate V2V Warning Messages for Drivers



Demonstration: V2P

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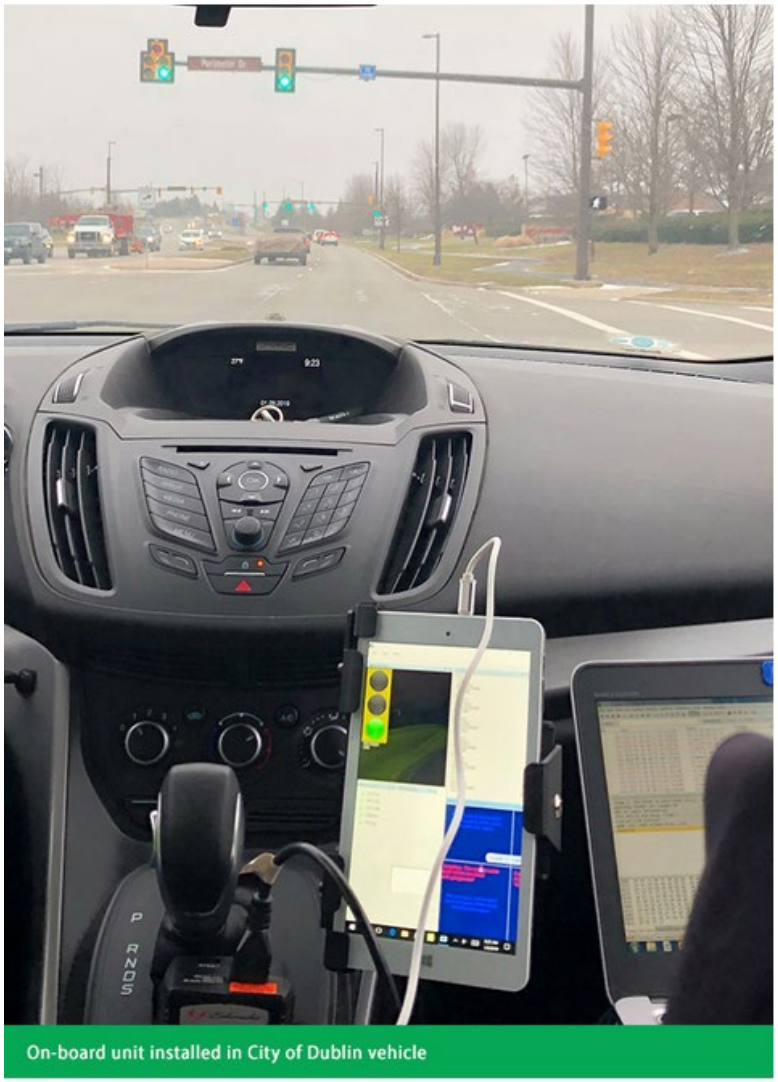
Operational Device: On-Board Unit (OBU)

- Device transmits/receives messages (data) from other devices in the vicinity
- Application process data and determine if a threat exists; issues a warning/alert to driver

Danlaw V2X ASD being installed in the participant vehicles of the NYCDOT CV Pilot



On-board unit installed in City of Dublin vehicle

Operational Device: Roadside UNIT (RSU)

- Transmits/receives messages from OBUs

Source: City of Dublin, OH

Operational Device: Roadside Equipment (RSE)

- Intersection level traffic controller processing equipment, includes RSU, and backhaul connectivity to Traffic Management Center (TMC)

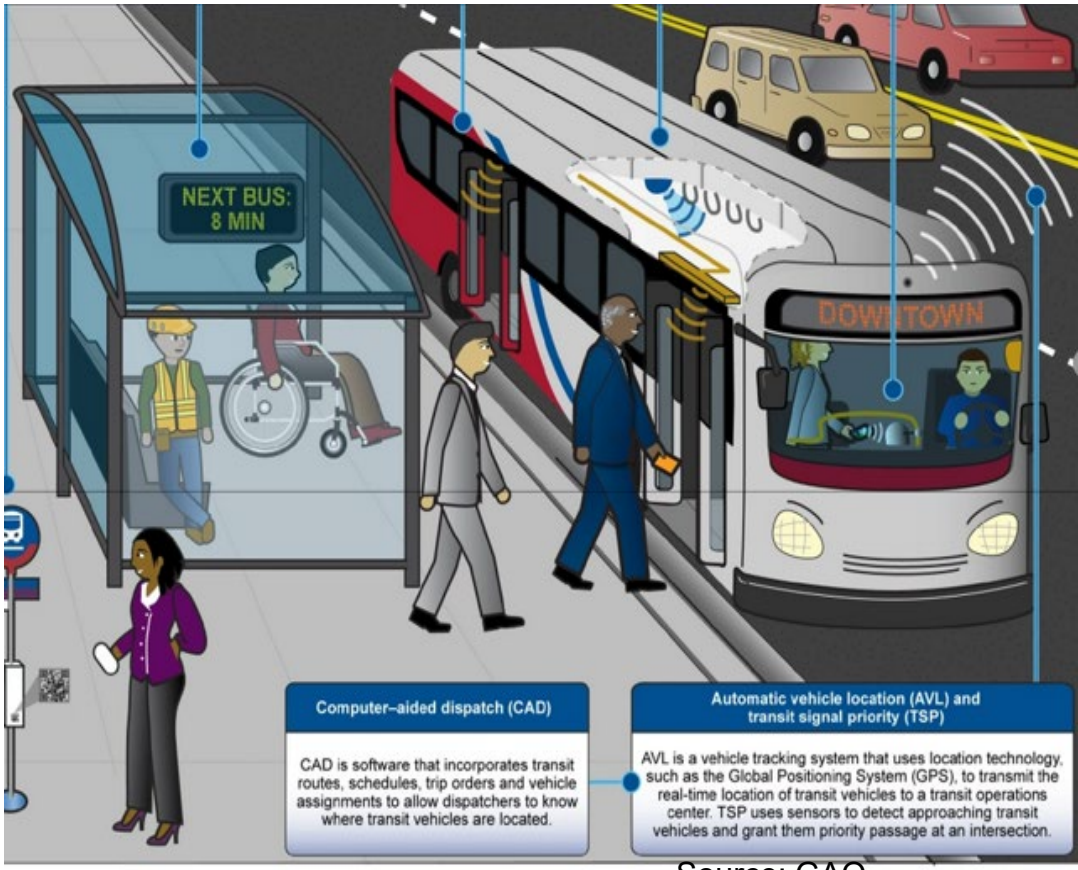
Transit CV Environment

What Transit Managers should Know about CV

- New class of safer-smarter transit vehicles have arrived….
- V2V will open the gates for V2X: V2I, V2P- all transit customers

OEM
Original Equipment Manufacturer

ASD
Aftermarket Safety Devices
e.g. NYC 8000 vehicles



Source: GAO

Transit CV Environment

What Transit Managers should Know about CV (2)

- Customer-centric Route-specific information
- How can the CV standards help me to improve my transit service?
- How can I manage CV technology?

Source: GAO analysis of interviews with transit providers regarding smart phone applications. | GAO-16-638

Traveler information systems (TIS)

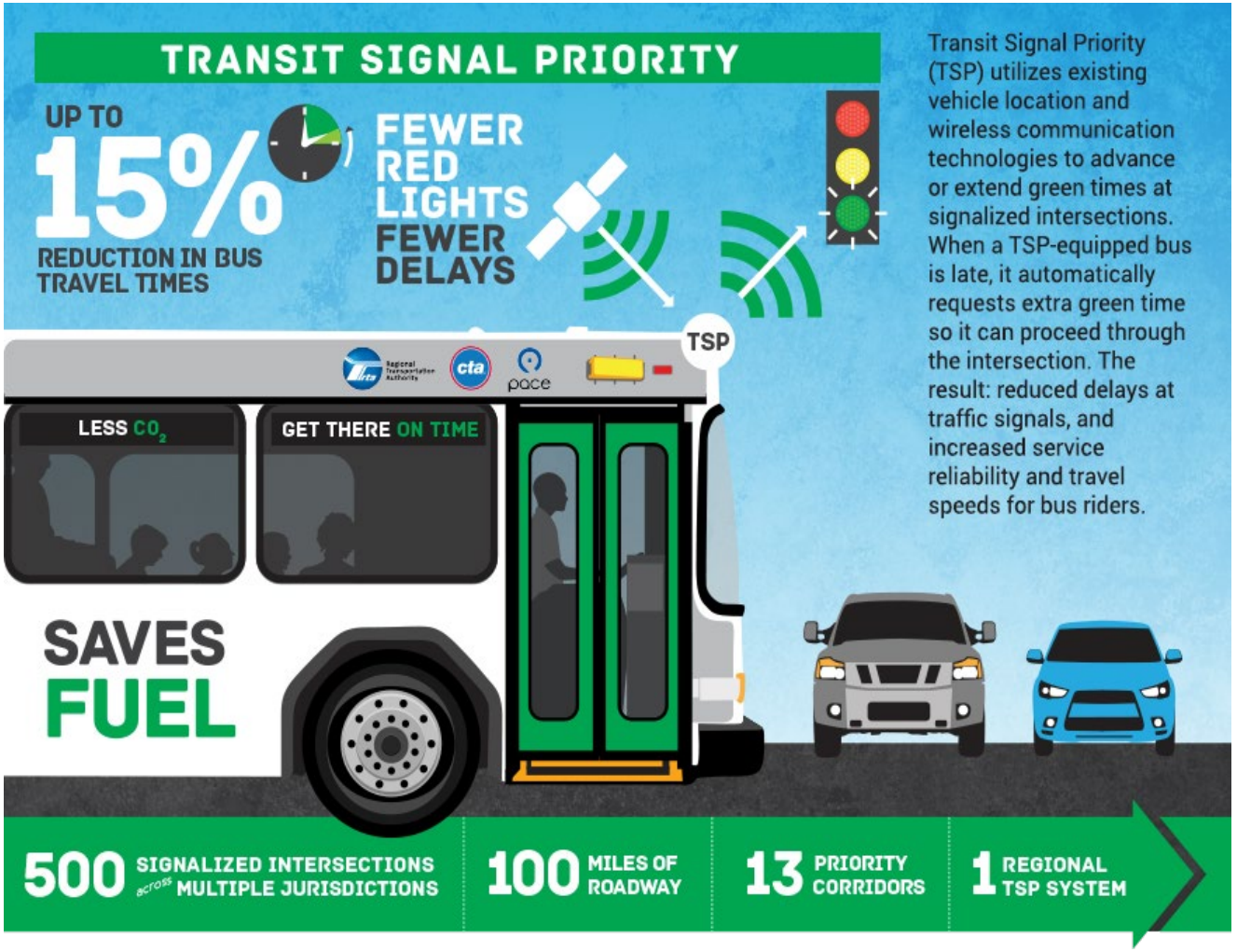
TIS enable transit customers to receive travel information such as arrival times, delays, or changes to service.

