March 6, 2019 - SHRP2 R16 Community of Interest (COI)

Connected and Automated Vehicles

What are they and what are the opportunities?

Brian Burkhard PE – Global Technology Leader – Advanced Mobility Systems for Jacobs Engineering Group

Agenda

- Defining
  - Automated vehicles (AV)
  - Connected vehicles (CV)
  - Connected and automated vehicles (CAV)
- Current state of CAV – industry and government
- Rail considerations
- Your 3 takeaways

Definitions

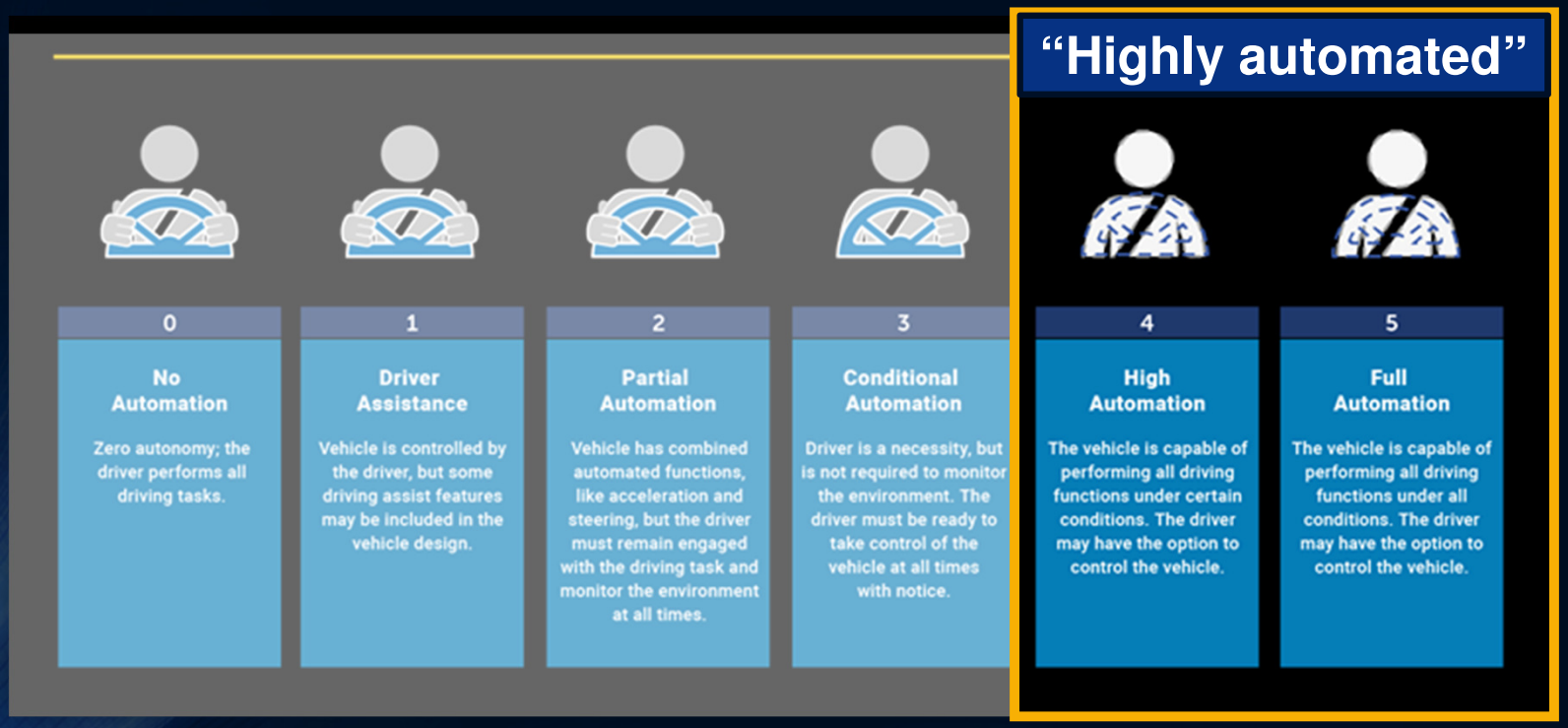
What are automated vehicles?

An Automated Vehicle (AV) is capable of driving itself by sensing the environment and navigating through:

- Radar
- LiDAR
- GPS
- Computer vision

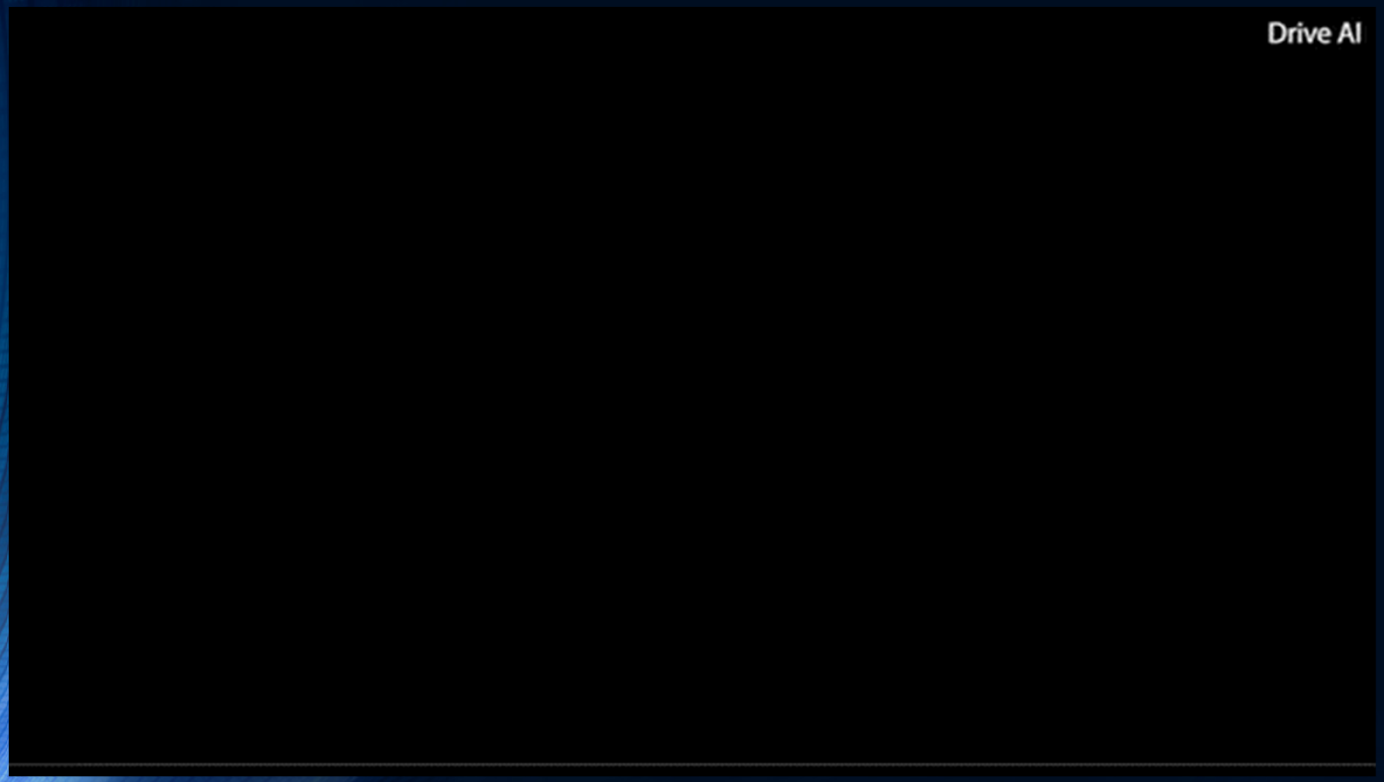
No driver is needed with a fully autonomous vehicle

