Welcome

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Free ITS Standards Training
Over 70 web modules on how to evaluate, procure, and deploy standards-based highway and transit technologies.

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MODULE 11:

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

Updated 2020
Instructor

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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 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
- Reduce pollution by ~10%

Total Emissions-
6,457 million metric tons of CO₂ equivalent
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.

![Graph showing Pedestrians Fatalities in 2018](ghsaa.org)

Source: NYCDOT
## Areas of Applications - Transit Examples

### 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 (BSL/CLW)
- 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)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Dynamic Speed Harmonization (SPD-HARM)
- Queue Warning (Q-WARN)
- Cooperative Adaptive Cruise Control (CAACC)
- 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
- 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

[Image of Forward Collision Warning (FCW)]
Illustrate V2V Warning Messages for Drivers

- Do Not Pass Warning
- Lane Change Warning + Blind Spot Warning
- Emergency Electronic Brake Light
- Forward Collision Warning
Demonstration: V2P

Pedestrian Safety Warning
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
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)
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
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?
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.
Highway-Rail Grade Crossings (V2V, V2I)

- 685 crashes in 2018
- 281 fatalities
ACTIVITY
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
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

- New Radio-NR Rel 17
- C-V2X Rel 14

Timeline:
- 1979: Introduction of Analog Telecommunications
- 1991: Text Messaging
- 1998: Mobile and Wireless Internet Connection
- 2008: Cloud, IP and Truly Mobile Broadband
- 2019: Launch of 5G
- 2017: New Radio-NR Rel 17
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 enables network independent communication. (PC5 Interface)

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

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.
Review of Communications Technologies

Competing CV Communications Alternatives

1. DSRC
   - Dedicated Short Range Communication
   - Defined by IEEE Standards (WAVE)
   - PHY layer 802.11 p standard
   - Dedicated Radio in 5.9 GHz spectrum

2. C-V2X
   - Defined by 3GPP, Release 14,....
   - Dedicated Radio in 5.9 GHz spectrum
   - Additional radio in the licensed cellular band (LTE/5GNR-Release 17)

Proven Technology

New-Emerging Technology
Possible new alternative under the reallocation of spectrum by FCC

Permit unlicensed devices to operate

DSRC

+ C-V2X

C-V2X and/or DSRC

C-V2X
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 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

Dedicated to Public safety applications e.g. collision warning

Advertises services available on other channels

DOWNLOAD - application software and operational parameters

Reserved for emergency vehicles uses higher power

DOWNLOAD 5.85 GHz

UPLOADING 5.895 GHz

reserved for emergency vehicles uses higher power

UPLOADING 5.925 GHz
DSRC

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

OBU

Dual Radio Solution

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
### 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
ACTIVITY
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/standards_modules.aspx
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


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/
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/
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
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)

<table>
<thead>
<tr>
<th>Message ID</th>
<th>Message Type</th>
<th>Time Stamp</th>
<th>Position</th>
<th>Velocity</th>
<th>Message Check</th>
</tr>
</thead>
</table>
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).
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
“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
“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."
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
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

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

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

Source: Battelle
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

Source: USDOT
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.*
System Integration Challenge: Multiple Vendors Relationships

Transit Buses Retrofitting

Vendor-C

Vendor-A

Interfacing RSU

Vendor-B

Advanced Solid-State Traffic Controller (ASTC)

Note: Ethernet ports available for connection to CV units
Deployment Challenges: Equipment Procurement

- Infrastructure (Bus Stops)
- Cabinet space to house external devices
- Reliable power supply
- Secure backhaul communications link
Deployment Challenges: Inside Vehicle Interfaces

Example; LA Metro TSP

Inside V

802.11 to Legacy CSP

DSRC to CV signal

Cellular to BSPaaS cloud

Other on-board systems

802.11/DSRC Radio

Cellular/Data Radio

CAD/AVL

DTRP

MGR

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
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)

<table>
<thead>
<tr>
<th>Wyoming Pilot (WYDOT)</th>
<th>Complete</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>WYDOT Maintenance Fleet</td>
<td>32</td>
<td>90</td>
</tr>
<tr>
<td>Subsystem On-Board Unit (OBU)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated Commercial Truck</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Subsystem OBU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retrofit Vehicle Subsystem OBU</td>
<td>20</td>
<td>255</td>
</tr>
<tr>
<td>WYDOT Highway Patrol</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td><strong>Total Equipped Vehicles</strong></td>
<td>52</td>
<td>405</td>
</tr>
<tr>
<td><strong>Roadside Units (RSU) along I-80</strong></td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tampa Pilot (THEA)</th>
<th>Complete</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Equipped with OBU</td>
<td>831</td>
<td>1,080</td>
</tr>
<tr>
<td>HART Transit Bus Equipped with</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>OBU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TECO Line Streetcar Equipped</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>with OBU</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Equipped Vehicles</strong></td>
<td>849</td>
<td>1,100</td>
</tr>
<tr>
<td>**Roadside Units (RSU) at **</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td><strong>Downtown Intersections</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

CV-Pilots Projects Deployments

Multiple-vendors ASD Interoperability Testing

CV Pilots progress reports/current activities available at: https://www.its.dot.gov/pilots/index.htm
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/standards_modules.aspx
ACTIVITY
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!
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!