STANDARDS ITS TRAINING

WELCOME

U.S. Department of Transportation

Office of the Assistant Secretary for
Research and Technology

Welcome

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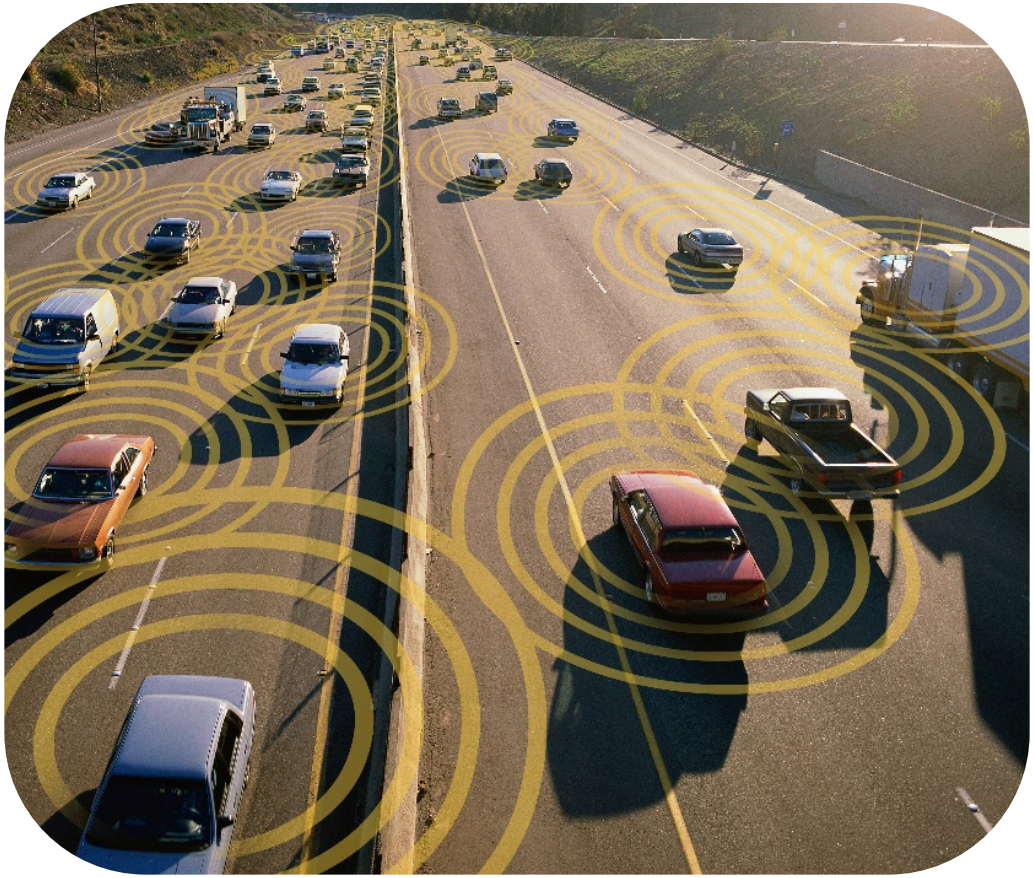
Module CV262:

Vehicle-to-Vehicle (V2V) ITS Standards for Project Managers



Updated November 2019

Instructor

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President

Trevilon LLC

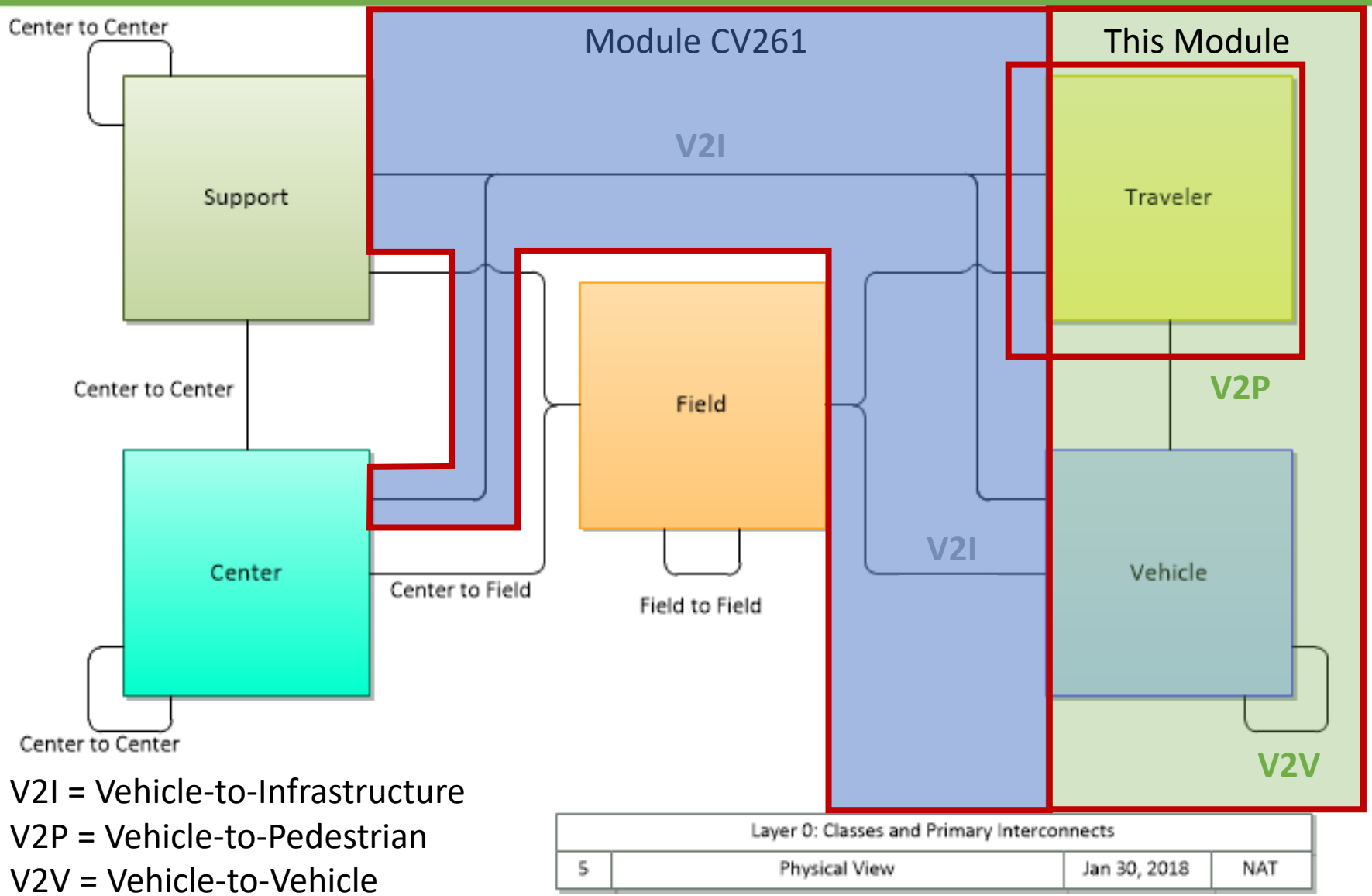
Learning Objectives

- Describe the connected vehicle environment
- Discuss V2V communications
- Describe the roles of standards for V2V communications
- Address challenges in realizing a V2V environment
- Describe the current status of connected vehicles

Learning Objective 1

Describe the connected vehicle environment

Illustrate the CV Environment



V2I = Vehicle-to-Infrastructure
V2P = Vehicle-to-Pedestrian
V2V = Vehicle-to-Vehicle

Illustrate the CV Environment

The CV Environment

CV environment consists of:

- Connected vehicles
- Connected vulnerable road users
- Connected infrastructure

CV Communications

- Wireless
- Mixture of
  - Short-range communications
  - Remote communications

Illustrate the CV Environment

The CV Environment

Goals

- Reduce accidents by 20-80%
  - ~40,000 fatalities/year
  - 6 million+ crashes/year
- Reduce congestion by 15-42%
  - 6 billion+ wasted hours/year
  - Support automated driving
- Improve mobility of those with disabilities
- Reduce pollution by ~10%
  - 8 million tons+ of CO2