Automated Vehicle – Levels of Automation



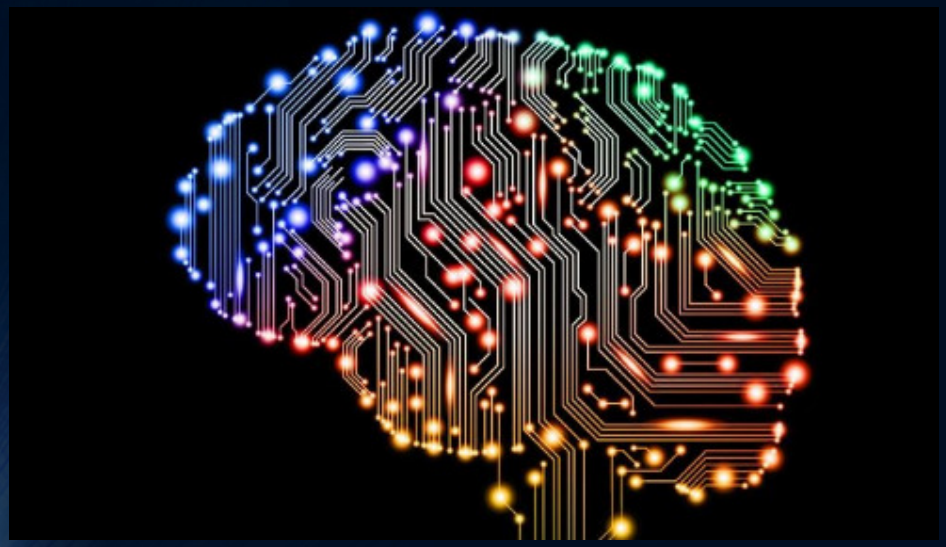
Source: NHTSA

Pilot AV Deployments – Frisco, TX



- 10,000 free rides
- On-demand, fixed stop
- 1 million miles
- Geo-fenced routes