Source: GAO

Transit CV Environment

Transit Signal Priority (TSP),Chicago

With about **300** million bus trips made each year by transit riders across the Chicago region, integration of TSP technology on CTA and Pace buses will provide riders with improved on-time dependability and reduced travel times.

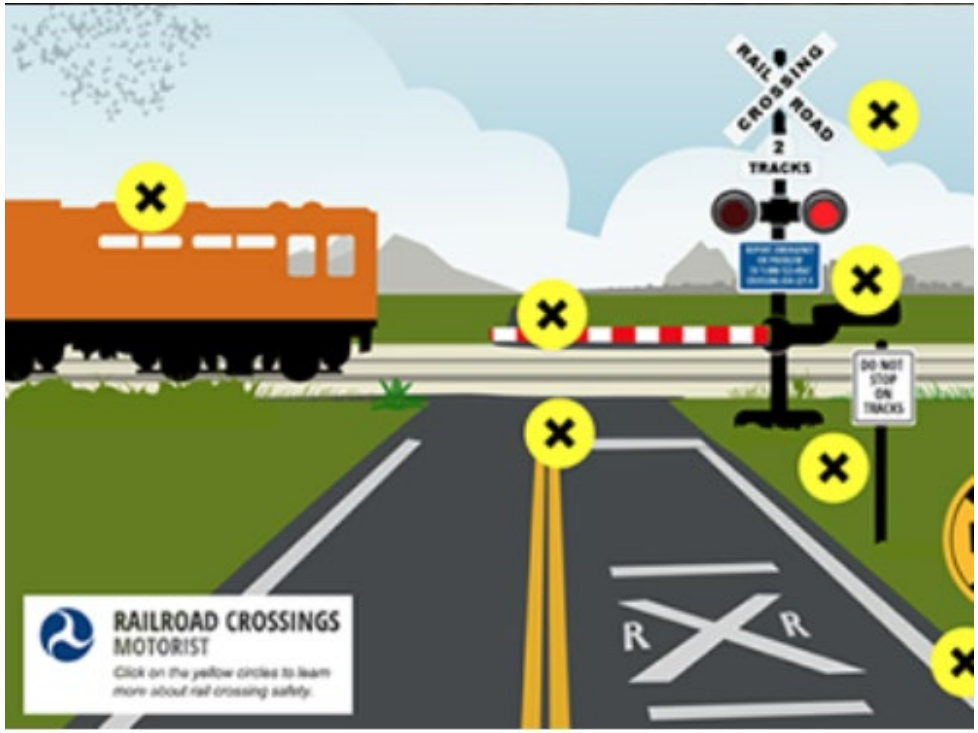


Source: RTA

Transit CV Environment

Highway-Rail Grade Crossings (V2V, V2I)

- 685 crashes in 2018
- 281 fatalities



Train Approaching Warning

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Question

Which of the following is an incorrect statement related to CV applications?

Answer Choices

a) On-Board Unit (OBU) is required for V2V communication.

b) Roadside Unit (RSU) is required for V2I communication.

c) ONLY Aftermarket Device (ASD) broadcasts Basic Safety Message (BSM).

d) V2X includes all forms of CV communication services.

Review of Answers

a) On-Board Unit (OBU) is required for V2V communication.

Incorrect. Statement is true, OBU does transmit/receive vehicle information and is required.

b) Roadside Unit (RSU) is required for V2I communication.

Incorrect. True statement, RSU will be needed for V2I communication.

c) ONLY **ASD** broadcasts Basic Safety Message (BSM).

Correct! Statement is false, functionally of both OBU and ASD are same, and can form and broadcast a BSM within the CV environment. ASD is referred by CV pilot projects for OBU.

d) V2X includes all forms of CV communication services.

Incorrect. True statement, V2X includes V2V, V2I and V2P applies to both DSRC and C-V2X approaches.

Learning Objective 2

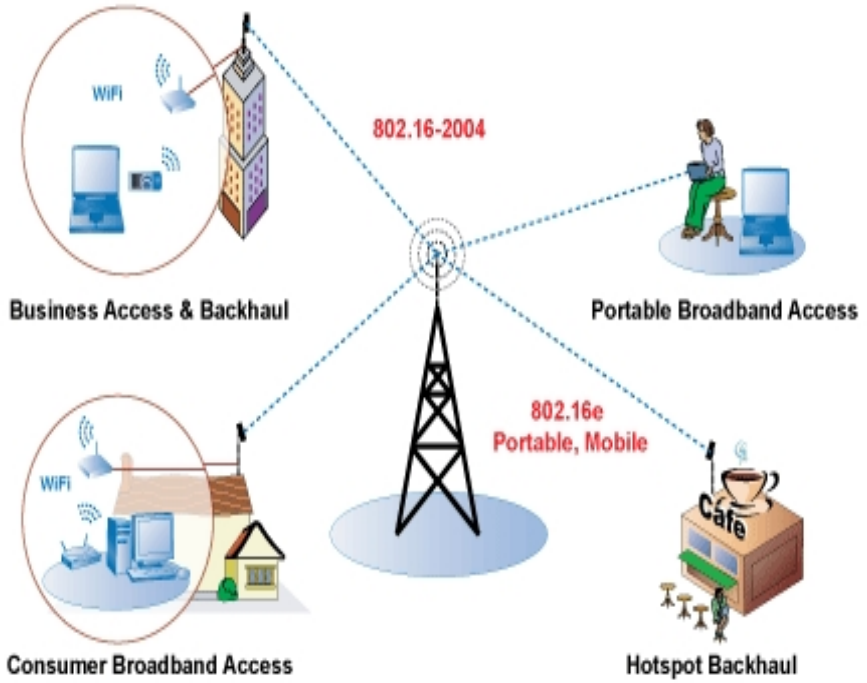
Identify potential communications technologies that may be used in a transit CV environment