Illustrate the CV Environment

The CV Environment

Cooperative ITS (C-ITS) vs. Traditional ITS

- Traditional ITS is a complex ***system***
- Cooperative ITS is a complex ***system of systems***
  - Systems owned and operated by different entities
  - No direct contract between these entities
  - Much more complex (especially for security)
- Most CV applications are C-ITS

Illustrate the CV Environment

V2V vs V2I

V2V course (this course):

- Vehicle-to-Vehicle
- Vehicle-to-Pedestrian
- ~300-meter range
- Support infrastructure

V2I course:

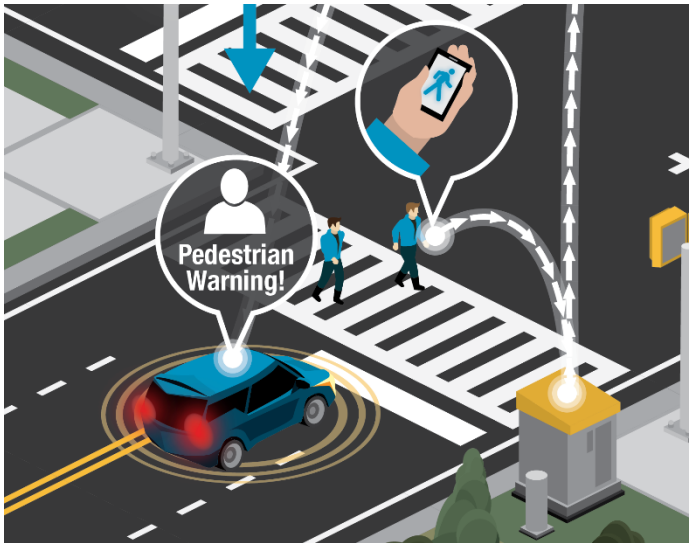
- Vehicle/Ped-to-Roadside
- Vehicle/Ped-to-Center
- Short range and wide area
- Support infrastructure

V2X is Vehicle-to-Anything

Illustrate the CV Environment

Vulnerable Road Users

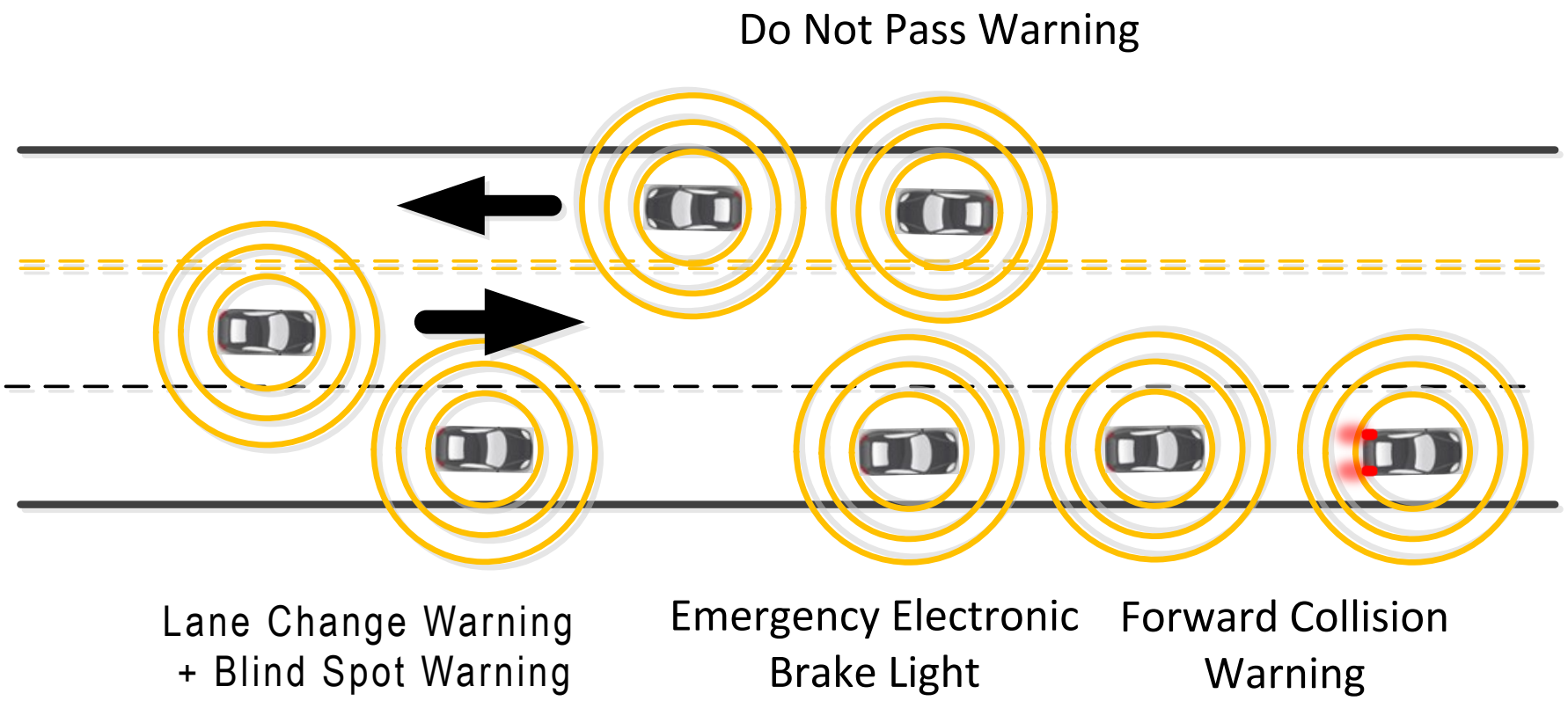
- Connected “vulnerable road users” include the following:
  - Pedestrians
  - Those with disabilities
  - Alternative modes (e.g., bicycles, e-scooters, etc.)
  - Maintenance and construction workers
  - Emergency personnel