The Latest in AV Technology

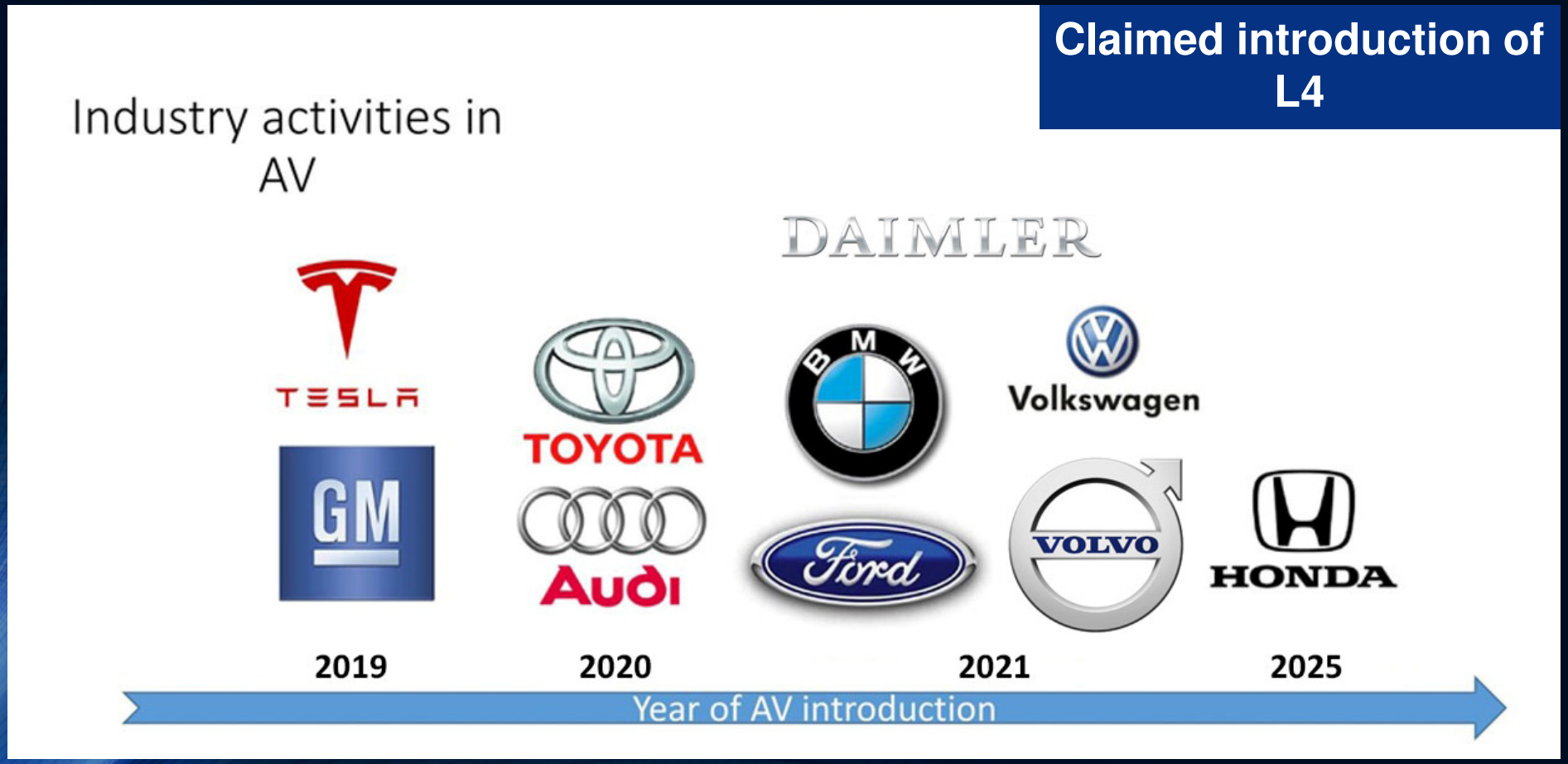


IBM Watson

Industry Activities in AV

- Shuttles or “shared autonomous vehicles” SAV

Market Activity in Automated Vehicles



What are connected vehicles?

A Connected Vehicle (CV) communicates with other connected vehicles, advanced roadside infrastructure, and cloud-based analytics:

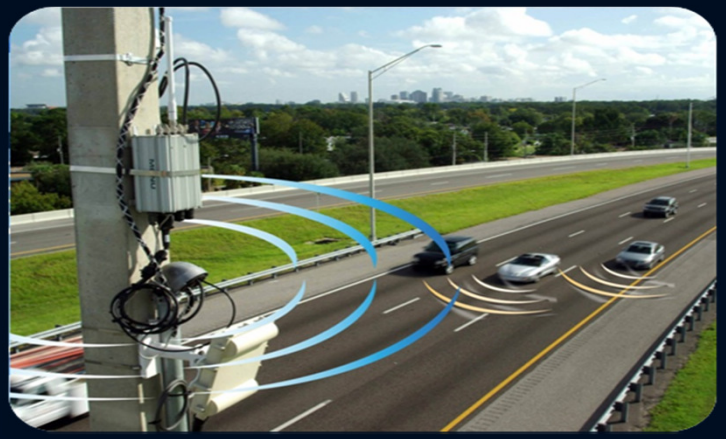
- Traffic signal phase and timing
- Work zones
- Communicates over a secure network

In-vehicle devices capture vehicle data

Location, speed, brake status, vehicle dimensions, and bumper height

Connected Vehicle Technology

- 5.9 Ghz Dedicated Short Range Radio (DSRC)
  - Dedicated FCC radio spectrum
  - 300m reliable range
- Basic Safety Message v1 (BSM)
  - Vehicle Position
  - Speed
  - Heading
  - Acceleration