Review of Various Communications Technologies

Wi-Fi

Data Rate: 6-54Mps
Bandwidth: 20Mhz
IEEE std. 802.11a

Wi-Max

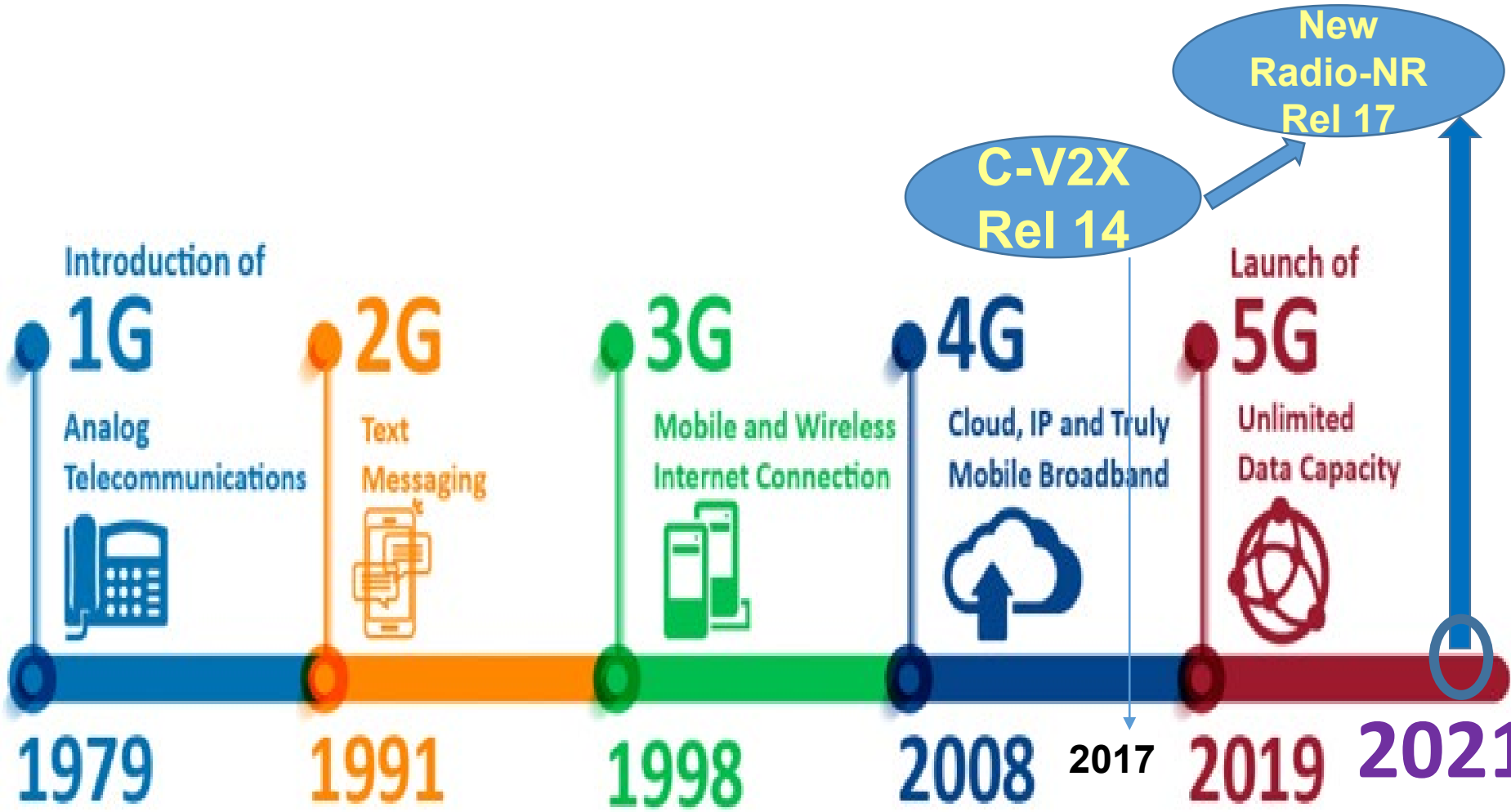


Data Rate: 1-32Mps
Bandwidth: 10Mhz
IEEE std. 802.16e

Review of Various Communications Technologies

LTE-Long Term Evolution

SUPPLEMENT



Review of Communications Technologies

3GPP (Third Generation Partnership Project)

Cellular (C) Data

- Based on cellular technologies (3GPP standards)
- Cellular data envisioned to support V2X, such as:
  - Infotainment
  - Large file transfers
  - Vehicle-to-Center communications

C-V2X proposed as a replacement for some/all of the 5.9 GHz spectrum assigned to WAVE (Wireless Access Vehicle Environment), but still for ITS usage

C-V2X enables network independent communication. (PC5 Interface)

C-V2X enables network services in licensed spectrum for complimentary services. (V2N-UU interface)

Review of Communications Technologies

Competing CV Communications Alternatives

1

DSRC

Dedicated Short Range Communication

Proven Technology

- ✓ Defined by IEEE Standards (WAVE)
- ✓ PHY layer 802.11 p standard
- ✓ Dedicated Radio in 5.9 GHz spectrum

2

C-V2X

New-Emerging Technology

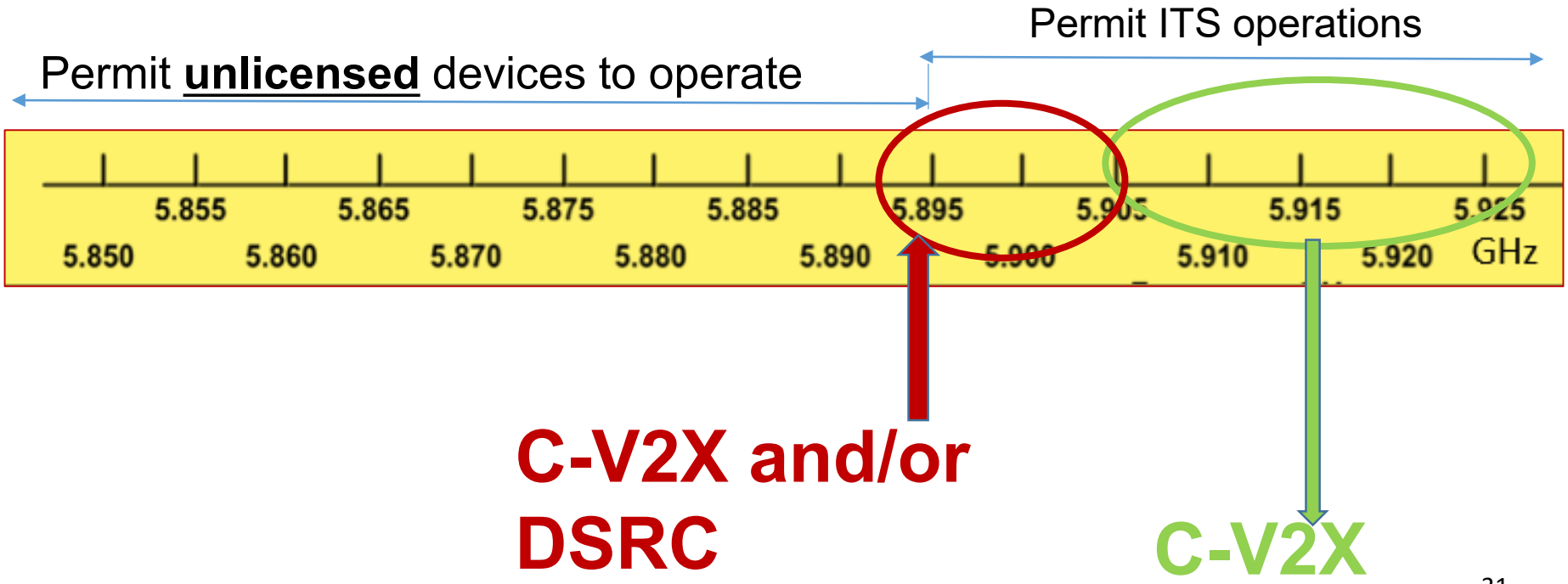
- ✓ Defined by 3GPP, Release 14….
- ✓ Dedicated Radio in 5.9 GHz spectrum
- ✓ Additional radio in the licensed cellular band (LTE/5GNR-Relese 17)

Review of Communications Technologies

3

DSRC + C-V2X

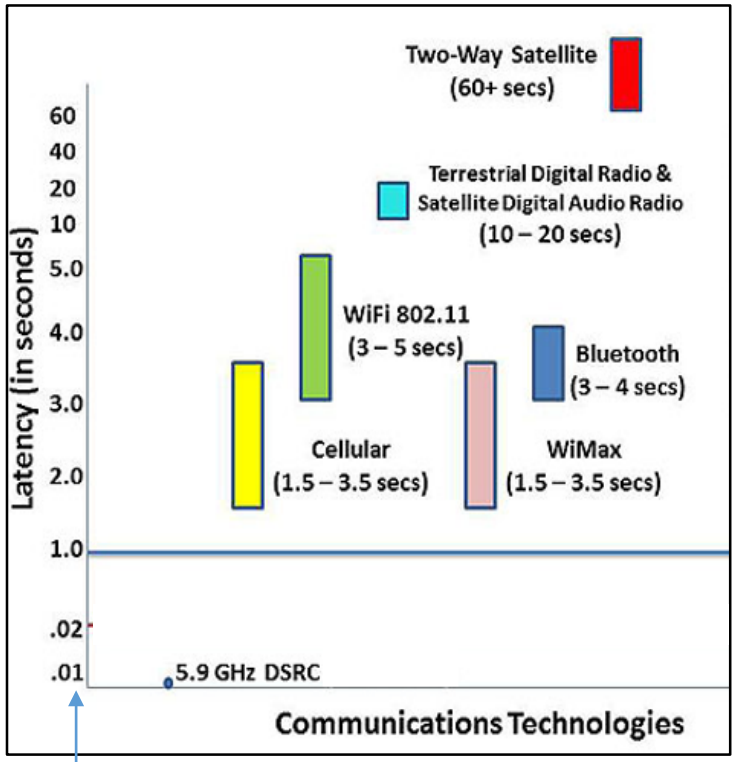
Possible new alternative under the reallocation of spectrum by FCC



Review of Communications Technologies

Key Factor: Latency-a measure of time delay experienced in a system

Example: FCW application limits 0.1 sec latency



DSRC offers low latency communication

DSRC (Dedicated Short Range Communication)