Identify V2V Services

V2V Services

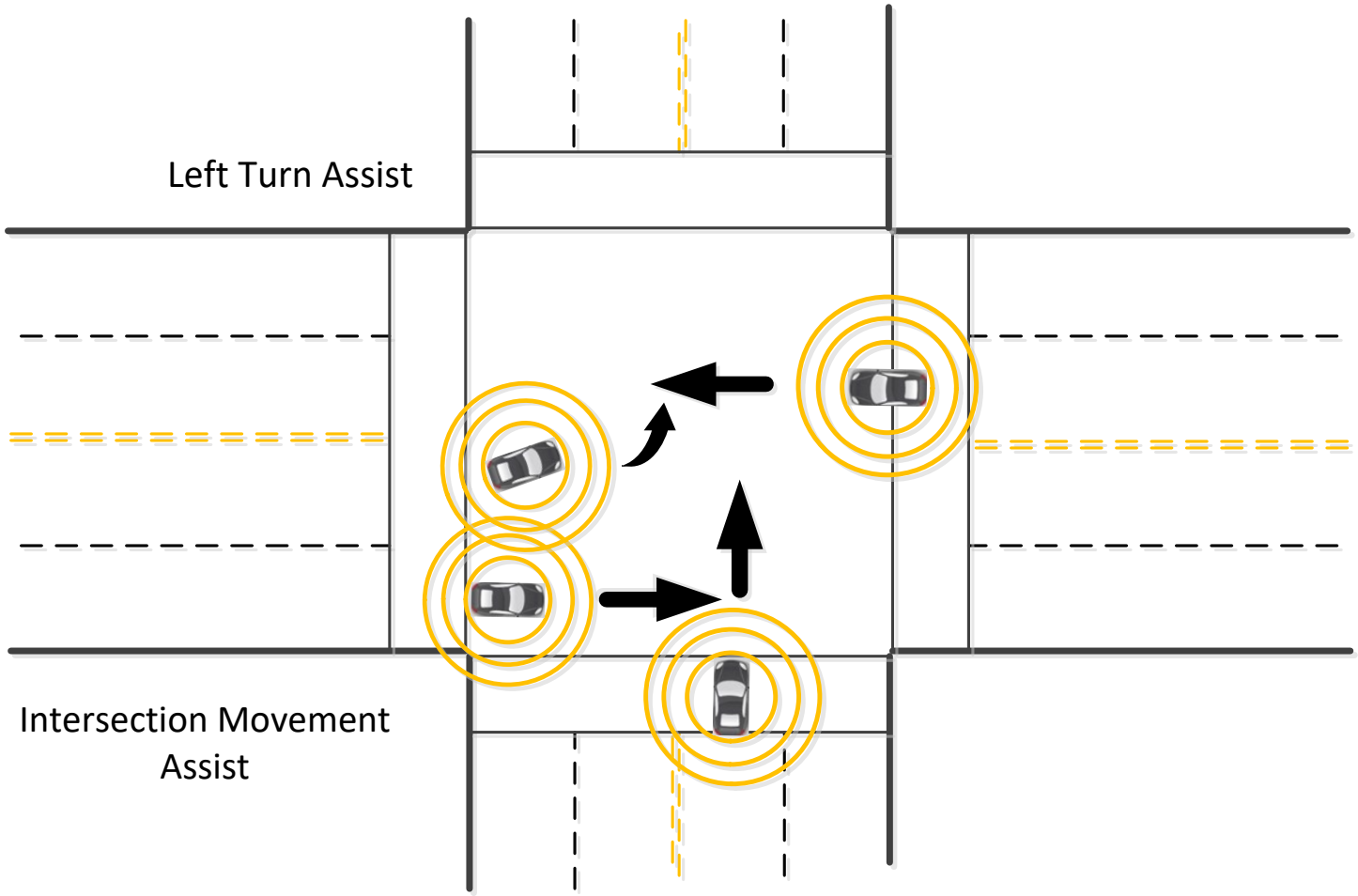
V2V Basic Safety Service Use Cases



Identify V2V Services

V2V Services

V2V Basic Safety Service Use Cases

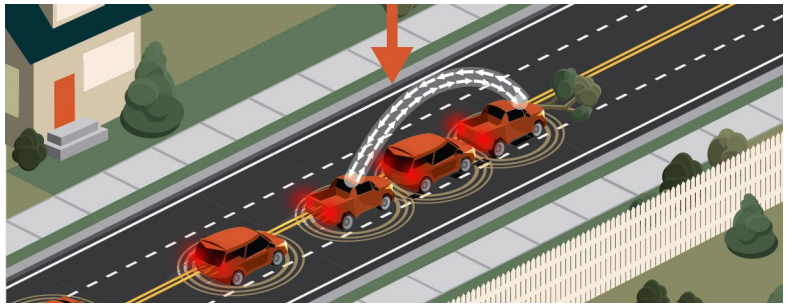


Identify V2V Services

V2V Services

V2V Safety Services

- General
  - V2V Basic Safety
  - Vehicle control events
  - Wrong way vehicle
  - Hazard notifications
- Agency-relevant
  - Slow/stationary vehicle
  - Work zone warnings
  - Emergency vehicle warnings
  - Vehicle emergency response
  - Vehicle turning in front of a transit vehicle



Identify V2V Services

V2V Services

V2V Mobility Services

- Queue warning
- Cooperative adaptive cruise control
- Platooning

V2V Environmental Services

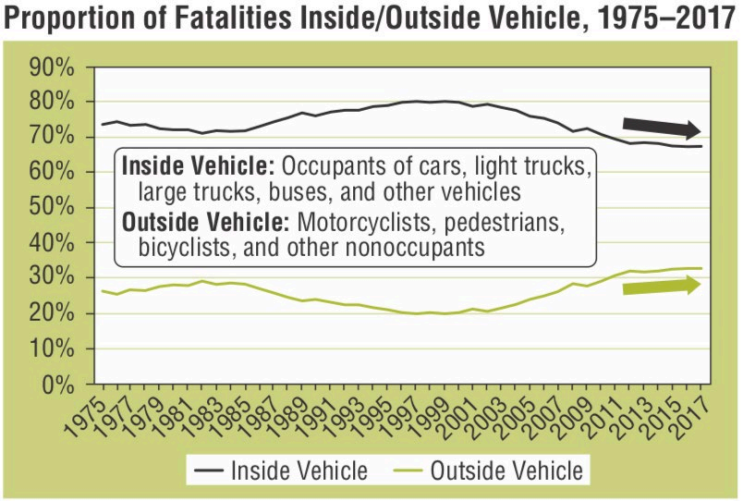
- Connected eco-driving
- Eco-cooperative adaptive cruise control

Identify V2V Services

Vehicle-to-Pedestrian (V2P) Safety

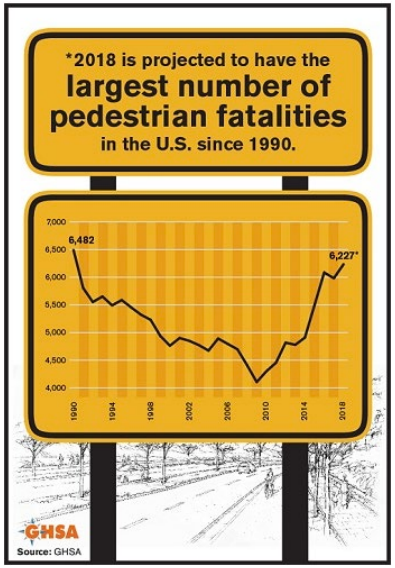
In 2017, a third of fatalities were vulnerable road users:

- 5,172 Motorcyclists
- 5,977 Pedestrians
- 783 Pedalcyclists
- 228 Other non-occupants (e.g., workers)



Source: FARS 1975–2016 Final File, 2017 ARF

Increase since 2009 has been in those aged 20-69 (from 1.6 to 2.2 per 100,000)