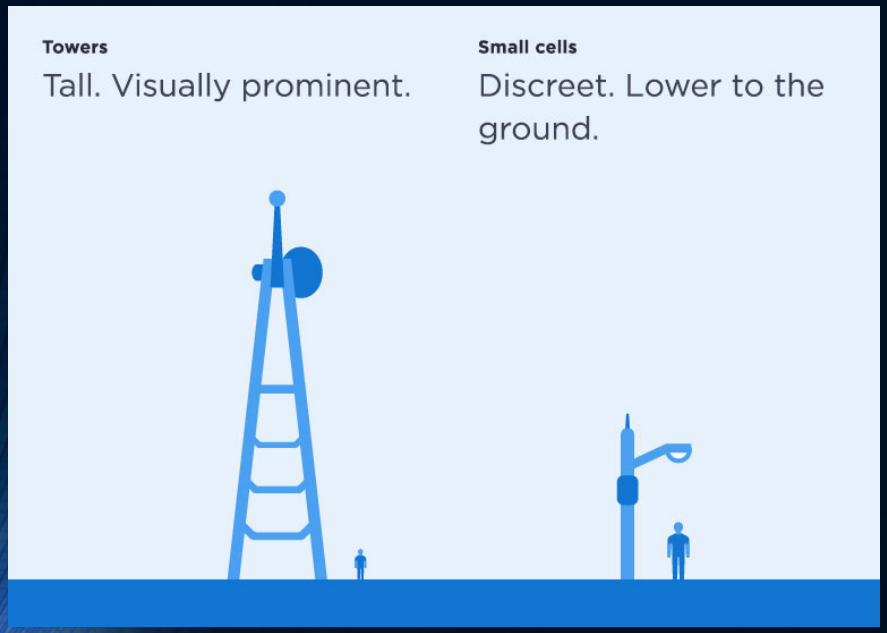


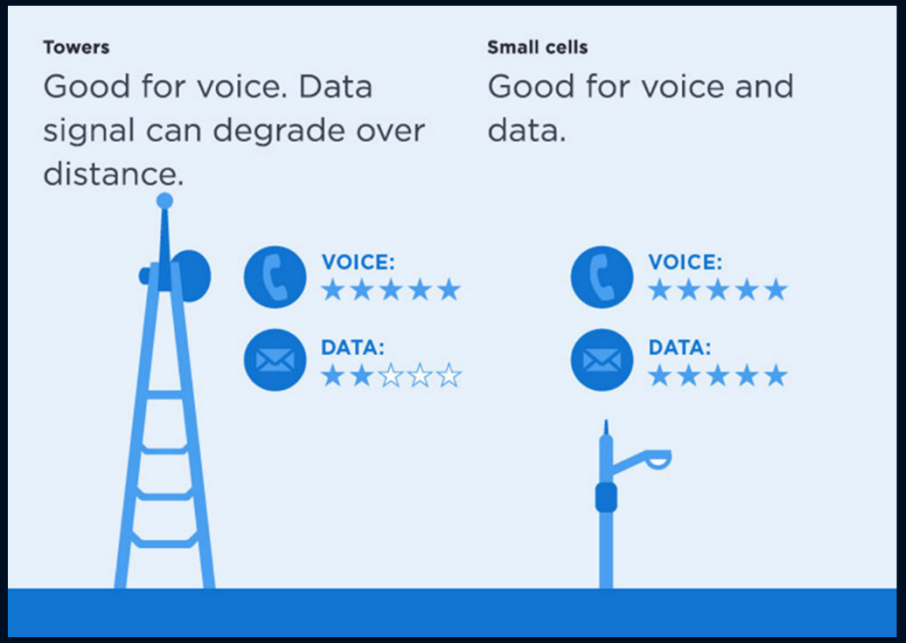
Cellular Makes a Vehicle Connected

Source: Hackaday.com

Source: The Gazette

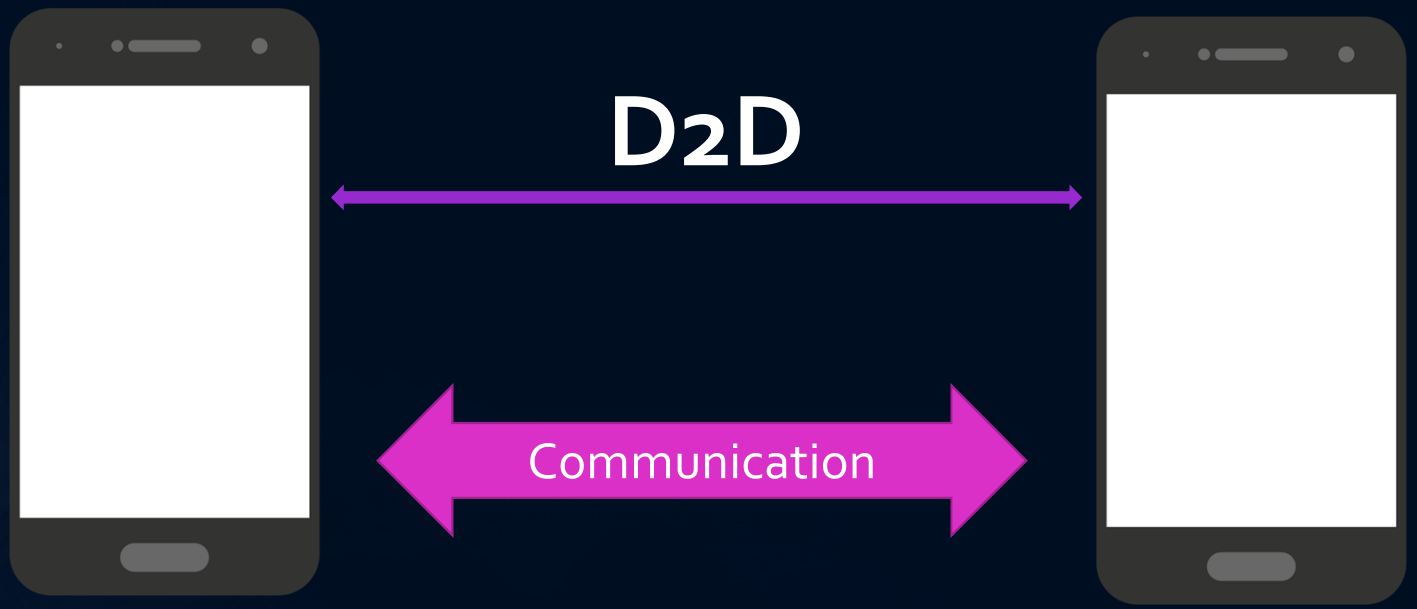
Characteristics of 5G





Source: Crown Castle

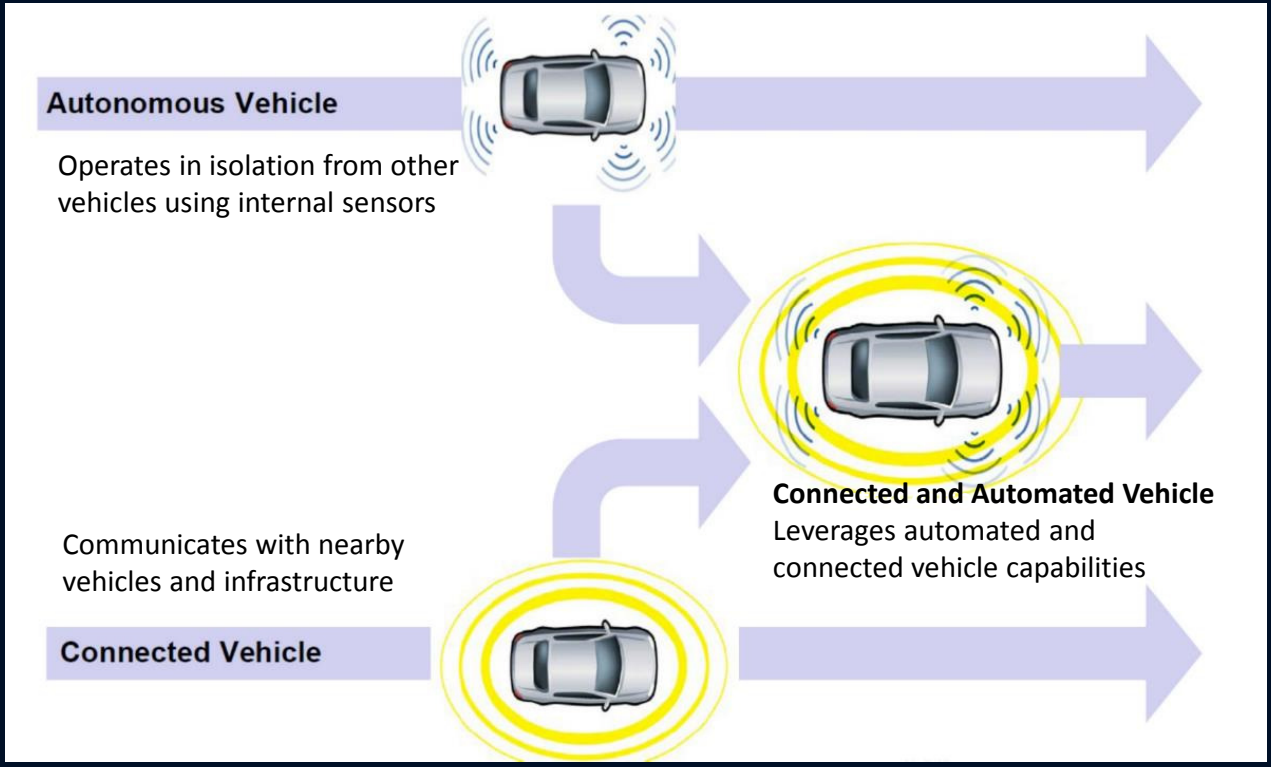
Characteristics of 5G



VHS vs. Betamax . . .again!