DSRC Communication Requirements

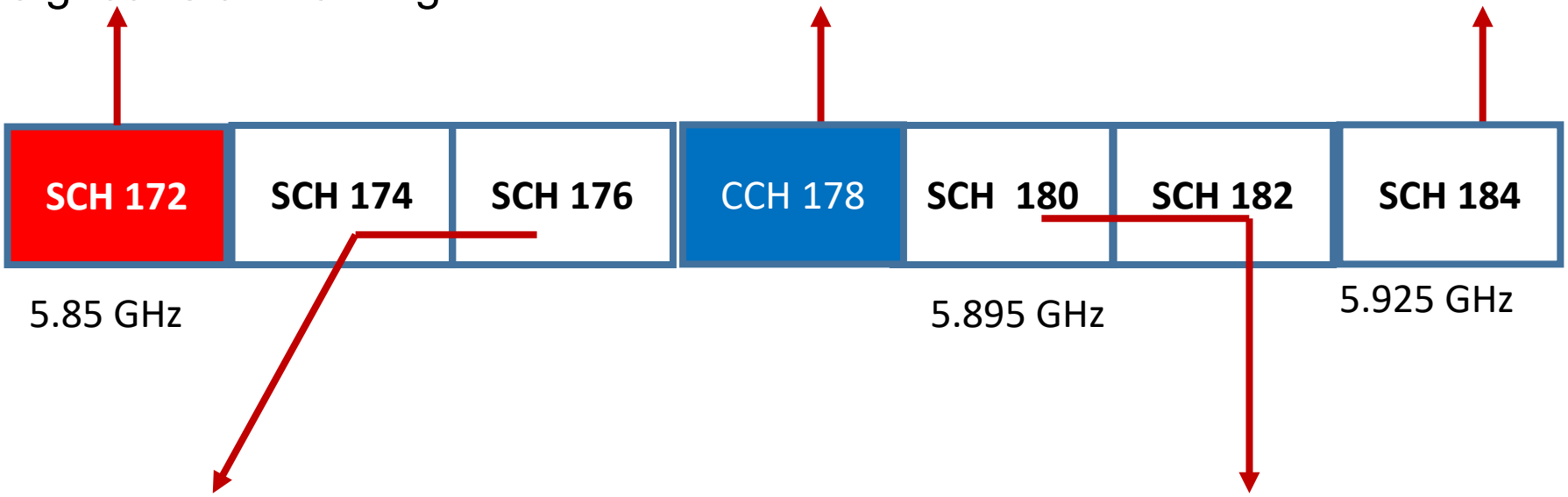
- 5.9 GHz dedicated spectrum
- IEEE 1609 Wireless Access in Vehicular Environments (WAVE) standards
- Security Credential Management System (SCMS)
- RSU and OBU (Aftermarket Safety Device-ASD)
- IEEE 802.11 for PHY layer single channel transmission

Current US Channel Assignments

Reserved for emergency vehicles uses higher power

Dedicated to Public safety applications
e.g. collision warning

Advertises services available on other channels



DOWNLOAD- application software and operational parameters

UPLOADING- mobility-operations and performance logs

DSRC

Channel Switching Issue: DSRC Radio Broadcasts on one channel at a time-a technology constraint

Dual Radio Solution

OBU

OBU Configures

Radio 1
Always-ON
Safety
Channel 172

Listening for Basic Safety Messages

Radio 2
Other
Channels
174-176-178-180-182-184

Listening for Other Messages Information

DSRC

Advantages

- Established, proven technology
- Tested environment sustainability
- No subscription necessary
- Low latency, higher data rate, 3-27 Mbps

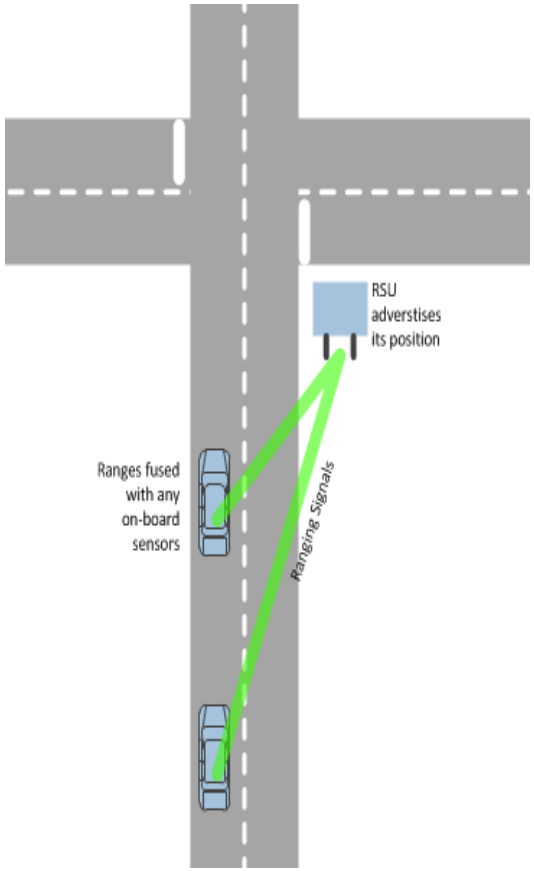
Disadvantages

- Needs Government support
- Limited Spectrum-channel congestion
- Potential impacts on SCH 172

Other Potential Deployment Issues…

- **Retrofitting** Vehicles: Limited RSUs deployed today
- **Spacing** RSE at 300 meter may be a disadvantage
- **Maintenance** is a long-term burden

Source: NYCDOT



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Question

Which of the following is NOT a current attribute of DSRC?

Answer Choices

a) Low latency

b) No subscription required

c) Widely deployed in vehicles

d) Short to medium range

Review of Answers

a) Low latency

Incorrect. Low latency is a benefit of DSRC.

b) No subscription required

Incorrect. DSRC does not require subscription which makes it more accessible.

c) Widely deployed in vehicles

Correct! At this time, there are relatively few vehicles equipped with DSRC. US is now engaged in testing deployments. This may change in future.

d) Short to medium range

Incorrect. Short to medium range is a core characteristic of DSRC.

Learning Objective 3

Review the standards that support the transit CV environment

Standards Required for Transit CV Environment

Types of Standards

Transmission Standards for Wireless Connectivity

- ✓ IEEE 802.11–**Radio Operation**
- ✓ IEEE 1609 Family of Standards for Wireless Access in Vehicular Environments (WAVE)

Interface and Dictionary Standards

- ✓ SAE J2945.x family: **Interface** Standards
- ✓ SAE J2735 DSRC **Message** Set Dictionary

Transit Applications Standards

- ✓ TCIP (Transit Communications Interface Profiles)
- ✓ SIRI (Service Interface for Real Time Information
- ✓ GTFS-RT (General Transit Feed Specification-Real-time)

Training Modules at:
https://www.pcb.its.dot.gov/stds_modules.aspx

Transmission Standards for Wireless Connectivity

IEEE 802.11 (2016)

- Describes specification for wireless connectivity using DSRC services for:
  - ASTM 2213-03 specification requirements
  - Media Access Control (**MAC**): the message protocols that allow applications to 'connect' to the PHY layer
  - PHY: the radio chips and the intervening environment in between
- IEEE 802.11 enables Ad-hoc wireless communication with IEEE 1609.x standards

Transmission Standards for Wireless Connectivity

IEEE 1609™ Family of Standards for Wireless Access in Vehicular Environments (WAVE) (2016)

IEEE 1609.0: Guide for Wireless Access in Vehicular Environments (WAVE) Architecture (2019)

IEEE 1609.2: Security Services for Applications and Management Messages

1609.2.1 adds SCMS (pending)

IEEE 1609.3: Network and Transport Services

IEEE 1609.4: Multi-Channel Operation Standards

IEEE 1609.12 Identifier Allocations

PCB Module CV 265 Covers IEEE 1609 WAVE Standards

Interface and Data Dictionary Standards

SAE J2945.X Sets Performance Requirements

- How to use management, facilities, and security to implement a specific application, as defined by use cases
- Performance/functional requirements:
  - What, when and how often a message is sent (minimum, typical, maximum)
  - Minimum quality requirements
  - Security requirements
  - Dialogs and data
  - Requirements Traceability Matrix (RTM)

https://www.sae.org/standards/content/j2945_201712/

Interface and Data Dictionary Standards

Completion of Key Interface Standards

- SAE J2945.0 Systems Engineering Guidance
- SAE J2945/1 V2V Safety Application
  - Conformance Test Specifications
- SAE J2945/2 V2V Awareness Application
- SAE J2945/9 Vulnerable Road User Application

https://www.sae.org/standards/content/j2945_201712/

Interface and Data Dictionary Standards

SAE J2735 DSRC Message Set Dictionary Defines Data Structure

Data Elements
Primitive Objects e.g. Speed,3D position, Acceleration.