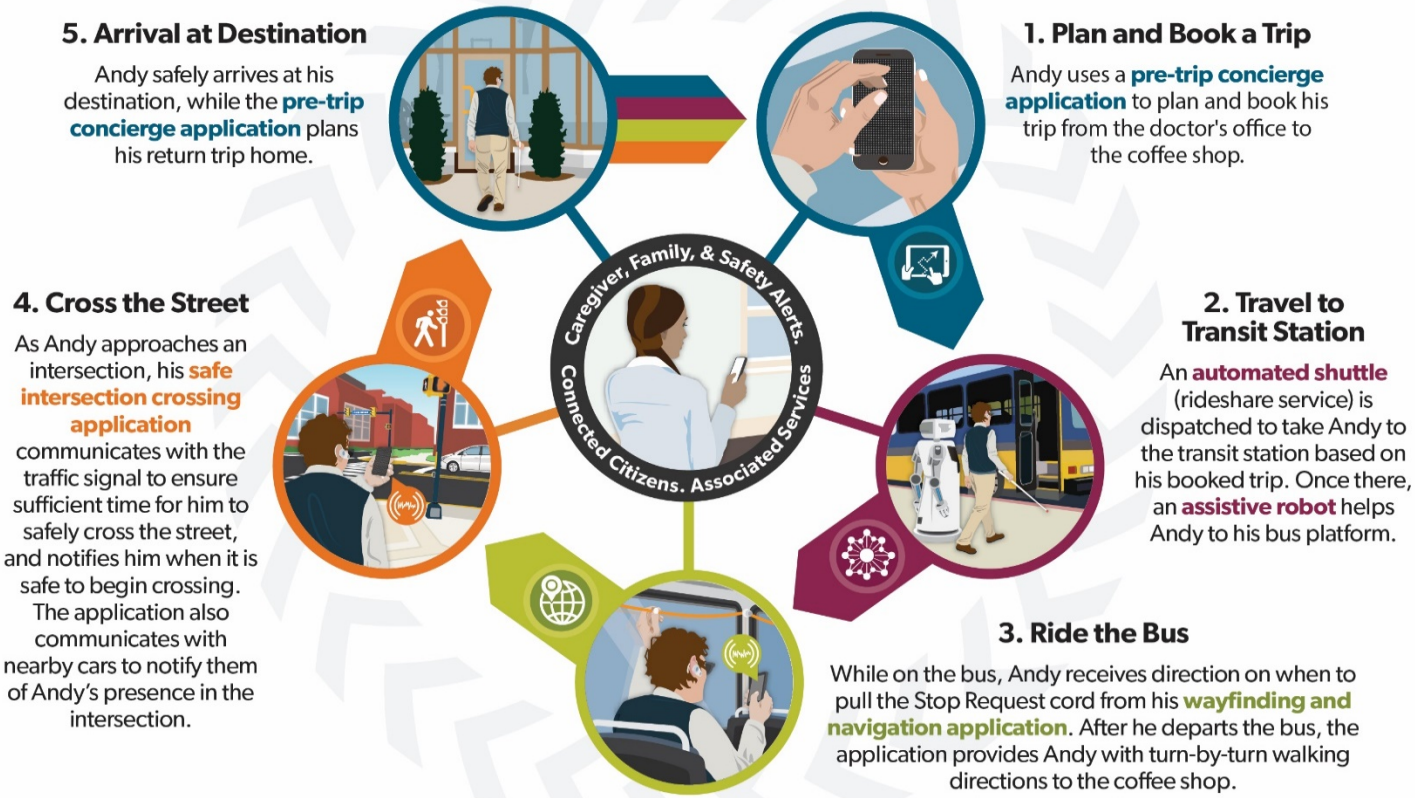


Identify V2V Services

V2P Mobility

THE COMPLETE TRIP

After his doctor's appointment, Andy decides to take a spontaneous trip to meet a friend at a coffee shop in an unfamiliar part of town. Using ATTRI's **pre-trip concierge**, **wayfinding and navigation**, **robotics and automation**, and **safe intersection crossing** applications, Andy can travel with confidence throughout his trip.



1. Plan and Book a Trip

Andy uses a **pre-trip concierge application** to plan and book his trip from the doctor's office to the coffee shop.

2. Travel to Transit Station

An **automated shuttle** (rideshare service) is dispatched to take Andy to the transit station based on his booked trip. Once there, an **assistive robot** helps Andy to his bus platform.

3. Ride the Bus

While on the bus, Andy receives direction on when to pull the Stop Request cord from his **wayfinding and navigation application**. After he departs the bus, the application provides Andy with turn-by-turn walking directions to the coffee shop.

4. Cross the Street

As Andy approaches an intersection, his **safe intersection crossing application** communicates with the traffic signal to ensure sufficient time for him to safely cross the street, and notifies him when it is safe to begin crossing. The application also communicates with nearby cars to notify them of Andy's presence in the intersection.

5. Arrival at Destination

Andy safely arrives at his destination, while the **pre-trip concierge application** plans his return trip home.

Source: Accessible Transportation Technologies Research Initiative (ATTRI)

Societal Benefits of Connected Vehicles

Safety Benefits

360-DEGREE VISIBILITY

IDENTIFY HAZARDS

REDUCE CRASHES

Mobility Benefits

REDUCED CRASHES = REDUCED CONGESTION

INCREASED MOBILITY FOR THOSE WITH DISABILITIES

SMOOTHER TRAFFIC FLOW

Environmental Benefits

REDUCED CONGESTION = REDUCED EMISSIONS

SMOOTHER TRAFFIC = REDUCED EMISSIONS

IMPROVED EFFICIENCY FOR AUTOMATED DRIVING SYSTEMS

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Question

Which of the following does the USDOT NOT include in its list of benefits of connected vehicles?

Answer Choices

a) Improved Safety

b) Improved Environment

c) Enhanced Entertainment

d) Improved Mobility

Review of Answers

a) Improved Safety

Incorrect. The USDOT has identified that safety is the primary benefit provided by the connected vehicle environment.

b) Improved Environment

Incorrect. The USDOT has identified various environmental benefits of connected vehicle services.

c) Enhanced Entertainment

Correct! While connected vehicles may be able to deliver entertainment, this is not included in the USDOT list of benefits since it is not a matter of major public interest.

d) Improved Mobility

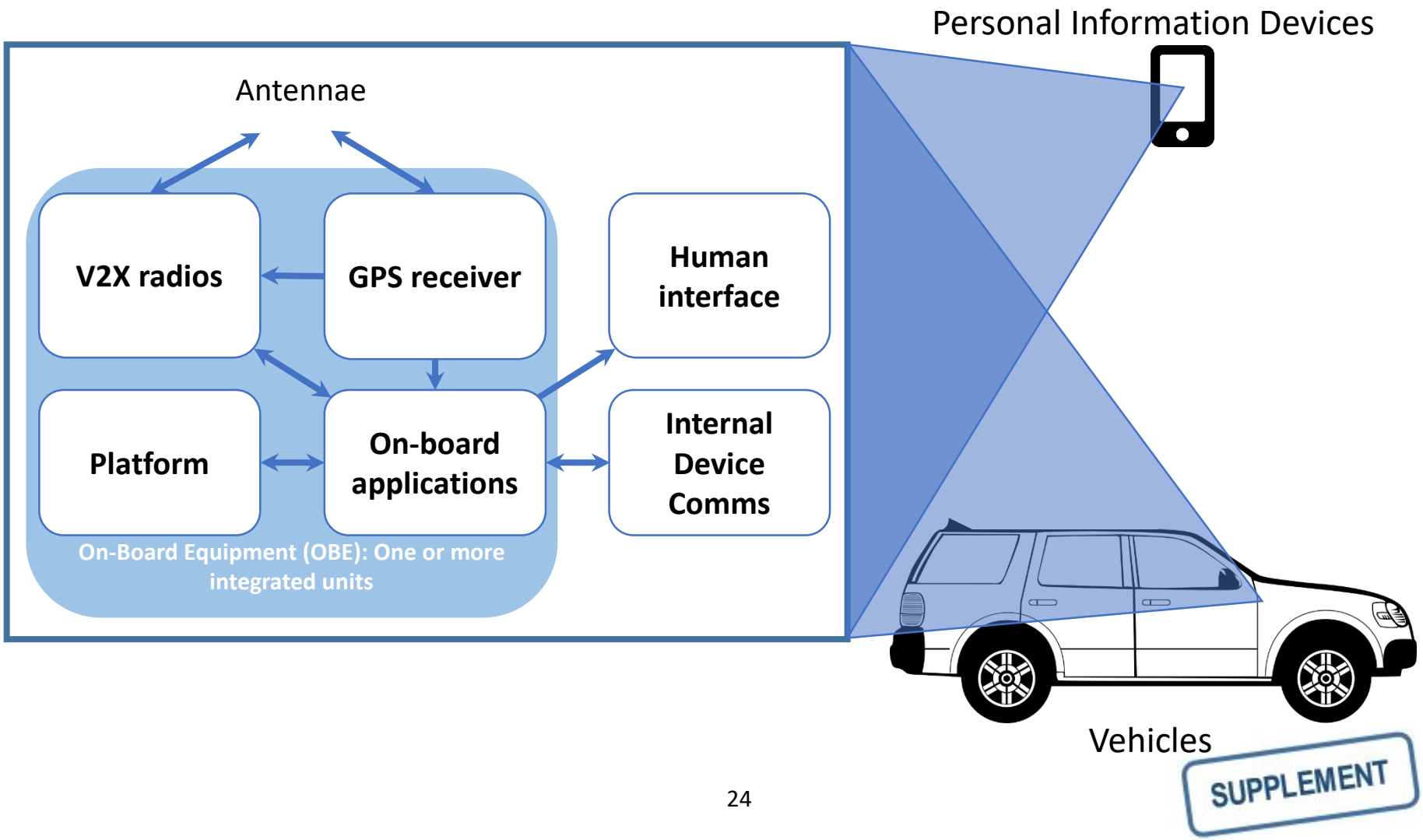
Incorrect. Mobility has also been identified as a benefit for connected vehicles.

Learning Objective 2

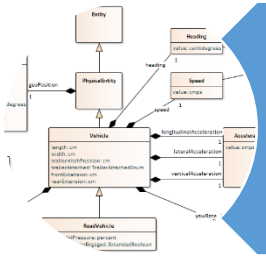
Discuss V2V communications

Identify the Components of the V2X Network

Components of a V2X Network



Describe the Information Exchange Requirements



Data requirements

Communication requirements

Security requirements

Describe the Information Exchange Requirements

Crash Avoidance Metrics Partners (CAMP)

Vehicle-to-Vehicle Basic Safety

- Includes
  - Forward collision warning
  - Intersection movement assist
  - Electronic brake light
  - Etc.