Background Image Source: Autotalks

Connected and automated vehicles (CAV) leverage capabilities of both

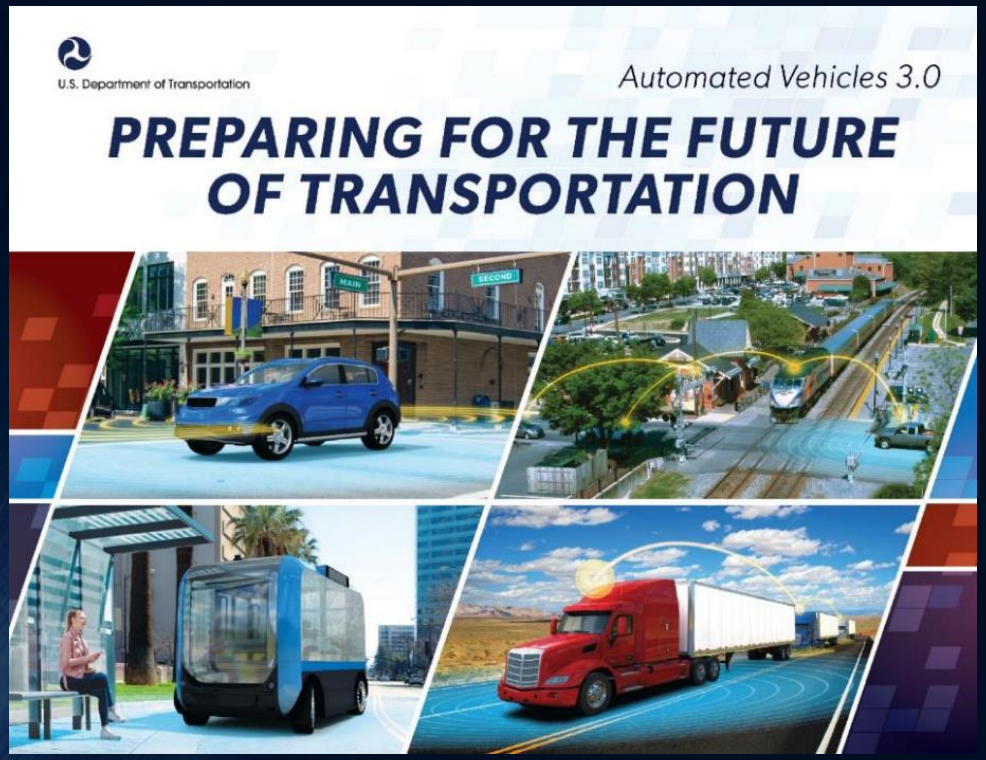


Data Sources: U.S. Department of Transportation ITS Joint Program Office

Current state of CAV – Government and Industry

US Government Activities in AV

US Government Activities in AV

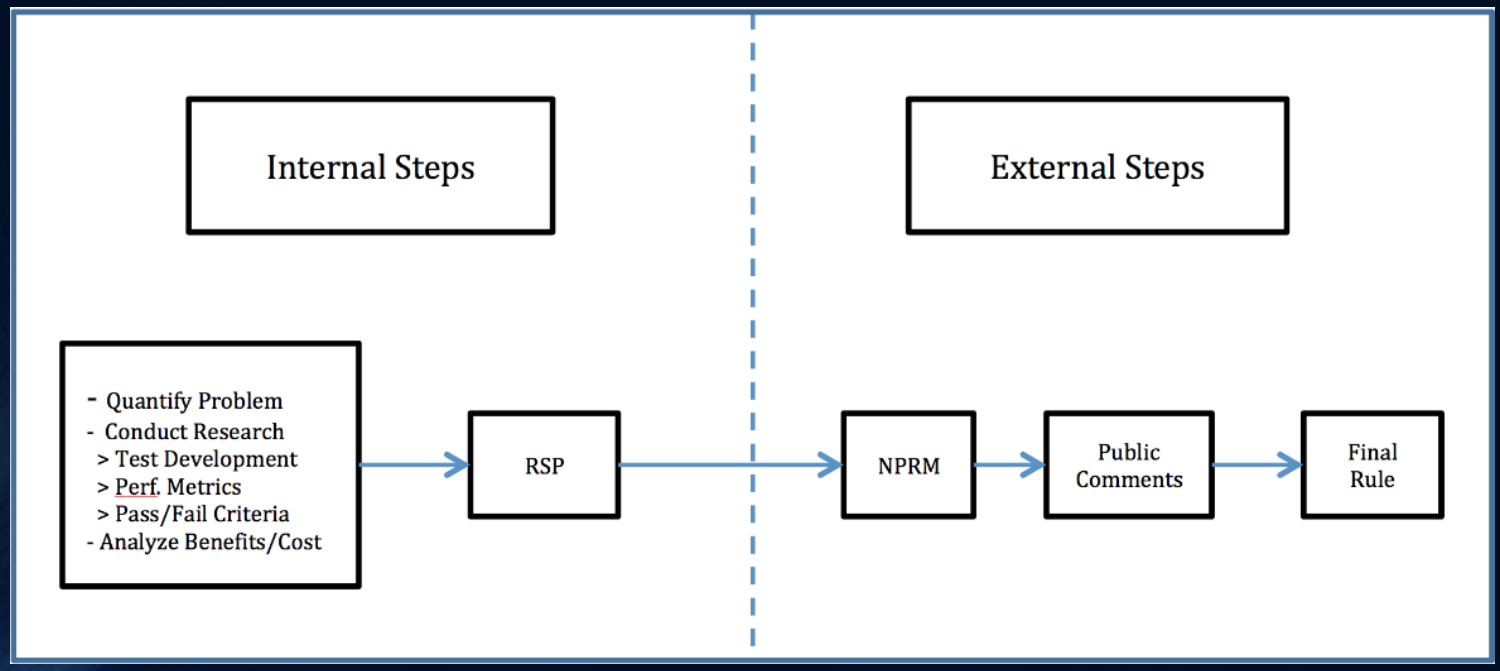


- Released October 4, 2018
- Voluntary guidance
- Not a regulation
- **(Future) Updating the Manual on Uniform Traffic Control Devices (MUTCD)**
- (Future) Process changes to NHTSA to allow acceleration of AV