Data Frames
Collection of Data Elements

Messages
Collection of Data Elements Data Frame(s)

Part I: Core data elements for safety applications, broadcasted **frequently**, e.g. speed

Part II: Data elements added to Part I data, but broadcasted **less frequently**, e.g. brake status

Interface and Data Dictionary Standards

SAE J2735 Messages for CV Applications

MessageFrame (FRAME)
BasicSafetyMessage (BSM)
CommonSafetyRequest (CSR)
EmergencyVehicleAlert (EVA)
IntersectionCollisionAvoidance (ICA)
MapData (MAP)
NMEAcorrections (NMEA)
PersonalSafetyMessage (PSM)
ProbeDataManagement (PDM

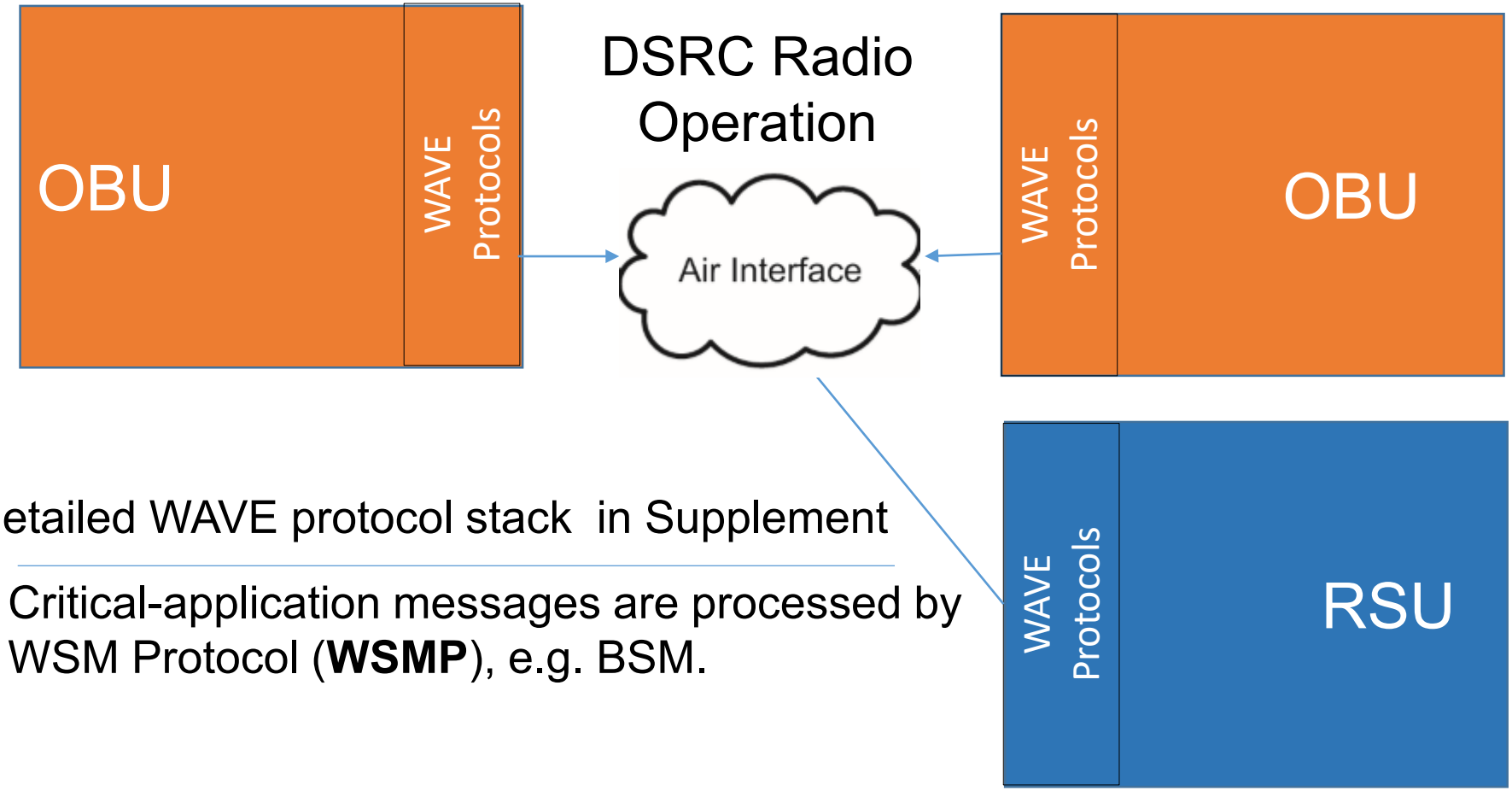
ProbeVehicleData (PVD)
RoadSideAlert (RSA)
RTCMcorrections (RTCM)
SignalPhaseAndTiming Message (SPAT)
SignalRequestMessage (SRM)
SignalStatusMessage (SSM)
TravelerInformation Message (TIM)
TestMessages

Example: BasicSafetyMessage (BSM)

Message ID	Message Type	Time Stamp	Position	Velocity	Message Check

Summary of CV Standards

Example of Safety Messages Processing



Detailed WAVE protocol stack in Supplement

Critical-application messages are processed by WSM Protocol (**WSMP**), e.g. BSM.

Non-safety application messages/information are processed by IPv6 protocol (not shown here).

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Question

Which of the following is NOT a Wireless Connectivity standard?

Answer Choices

a) IEEE 1609 family

b) SAE J2735 data dictionary

c) APTA TCIP

d) IEEE 802.11

Review of Answers

a) IEEE 1609 Family

Incorrect. Statement is true, we need IEEE 1609 family standards to enable wireless connectivity.

b) SAE J2735 data dictionary

Incorrect. Statement is true, J2735 is a dictionary standard that provides for the BSM.

c) APTA TCIP

Correct! The TCIP is an application-oriented standard for transit and it is not required for wireless functionality.

d) IEEE 802.11

Incorrect. This standard is the baseline standard needed to deal with PHY layer medium connection in WAVE implementation.

Learning Objective 4

Describe the applications being developed in a transit CV environment

CASE STUDY

STANDARDS ITS TRAINING TRANSIT

U.S. Department of Transportation
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Image Source: Thinkstock USDOT

V2I Transit Safety Applications

"After a bus killed a 23 year old women at a Queens intersection, the DOT redesigned the intersection for the safety. And now, a bus has killed a man at the same spot."
–WNYC.org

V2I Transit Safety Applications

"*Edgar Torres* was walking to his 6 a.m. dialysis appointment at Wyckoff Medical Center.

At 5 a.m., he reached the intersection of Myrtle Avenue, Wyckoff Avenue, and Palmetto Street. Witness Jose Velez said Torres had the light and was in the crosswalk when the crash occurred.

"He was already halfway through the intersection when the bus came turning and boom!" Velez said of the collision. "I seen the body there laying."