Information exchange requirements define:

- What data is needed
- When data is needed
- From whom are data needed
- Under what conditions are data needed
- How are data exchanged (Learning Objective #3)

Describe the Information Exchange Requirements

Data Requirements: Answers "What"

Vehicle-to-Vehicle Basic Safety

- Location (latitude, longitude, elevation)
- Speed
- Acceleration
- Direction of travel
- Acceleration rate
- Brake status (including anti-lock braking, traction control, etc.)
- Length and width of vehicle
- Steering wheel angle
- Others available as needed

Describe the Information Exchange Requirements

Communication Requirements: Answers "What" and "When"

Vehicle-to-Vehicle Basic Safety

- How accurate does data need to be?
  - Defined for each field
- How often is data needed?
  - Latency less than 10 ms
  - Generally, every 100 ms

Communication Requirements

Communication Requirements: Answers "Who" and "Where"

Vehicle-to-Vehicle Basic Safety

- Everyone within reaction distance
  - Two cars approaching at a combined speed of 140 mph
  - 140 mph = 205 ft/s = 62.6 meters/sec
  - 300 meters provides a 4.8 sec horizon
- Factors that favor minimizing distance
  - Larger transmission distance might overload network
  - Privacy requires minimizing who has access to information
- Radio transmission distances vary based on environment

Communication Requirements

Key V2V Basic Safety Requirements

- Low latency: ~10ms
- Frequent communications (i.e., every 100 ms)
- Large, dynamic number of devices
- Continuum of devices
- Needs to work in rural areas without infrastructure
- Target transmission range: 300 meters
- No subscription necessary
- Not all applications have such strict requirements
- Some have more strict requirements

Security Needs

Security Requirements

- Protect confidential information
  - Personally identifiable information
  - Management information
- Prevent information leakage through data fusion
- Authenticate: Is the data from the claimed source?
- Authorize: Is the source of a request authorized to make the request?
- Provide this security within the connected vehicle environment
  - Devices may have never previously encountered each other
  - Time-critical nature of security approvals

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Question

What data is NOT included as a Basic Safety requirement?

Answer Choices

a) Location of vehicle

b) Weight of vehicle

c) Length of vehicle

d) Steering wheel angle

Review of Answers

a) Location of vehicle

Incorrect. The location is used to determine how close the vehicle is.

b) Weight of vehicle

Correct! The basic safety application is intended to avoid collisions and the weight of the other vehicle has not been deemed to be a significant factor in these calculations.

c) Length of vehicle

Incorrect. The length of the vehicle is used to determine the limits of the vehicle.

d) Steering wheel angle

Incorrect. The steering wheel angle can be used to identify when the vehicle is sliding.

Learning Objective 3

Describe the roles of standards for V2V communications

Summarize the Benefits of Standards

Standards are Essential!

- Standards enhance interoperability in a multi-vendor environment
  - Interoperability – degree to which two or more systems, products or components can exchange information and use the information that has been exchanged[1]
- Makes testing, integration, and management easier
- Helps with the design and procurement of a system

[1] *ISO/IEC/IEEE 24765:2017 Systems and Software Engineering – Vocabulary*

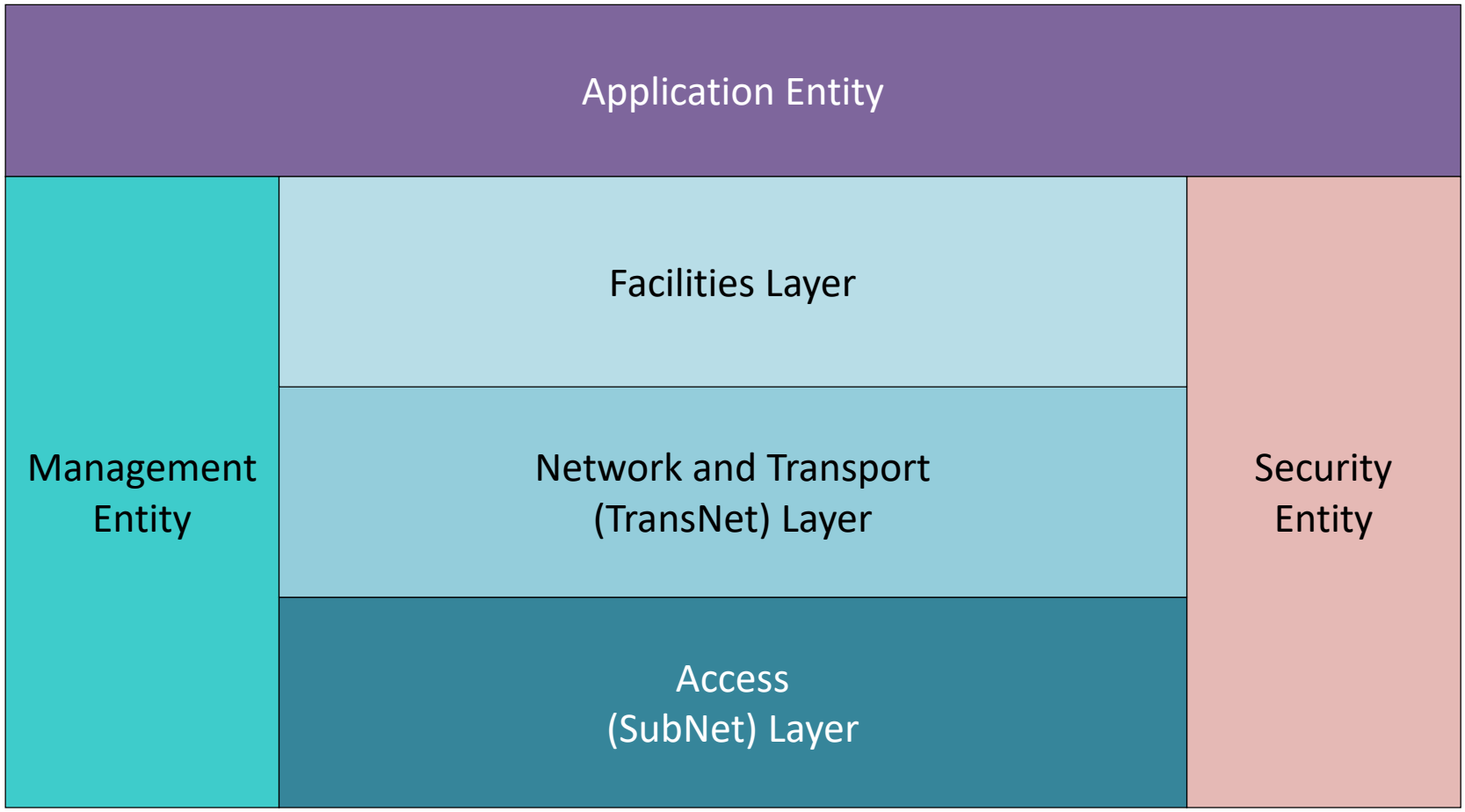
Summarize the Benefits of Standards

Benefits

- Define common baseline (terminology, level of quality, testing, etc.)
- Reduce risks by clearly defining functionality
- Improves interoperability and interchangeability
- Reduces costly and risky customized integration efforts
- Creates a more competitive marketplace
- Encourages deployment of new and emerging technologies

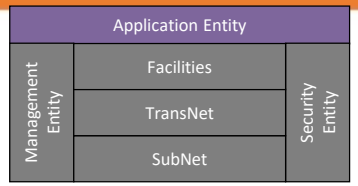
Identify the Standards to Support V2V Communications