US Government Activities in CV

NHTSA
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Federal Rulemaking for V2V began in December 2016



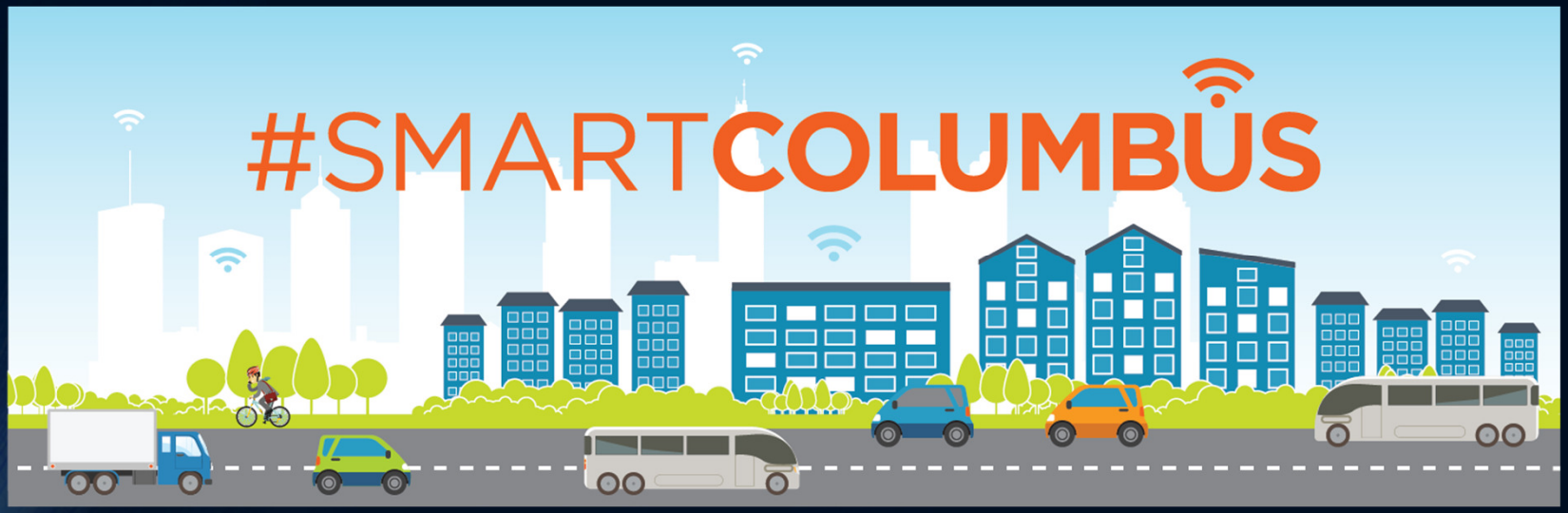
Source: Eno Center for Transportation

US Government Activities in CV(Take Note)

Rulemaking **uncertain**

- White House not interested in moving forward with "mandates"
- USDOT has stated it's moving on it's current timeline