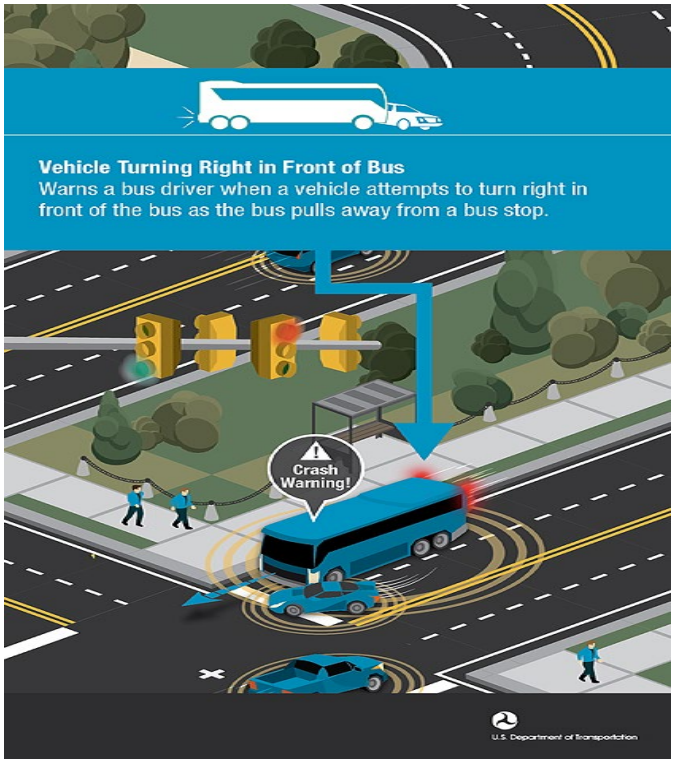
by Jim O'Grady wnyc.org

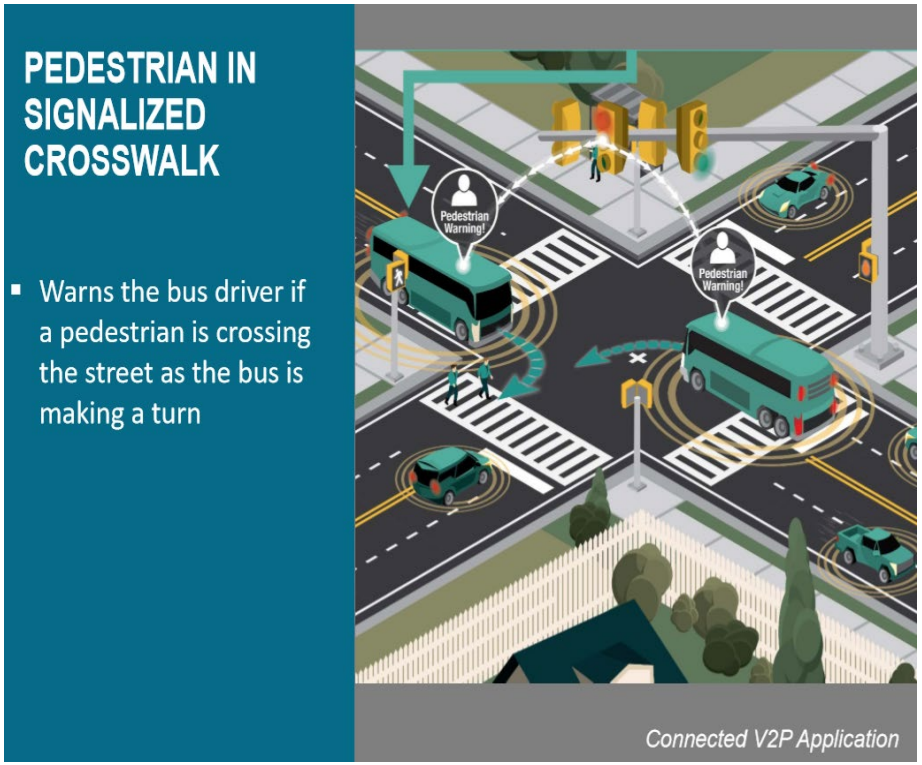
V2I Transit Safety Applications

NYC CV Pilot Pedestrian Safety Applications

- **VTRW** (Vehicle Turning Right in Front of Bus)
- **PCW** (Pedestrian in Crosswalk Warning)

1500 MTA Transit Buses-Heavily Traveled Routes





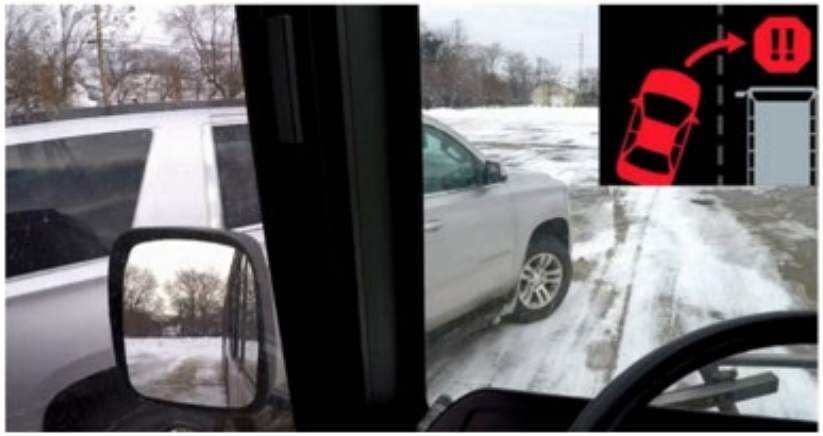
V2I –V2V Transit Safety Applications

Greater Cleveland Regional Transit Authority (GCRTA)

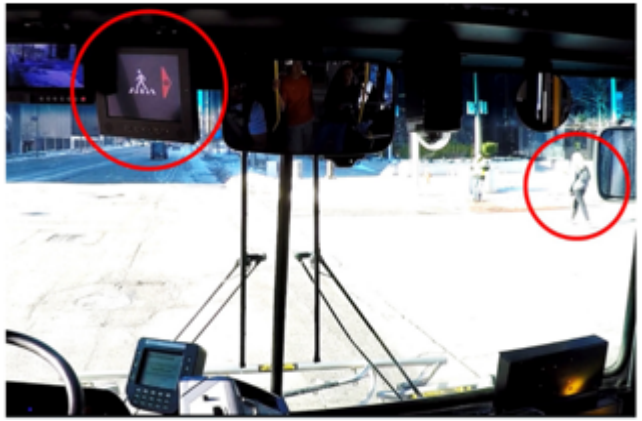
- **E-TRP** (Enhanced Transit Safety Retrofit Package Project)

24 Transit Vehicles, 3 Intersections

Enhanced-Vehicle Turning Right in Front of Bus Warning (**E-VTRW**)



Enhanced-Pedestrian in Crossing Warning (**E-PCW**)

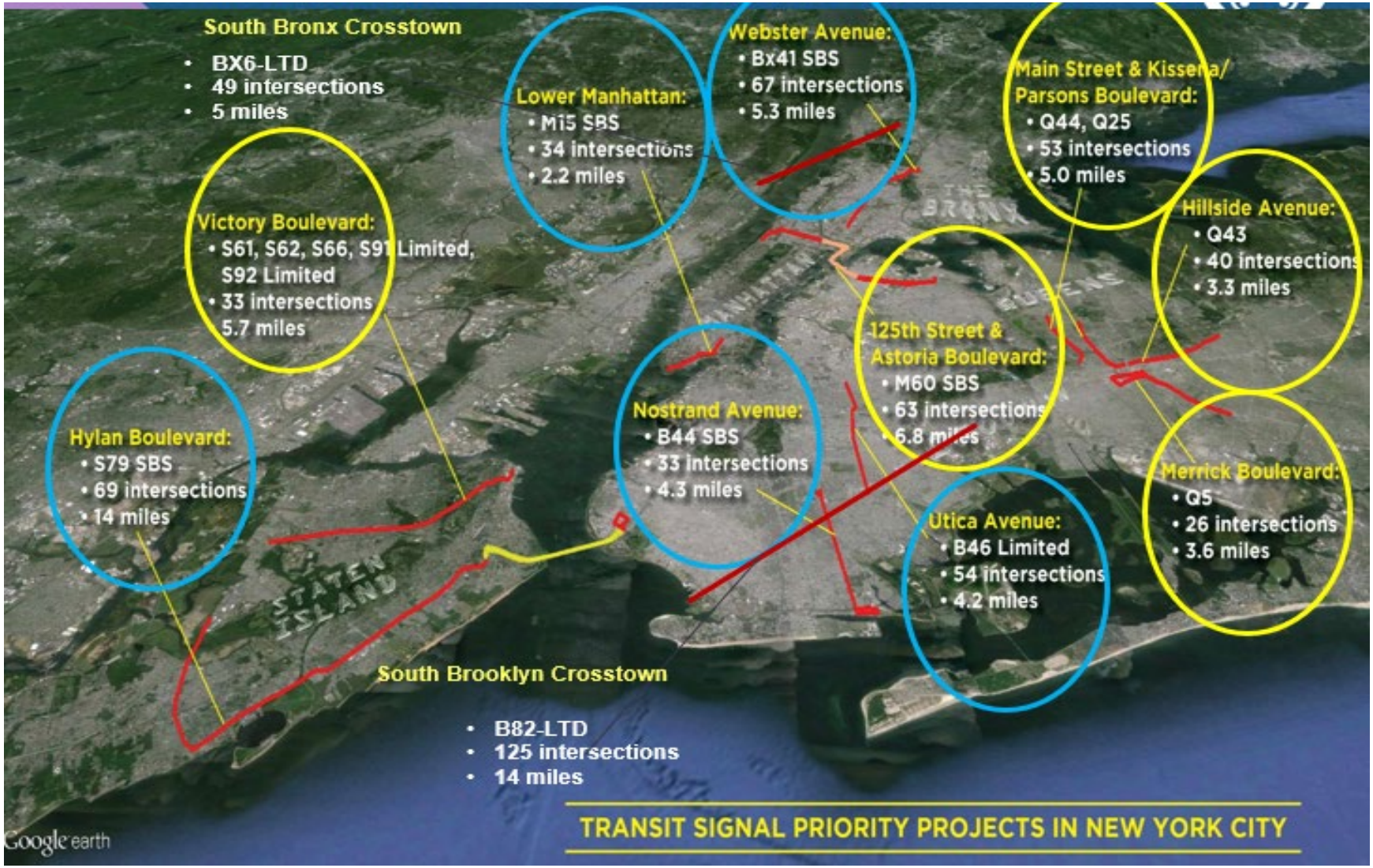


Source: Battelle Memorial Institute-USDOT

81% Correct alerts
10% Incorrect alerts
9% False alerts
16% Increase in driver braking response

GCRTA

V2I Transit Safety Applications



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Question

Which of the following is not a transit CV safety application?

Answer Choices

a) Pedestrian turning in Front of Bus Warning (VTRW)

b) Enhanced Forward Collision Warning (E-FCW)

c) Highway-Rail Grade Crossing

d) Transit Signal Priority (TSP)

Review of Answers

a) Pedestrian turning in Front of Bus Warning (VTRW)

Incorrect. VTRW avoids a potential conflict with pedestrian movement.

b) Enhanced Forward Collision Warning (E-FCW)

Incorrect. E-FCW issue a warning alert avoiding potential V2V collision.

c) Highway Grade Crossing

Incorrect. It is a potential use case-application having impacts on collisions.

d) Transit Signal Priority (TSP)

Correct! TSP is a V2V-V2I mobility improvement application.