ITS Station Architecture



Source: ISO 21217:2019

Identify the Standards to Support V2V Communications

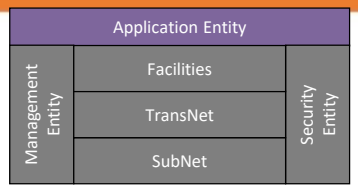


Application Entity

SAE J2945 Family

- Defines how to use Management, Facilities, and Security to implement a specific application, as defined by use cases
- Includes performance requirements
- Follows format defined in J2945 (a.k.a, “/0”):
  - Concept of Operations
  - Functional Requirements
    - What, when and how often a message is sent
    - Minimum quality requirements
    - Security requirements
  - Dialogs and Data
  - Requirements Traceability Matrix

Identify the Standards to Support V2V Communications



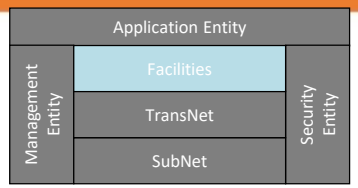
Application Entity

V2V-related standards in SAE J2945 Family

- J2945/1 2016: V2V Safety application
- J2945/2 2018*: V2V Awareness application
  - Emergency vehicle alert
  - Roadside alert (stopped/slow vehicles)
  - Safety awareness (objects and road conditions)
- J2945/6[W]: Cooperative Adaptive Cruise Control and Platooning
- J2945/8[W]: Cooperative Perception System
- J2945/9 2017*: Vulnerable Road User

* *Recommended Practice* [W] Work in Progress

Identify the Standards to Support V2V Communications



Facilities Layer

SAE J2735 (2016)

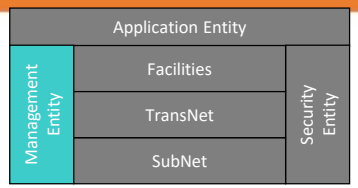
Dedicated Short Range Communications (DSRC) Message Set Dictionary

- Primary message set for CV communications in North America
- Defines messages and data elements

e.g., Basic Safety Message (BSM)

- Part I contains data elements that are necessary for safety applications and are expected to be broadcasted frequently
  - Vehicle location, speed, heading, etc.
- Part II data elements are broadcasted less frequently
  - Emergency braking, anti-lock brake activation, etc.

Identify the Standards to Support V2V Communications

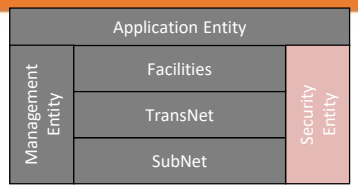


Management Entity

Management

- Included within other standards and proprietary definitions
- For example:
  - Application might require use of a specific radio (e.g., DSRC) or channel, or define priorities for SAE J2735 messages
  - A jurisdiction might transmit configuration or operational parameters that affect device operation

Identify the Standards to Support V2V Communications



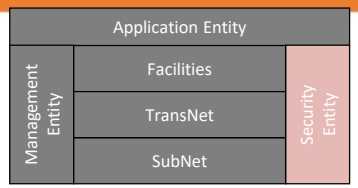
Security Entity

IEEE 1609.2 (2016 plus amendments)

Security Services for Applications and Management Messages

- Specifies:
  - Base security processing requirements
  - Communications security for Wireless Access in Vehicular Environments (WAVE) Service Advertisements and WAVE Short Messages
  - Additional security services that may be provided
- Key portions adopted internationally (not just WAVE)
- Might have applications beyond ITS
- See Module CV265 for more details

Identify the Standards to Support V2V Communications

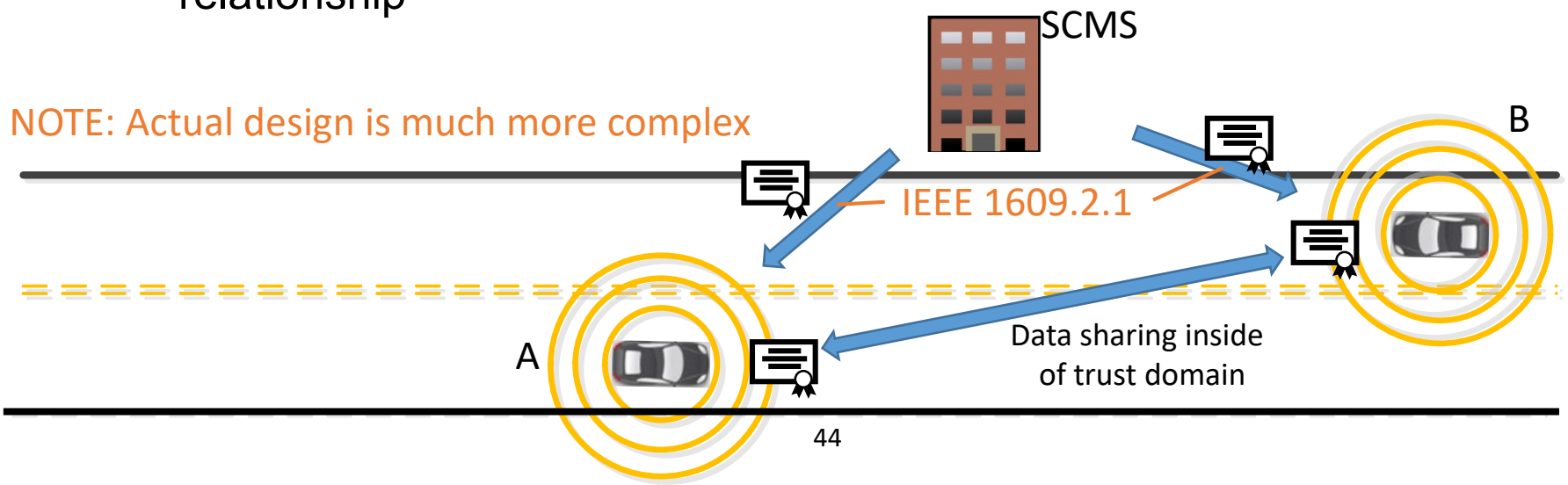


Security Entity

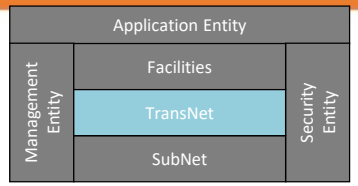
IEEE 1609.2.1 (WIP)

Certificate Management Interfaces for End-Entities

- Defines how digital certificates are provided to and managed within end entities
- Digital certificates are provided by the Security Credential Management System (SCMS)
  - Creates an ITS trust domain among entities that have no direct relationship



Identify the Standards to Support V2V Communications



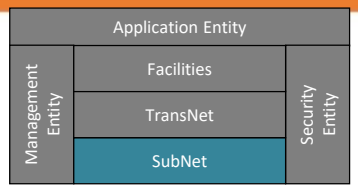
TransNet Layer

IEEE 1609.3 (2016)

Networking Services

- Specifies:
  - Use of standard IPv6 protocol,
  - WAVE Short Message Protocol (WSMP),
  - Associated management functions

Identify the Standards to Support V2V Communications



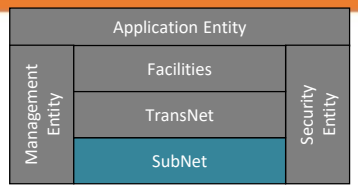
SubNet Layer

FCC allocated 5.9 GHz spectrum in 1999 for:

non-voice radio techniques to transfer data over short distances between roadside and mobile radio units, between mobile units, and between portable and mobile units to perform operations related to the improvement of traffic flow, traffic safety and other intelligent transportation service applications in a variety of public and commercial environments. DSRC systems may also transmit status and instructional messages related to the units involved.