US Government Activities in CV



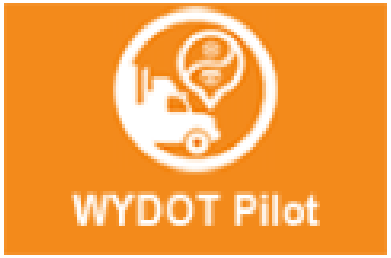
US Government Activities in CV

Connected Vehicles

Connected Vehicle Pilot Deployment Program

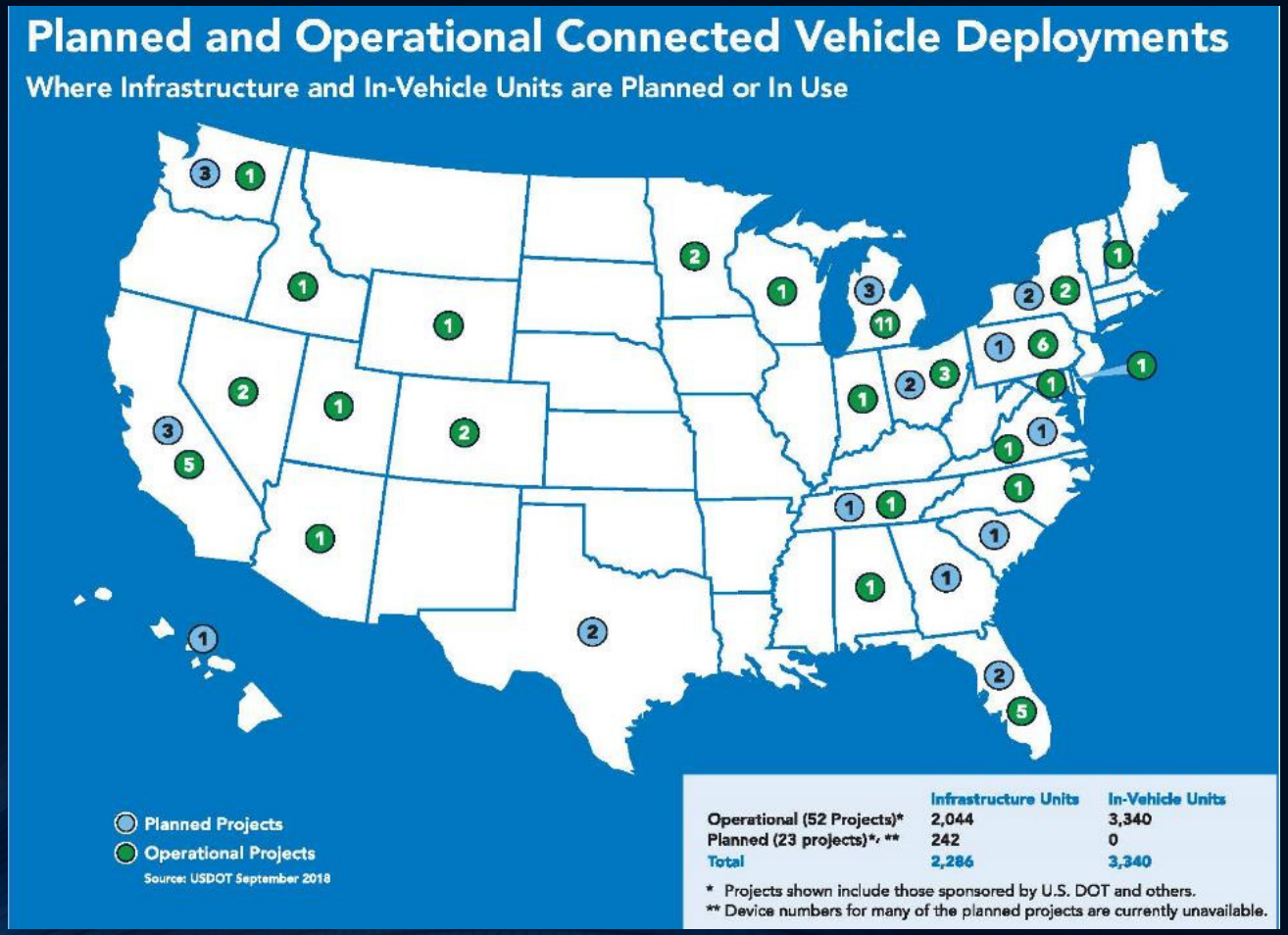
New York City DOT Pilot

Tampa-Hillsborough Expressway Authority Pilot

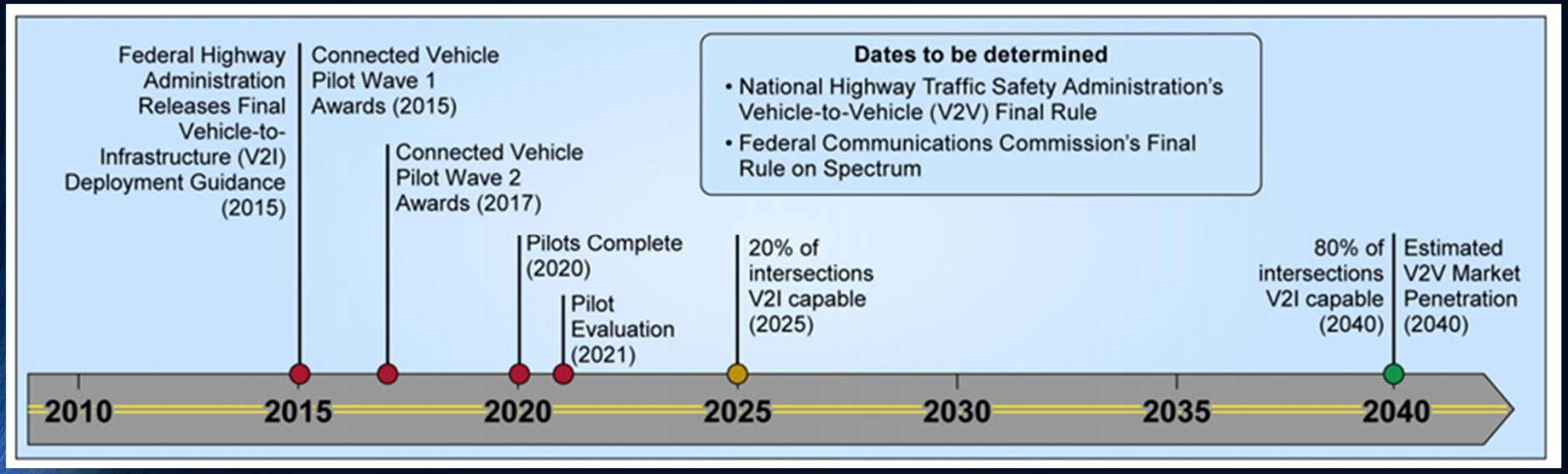


Wyoming DOT Pilot

State Government Activities in CV



US Government Timeline for CV



Source: GAO

CAVs have the potential to

- Improve public safety
- Reduce travel time
- Improve mobility
- Improve the environment
- Improve energy efficiency
- Enable new models for vehicle ownership
- Enable new models for mobility

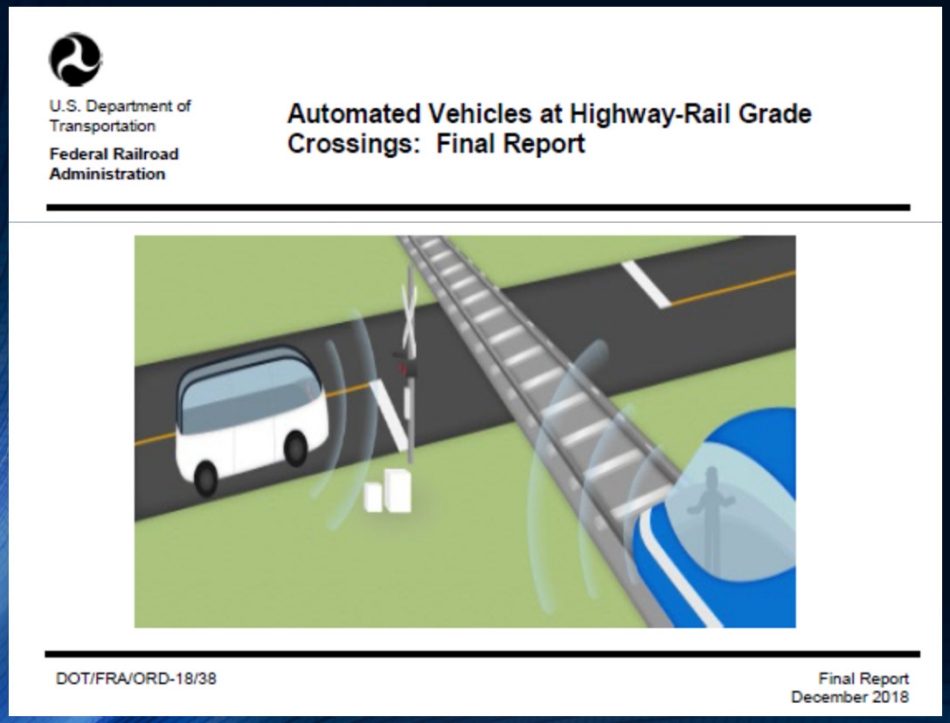
Rail Considerations

Rail Considerations for AV

- Per latest AV 3.0 guidance, FHWA will update its Manual on Uniform Traffic Control Devices (MUTCD) and review existing standards for traffic control devices.
  - May result in the roll out of changes/improvements to current signage and markings
  - May result in changes in standards
- NCHRP 20-102(6) study, "Road Markings for Machine Vision"
  - Suggests that contrast ratio of reflected luminance = 3x pavement markings
  - "Broken markings" should have higher contrast
  - Raised markings not suitable