Learning Objective 5

Identify the challenges and approaches to the successful deployment of a transit CV environment

Challenges and Approaches to the Successful Deployment of a Transit CV Environment

Key Areas of Challenges

User Group
Transit Agency
Traffic Managers
Roadway Engineers
Maintenance Staff
Transit Vehicle Driver
Transit Passengers
Pedestrians and Other Drivers

Source: Battelle

What should we consider?

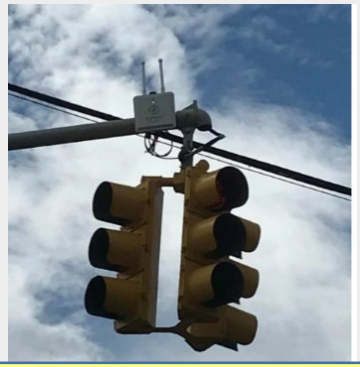
- Institutional Framework
- Technology
- System Integration Issues
- Procurement-Deployment Issues
- Security

Challenges and Approaches to the Successful Deployment of a Transit CV Environment

Institutional Framework Requirements

Jurisdictional Partnerships

TRANSIT-TRAFFIC



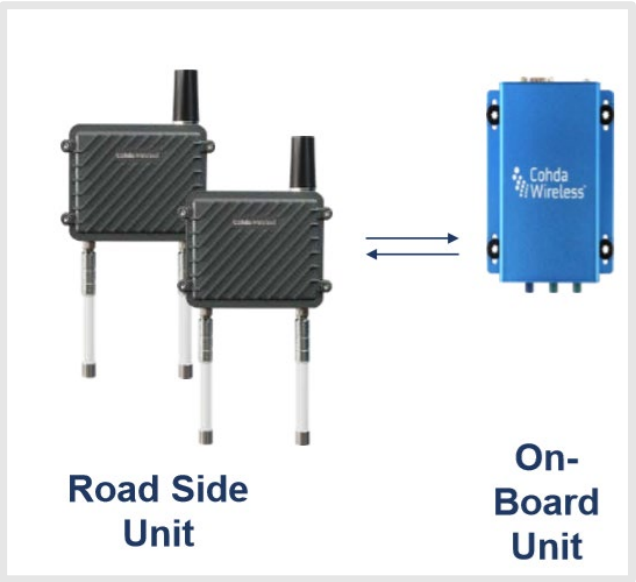
Data Management

TMC Backhaul processing

Coordinated Infrastructure Deployment: collect data, share data and interact

Technology Challenges: DSRC Foundation Work

- NHTSA- ANPRM Only applies to V2V communications, V2I is not mandated
- Devices Speak the same “language”
- Understand standardized BSMs



National Highway Transportation Safety Administration (NHTSA)
Advanced Notice of Proposed Rulemaking (ANPRM)

Expertise/Training Needed to Resolve Implementation Issues

Survey Question:
What challenges did you face during implementation of the system?

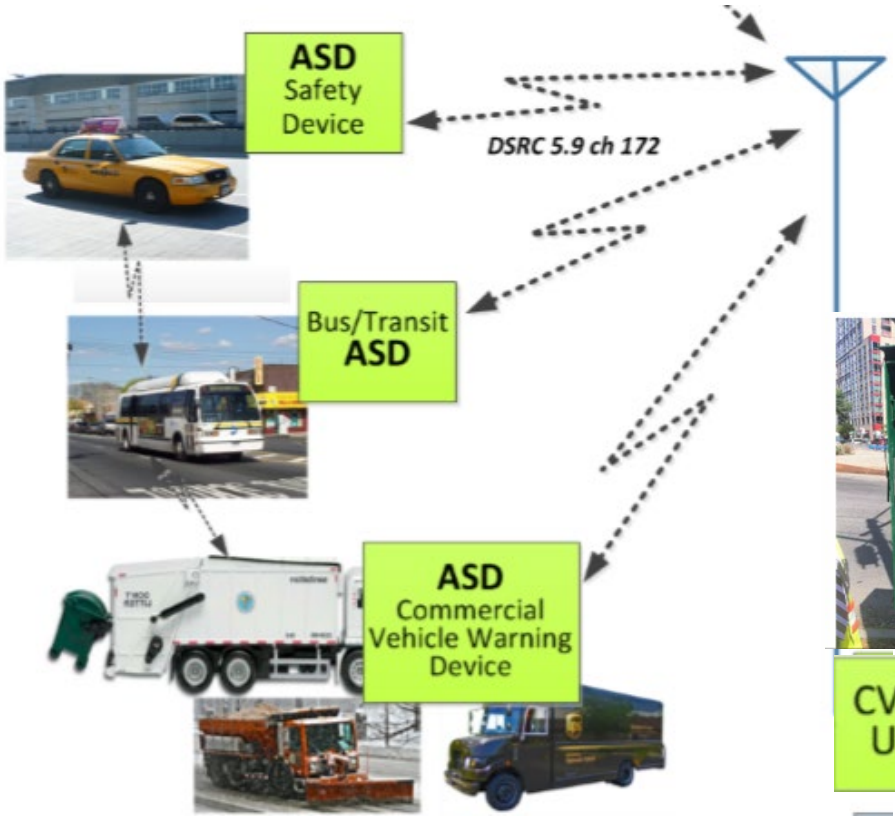
> Controller Area Network (CAN): *information/addresses varied even across the same model of bus and required more coordination with bus manufacturers than anticipated.*
>
> *Engineering challenges typical of integration work.*

GCRTA E-PCW Evaluation Report

System Integration Challenge: Multiple Vendors Relationships

Interfacing RSU Vendor-A

Transit Buses Retrofitting



Vendor-C

Advanced Solid-State Traffic Controller (ASTC)

Note: Ethernet ports available for connection to CV units

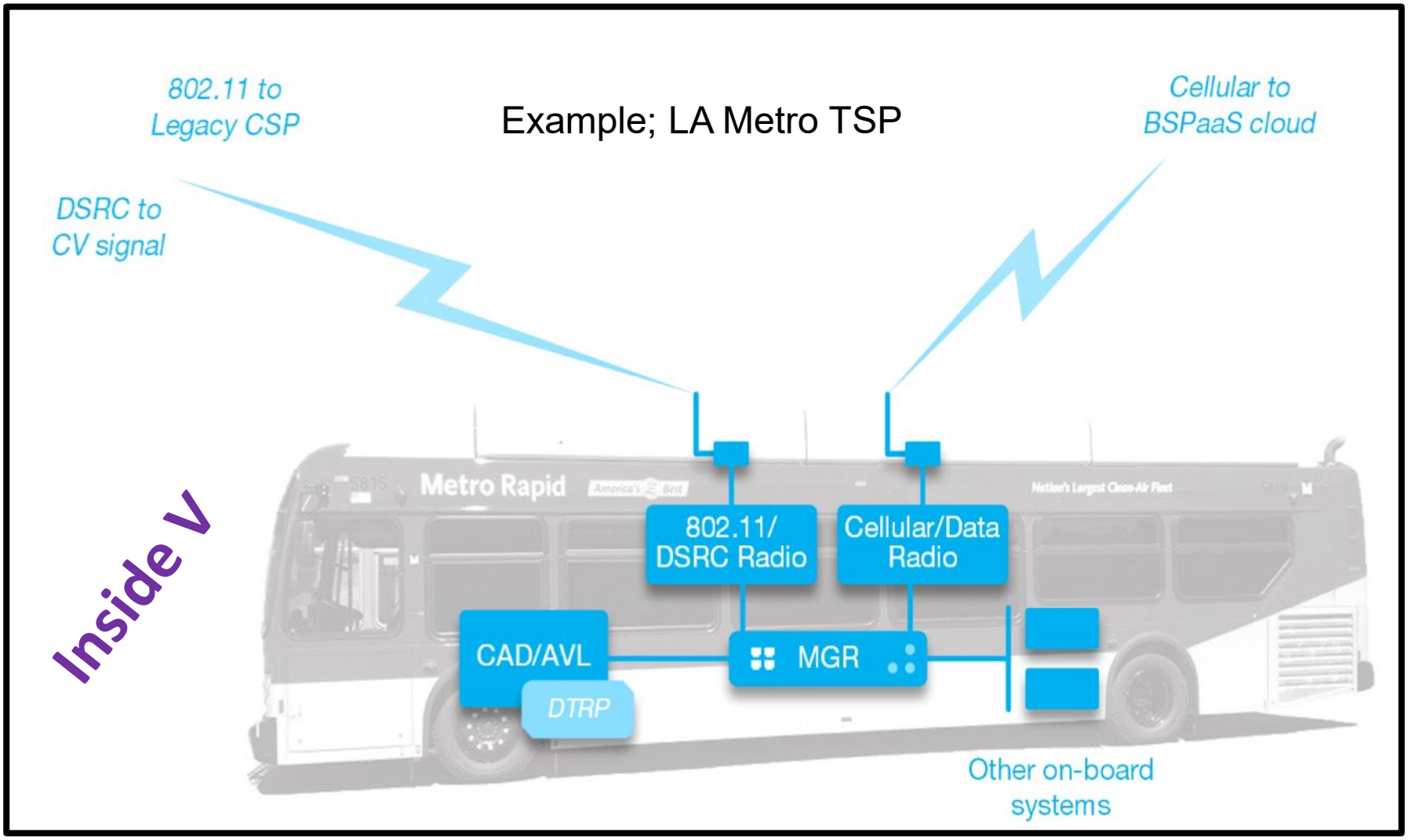
Vendor-B

Deployment Challenges: Equipment Procurement

Outside V

- Infrastructure (Bus Stops)
- Cabinet space to house external devices
- Reliable power supply
- Secure backhaul communications link