Source: Federal Communications Commission, Dedicated Short Range Communications of Intelligent Transportation Services – Final Rule, FR Doc No: 99-30591

Identify the Standards to Support V2V Communications



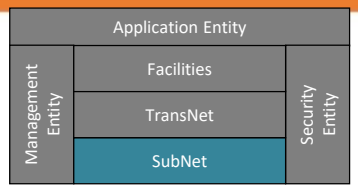
SubNet Layer

IEEE 1609.4 (2016)

Multi-channel Operation

- Identified as protocol for 5.9 GHz spectrum in 2003
- Specialized Wi-Fi technology (references IEEE 802.11)
  - Multiple access collision avoidance proven for decades
  - Specialized version extensively tested since early 2000's
- Basis for all existing U.S. "deployments" to date
- Efforts underway to update standards to support new features
- Slow deployment has resulted in FCC review, which may result in:
  - Assignment of spectrum to an alternative technology
  - Spectrum sharing
  - Loss of spectrum

Identify the Standards to Support V2V Communications



SubNet Layer

3GPP

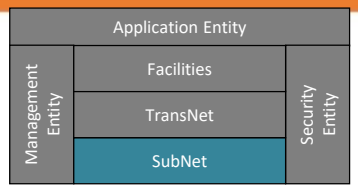
Cellular Data

- Based on cellular technologies (3GPP standards)
- Cellular data has always been envisioned to support V2X, such as:
  - Infotainment
  - Large file transfers
  - Vehicle-to-Center communications
- "***Cellular – Vehicle to Anything (C-V2X)***" has been ***proposed*** as a ***replacement*** for some/all of the 5.9 GHz band currently assigned to WAVE, but still for ITS usage

*The IEEE 802.11 Wi-Fi community has separately **proposed** to **share** the 5.9 GHz spectrum; this would intermix ITS and non-ITS uses*

C-V2X has been chosen as the DSRC deployment technology in China

Identify the Standards to Support V2V Communications



SubNet Layer

3GPP

Multiple releases; multiple bands

- Release 8 (first Long-Term Evolution (LTE) version, 2008)
- Release 14 (last Long-Term Evolution (LTE) version, 2017)
  - Added stand-alone capability
  - Claims to provide sufficiently low-latency
  - Proprietary logic claimed to allow V2V Safety needs
    - To be standardized in SAE J3161
  - USDOT is testing technology against DSRC requirements
- Release 16 (5th Generation (5G), 2020)
  - 5G is not backwards compatible with LTE in same band
  - Ultra-low latency (e.g., for platooning) in a different band
  - Timing of decisions and deployments might affect whether C-V2X is based on LTE or 5G technology

NOTE: First commercial products typically follow 1-2 years later

Identify the Standards to Support V2V Communications

SubNet Layer

Current Situation

- Infrastructure deployments are underway using DSRC/WAVE
- Deployments provide agencies with experience and begin deploying core technologies
- Deployments of infrastructure encourage automobile manufactures to use technology
- Modular equipment exists that can support both technologies

Recommendation:

- Infrastructure deployments should proceed
- Deployments should use modular equipment that allows upgrades to radios, hardware, and software when needed

Testing and Conformance

Conformance Testing Program / Certification

- Conformance test specifications have been developed by the USDOT for SAE J2945/1
  - https://www.its.dot.gov/research_archives/connected_vehicle/pdf/J2945_1_TSS_TP_Test_Specification-20160405.pdf
- Private testing market with multiple vendors

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Question

Which of the following is NOT part of the ITS Station Architecture?

Answer Choices

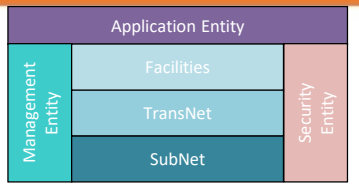
a) Application Entity

b) Facilities Layer

c) Security Entity

d) Presentation Layer

Review of Answers



a) Application Entity

Incorrect. The Application Entity sits at the top of the stack.

b) Facilities Layer

Incorrect. The Facilities Layer sits just below the Application Entity in the Data Plane.

c) Security Entity

Incorrect. The Security Entity is on the right side of the stack.

d) Presentation Layer

Correct! The Presentation Layer is a part of the Open Systems Interconnect Reference Model and is fully contained within the Facilities Layer of the ITS Station Architecture.

Learning Objective 4

Address challenges in realizing a V2V environment

Items Recently Addressed (2015-2019)

Completion of key standards

- SAE J2945/1 *V2V Safety Application*
- SAE J2945/2 *V2V Awareness Application*
- SAE J2945/9 *Vulnerable Road User Application*
- *Conformance test specifications for SAE J2945/1*

Revisions of other standards

- SAE J2735 *DSRC Message Set Dictionary*
- IEEE 1609.2 *Security Services for Applications and Management Messages*
- IEEE 1609.3 *Networking Services*
- IEEE 1609.4 *Multi-channel Operation*

Remaining Challenges to Realize V2V

Technical Challenges

- Access Layer challenges
- Implementation issues
- New applications and software updates
- Standards evolution

Institutional Challenges

- Data ownership and privacy
- Testing and certification
- Long-term support for SCMS

Describe Remaining Technical Challenges to Realize V2V

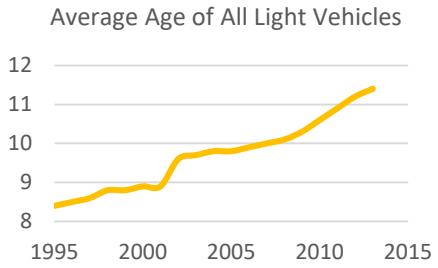
Access Layer Challenges

- Challenges that apply to both C-V2X and WAVE
  - Consistency of deployed technology
  - Co-existence of C-V2X and WAVE in 5.9 GHz band
  - Co-existence with non-ITS Wi-Fi (a.k.a. spectrum sharing)
  - Evolution of selected technology
- Additional challenges that apply to C-V2X
  - Communication scheduling in a dynamic environment
  - True broadcast capability
  - Potential stalking distance
  - Anonymity capability
  - Overall performance of C-V2X in all environments
  - Impacts to existing investments
  - Royalty/service fee policies are unclear

Describe Remaining Technical Challenges to Realize V2V

Implementation Issues

- V2V: Two vehicles need to be equipped and interoperable for benefits
  - One vehicle must broadcast, and another vehicle must receive at the same time
    - No manufacturer has more than 17% market share
    - The average car is more than 11 years old
- Level of technology will vary
  - Many vehicles will predate technology
  - Some vehicles may have after-market listen only devices
  - Equipped vehicles will have various levels of support
    - Basic safety will generally be supported
    - Reporting remote objects requires specialized sensors
    - Some vehicles might be equipped with automated driving systems
  - Interaction with driver will vary
    - How do drivers of rental vehicles react?



Describe Remaining Technical Challenges to Realize V2V

Implementation Issues

- Agencies have little experience in deploying V2V technologies
  - Slow/stationary vehicle
  - Work zone warnings
  - Emergency vehicle warnings
  - Vehicle emergency response
  - Vehicle turning in front of a transit vehicle

- Deployment strategy for connected vehicle technologies
  - Develop a deployment timeline to meet likely constituent demands
  - Consider institutional issues such as need to develop and update agency policies and practices to meet V2V needs
  - $ Establish a budget for deployment and maintenance
  - Access necessary expertise for successful projects

Describe Remaining Technical Challenges to Realize V2V

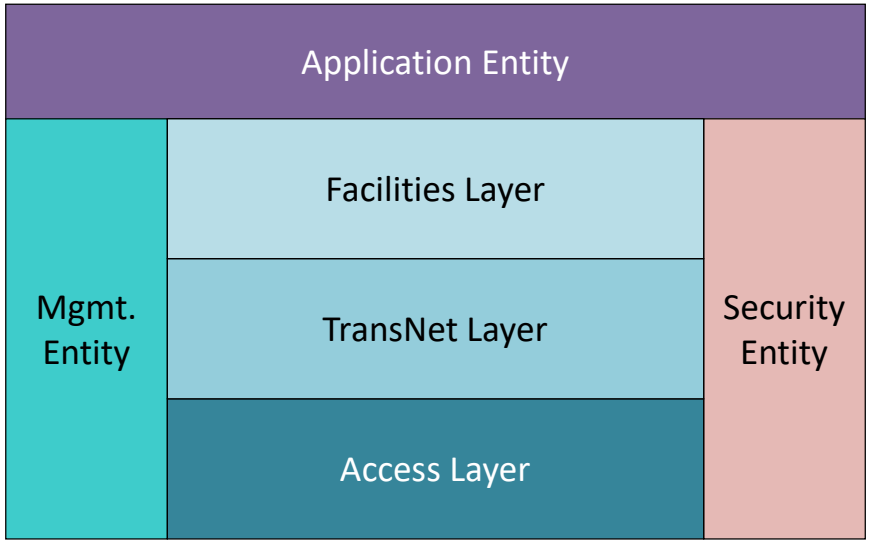
New Applications and Software Updates

- New applications will emerge and update continually
- Can new/updated applications be installed into vehicles?
  - Conceptually, they could be installed as with a smart phone
  - Safety-critical nature of a vehicle complicates installation
  - Applications and interactions between applications are likely to require extensive testing