Deployment Challenges: Inside Vehicle Interfaces



Source: DKS-PCB Module 24

Challenges and approaches to the successful deployment of a transit CV environment

Example: MTA Transit Bus Retrofitting-Testing

- V2V communication RF (radio frequency) testing
- Through the glass antenna, roof drilling-not allowed
- Create an installation template

Challenges and Approaches to the Successful Deployment of a Transit CV Environment

Standards-based Specifications

- Include **Conformance Requirements** for Communications media(s), standards, and security infrastructure.
- **Develop Test Plans:**
  - Identify how to verify conformance to the referenced standards
  - Identify the system requirements
  - Identify how testing will be performed, by Who?
  - Consult PCB training modules: T101, T202 for detailed discussion

Privacy Challenges

- Privacy between users and third parties
- Can’t track a vehicle to its source and destination without appropriate authorization (for example, electronic payments)
- IEEE 1609.3 describes the use of changing MAC address at random intervals
- SAE J2945 standards address this by assigning and changing an identifier on a frequent basis

Security Challenges

- Security Credential Management System (SCMS) developed by USDOT:
  - Provides the security infrastructure to issue and manage the security certificates
  - Safety Message validity with SCMS to support trusted, safe/secure V2X communications and to protect driver privacy appropriately
  - CV devices enroll into the SCMS, obtain security certificates and attach those certificates to their messages as part of a digital signature
  - The certificates prove the device is a trusted actor
  - System identifies bad actors and revoke message privileges, when necessary (IEEE 1609.2.1 pending)

Cyber security issues must be addressed in addition to the overall security needs.
More on cyber-security in Module CSE 202, under preparation.

Lessons Learned

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**

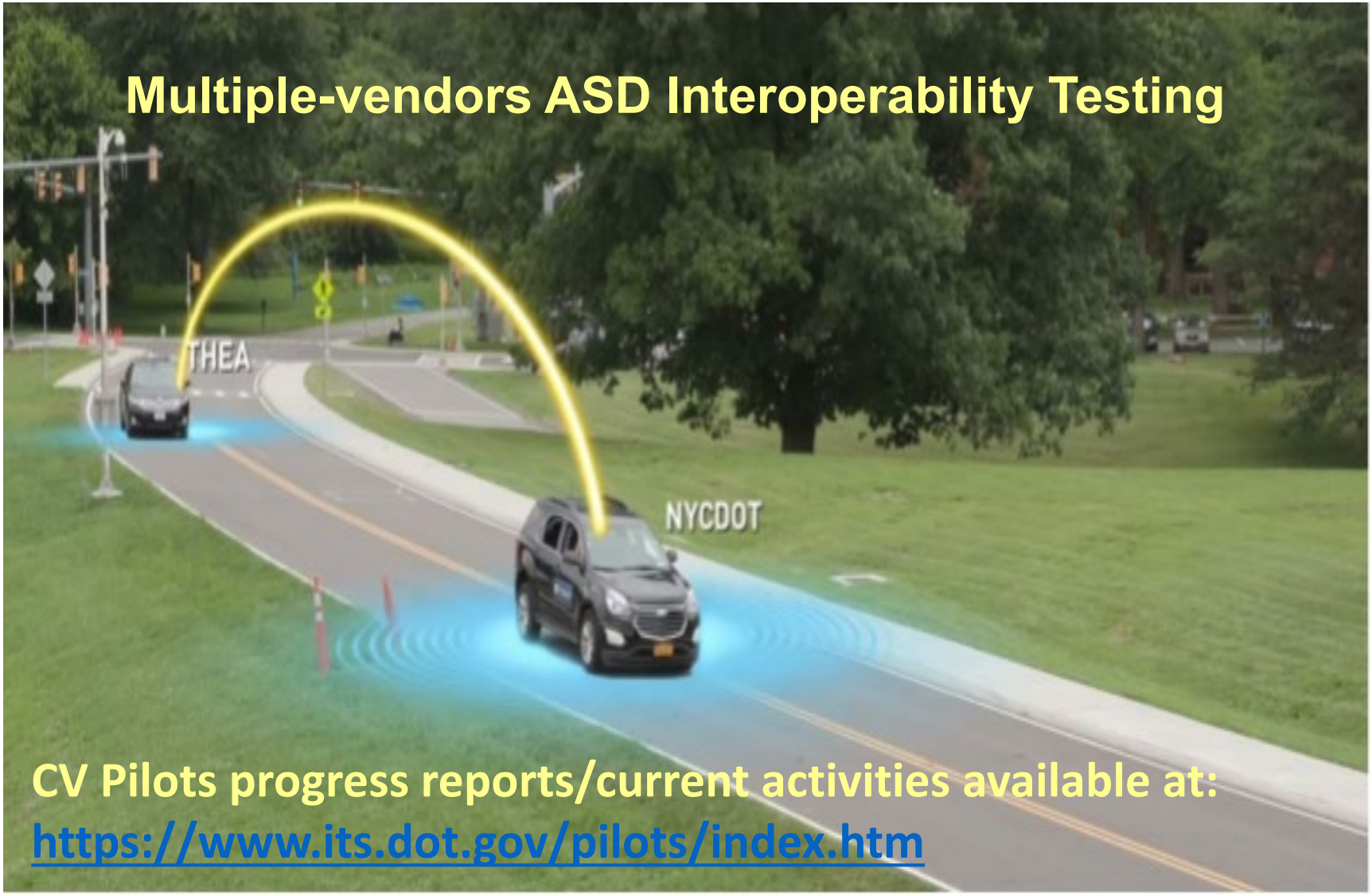
Tampa Pilot (THEA)	Complete	Target
Vehicle Equipped with On-Board Unit (OBU)	831	1,080
HART Transit Bus Equipped with OBU	10	10
TECO Line Streetcar Equipped with OBU	8	8
Total Equipped Vehicles	**849**	**1,100**
Roadside Units (RSU) at Downtown Intersections	**44**	**44**

New York City Pilot (NYCDOT)	Complete	Target
Taxi Equipped with Aftermarket Safety Device (ASD)	1	3,200
DCAS Fleet Equipped with ASD	0	3,200
MTA Fleet Equipped with ASD	700	700
OCME Fleet Equipped with ASD	4	TBD
NYCDOT Fleet Equipped with ASD	639	700
DSNY Fleet Equipped with ASD	0	170
Total Equipped Vehicles	3000	**8,000**
Roadside Units (RSU) at Manhattan and Brooklyn Intersections and FDR Drive	**275**	**400**
Vulnerable Road User (Pedestrians/Bicyclists) Device	**0**	**100**
PED Detection System	**9**	**10**

U.S. Department of Transportation

Lesson Learned

CV-Pilots Projects Deployments



Resources for Further Reading

- CV training modules available:
  - Updated: Module CV-261 (V2I)
  - Updated Module CV-262 (V2V)
  - CV-273 (SPaT/MAP)
  - Transit Module 24 (TSP)
  - CV 265 IEEE (WAVE)
  - CSE 202 (Cybersecurity)
  - Additional transit applications modules are listed at:

https://www.pcb.its.dot.gov/stds_modules.aspx

ACTIVITY

STANDARDS ITS TRAINING

U.S. Department of Transportation
Office of the Assistant Secretary for
Research and Technology

Question

Which of the following is (are) a potential barrier to implementation of transit connected vehicles?

Answer Choices

a) Security

b) Privacy

c) Evolving standards

d) All of the above

Review of Answers

a) Security

Incorrect, Not the only one, but Security concerns are a potential barrier because transit agencies must trust and authenticate the information.

b) Privacy

Incorrect, Not the only one, but Privacy concerns are a potential barrier to protect a transit passenger's data from other than their intended use.

c) Evolving standards

Incorrect, Not the only one, but Evolving standards are a potential barrier because interoperability is affected.

d) All of the above

Correct! All of the above are potential barriers/issues. But know that we are currently testing CV and will soon find out!

Learning Objectives

Describe the connected vehicle (CV) environment

Identify potential communications technologies that may be used in a transit CV environment

Review the standards that support the transit CV environment

Describe transit CV applications

Identify the challenges and approaches to the successful deployment of transit CV applications

Thank you for completing this module

Feedback

Please use the Feedback link below to provide us with your thoughts and comments about the value of the training.

Thank you!