Describe Remaining Technical Challenges to Realize V2V

Standards Evolution

- The emergence of C-V2X highlights the need to consider standards evolution
  - How will a version 1 car interoperate with version 2 cars?
  - Question has to be asked for each area of communications stack



Describe Institutional Challenges

Data Ownership and Privacy

- Need to limit distribution of sensitive data
  - Prevent sharing of sensitive data that can be combined to reveal personally identifiable information
  - Establish rules on what information can be shared and used for what purposes
- Need for anonymity of vehicles and vulnerable road users
  - Prevent tracking of individuals
  - Allow personal information when needed (e.g., tolling)
  - Still an open issue for C-V2X

Describe Institutional Challenges

Testing and Certification

- For V2V, largely left to private sector
- Supported by USDOT projects as appropriate
  - E.g., development of common test procedures

Describe Institutional Challenges

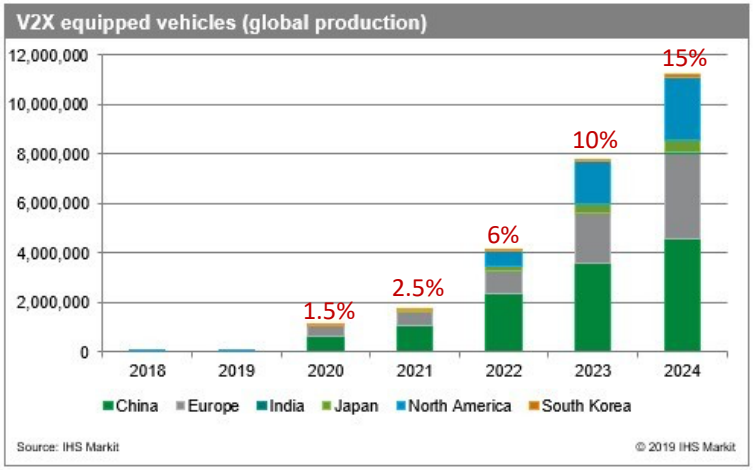
Security and Credentials Management System (SCMS)

- In 2017, the USDOT established SCMS Proof-of-Concept (POC)
  - Intended to operate through 2020
- USDOT's National SCMS Development project
  - Working closely with stakeholders to develop a viable ecosystem
  - Develop a National SCMS Deployment Strategy
  - Define long-term governance of National SCMS

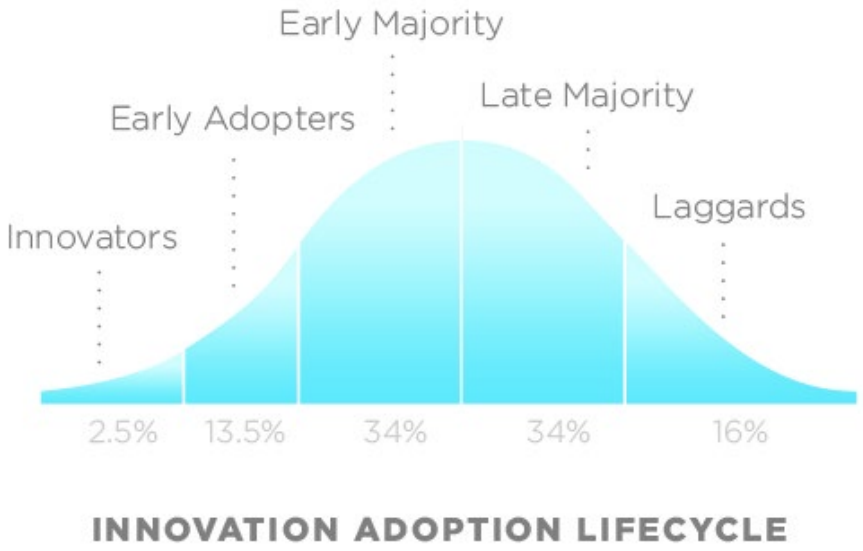
Describe Actions that Transportation Agencies Can Take

Deployment

- Develop plans to begin phasing in agency applications
  - Slow/stationary vehicle safety
  - Work zone/worker safety
  - Emergency vehicle warnings
- Ensure deployments rely on modular designs that allow upgrading to new technologies



* Percent of annual global production



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Question

Which of the following has NOT been identified in this presentation as a V2V service that agencies might need to consider implementing?

Answer Choices

a) Work zone warnings

b) Fleet management

c) Emergency vehicle warnings

d) Slow vehicle warnings

Review of Answers

a) Work zone warnings

Incorrect. Agencies should consider equipping their work zone vehicles with technologies to alert motorists of their presence.

b) Fleet management

Correct! While agencies may need to manage a fleet of vehicles, a V2V component of this was not identified in this presentation.

c) Emergency vehicle warnings

Incorrect. Agencies should consider equipping their emergency vehicles with technologies to alert motorists of their presence.

d) Slow vehicle warnings

Incorrect. Agencies should consider equipping their slow vehicles with technologies to alert motorists of their presence.

Learning Objective

Describe the current status of connected vehicles

Introduce Standards and Research Underway

- National SCMS Development project
  - SCMS POC ends December 2020
- USDOT is testing V2X SubNet Layer
  - Wi-Fi spectrum sharing with DSRC
  - C-V2X
  - Military radar interference
- C-V2X specification (SAE J3161)
- Platooning and Cooperative Adaptive Cruise Control (SAE J2945/6)
- Cooperative perception (SAE J2945/8)
- Continual maintenance of standards

CASE STUDY

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U.S. Department of Transportation
ITS Joint Program Office
Image Source: Thinkstock USDOT

Connected Vehicle Pilot Deployments

Pilot deployments identified and helped to address V2V challenges to kickstart the CV ecosystem, including the following:

- Promoting privacy by refining security certificate policies
- Refining the definition of crosswalks within MAP messages
- Demonstrating over-the-air interoperability
- Highlighting the need for vehicles to support dual 1609.4 radios

Addressing these key issues will facilitate all future deployments

SUPPLEMENT

List Resources for Further Reading and Information

Architecture Reference for Intelligent and Cooperative Transportation (ARC-IT)

- A reference architecture that spans all ITS and includes detailed references to standards with explanations of gaps, overlaps and inconsistencies between the standards
- Can be used as a resource for planning or deployment
- http://arc-it.org

SUPPLEMENT

ACTIVITY

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Question

Which of the following is the USDOT currently testing in relation to communication technology alternatives offered by C-V2X and DSRC?

Answer Choices

a) Access Layer

b) TransNet Layer

c) Facilities Layer

d) Management entity

Review of Answers

a) Access Layer

Correct! DSRC and C-V2X are competing Access Layer communication technologies.

b) TransNet Layer

Incorrect. The TransNet Layer is defined by IEEE 1609.3.

c) Facilities Layer

Incorrect. The Facilities Layer is defined by SAE 2735.

d) Security Entity

Incorrect. The Security Entity is defined by IEEE 1609.2.

Module Summary

- Describe the connected vehicle environment
- Discuss V2V communications
- Describe the roles of standards for V2V communications
- Address challenges in realizing a V2V environment
- Describe the current status of connected vehicles

Connected Vehicle Modules

For Project Managers

Module 1. I101: Using ITS Standards: An Overview

Module 46. CV261: Vehicle to Infrastructure (V2I) ITS for Project Managers

Module 38. CV262: Vehicle-to-Vehicle (V2V) ITS for Project Managers

More Detailed Connected Vehicle Modules

CV263: Roadside Equipment Requirements

CV265: Introduction to IEEE 1609 Family of Standards for Wave

CV273: Introduction to SPaT/MAP Messages

CSE201: Introduction to SCMS

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!