Rail Considerations for AV

- USDOT AV at Grade Crossing – Dec 2018
  - Outlines scenarios in which AVs and CAVs should be able to act



U.S. Department of Transportation
Federal Railroad Administration

Automated Vehicles at Highway-Rail Grade Crossings: Final Report

DOT/FRA/ORD-18/38

Final Report
December 2018

- Association of American Railroads filed comments to AV3.0 in Dec 2018
  - Call for need for AV's to account for crossings

BEFORE THE
U.S. DEPARTMENT OF TRANSPORTATION
OFFICE OF THE SECRETARY OF TRANSPORTATION

DOCKET NO. DOT-OST-2018-0149
PREPARING FOR THE FUTURE OF TRANSPORTATION: AUTOMATED VEHICLES 3.0 (AV 3.0)

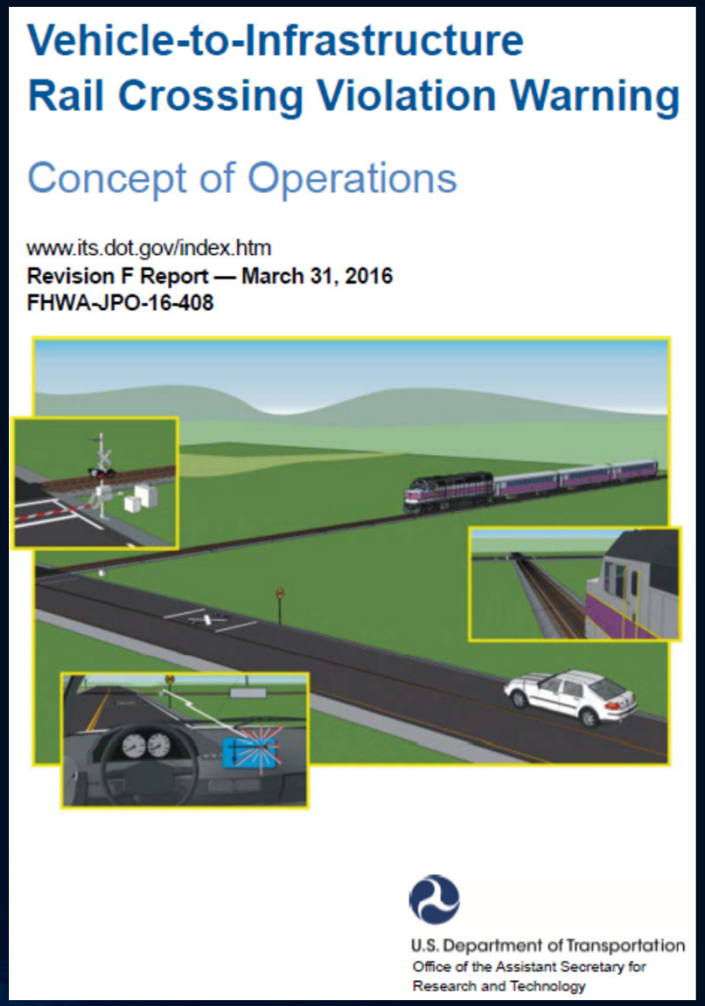
SUBMITTED BY
THE ASSOCIATION OF AMERICAN RAILROADS

The Association of American Railroads ("AAR"), on behalf of itself and its member railroads, submits these comments in response to DOT's notice of request for comment on its publication, *Preparing for the Future of Transportation: Automated Vehicles 3.0* ("AV 3.0").[1] AV 3.0 builds upon *Automated Driving Systems 2.0: A Vision for Safety* and seeks to provide a framework and multimodal approach to the safe integration of Automated Vehicles ("AVs") into the broader national surface transportation system.

The railroads applaud DOT for articulating a regulatory approach to automated vehicles

Rail Considerations for CV

- Major conclusion of AV reports:
  - AVs are only as good as they are CAVs.
  - Connectivity address uncertainty and inconsistency of AV recognition
  - Cornerstone is roadside to vehicular communication – similar to Signal, Phase and Timing (SPaT) messaging

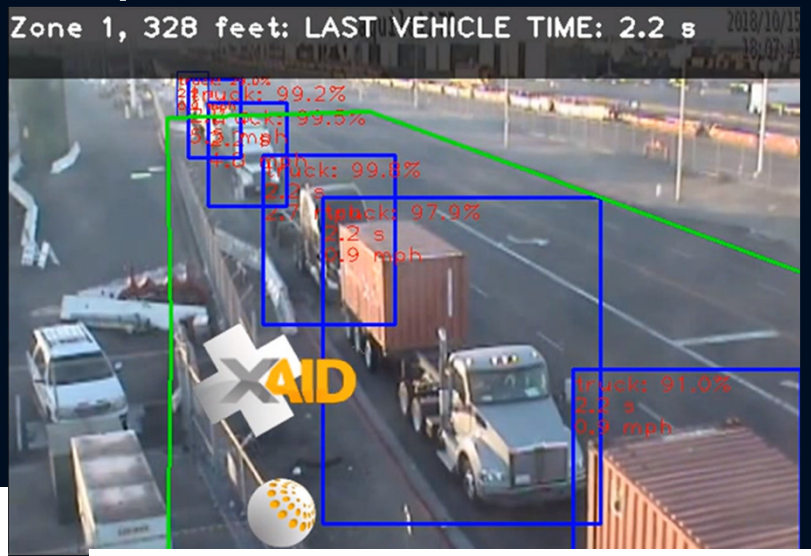


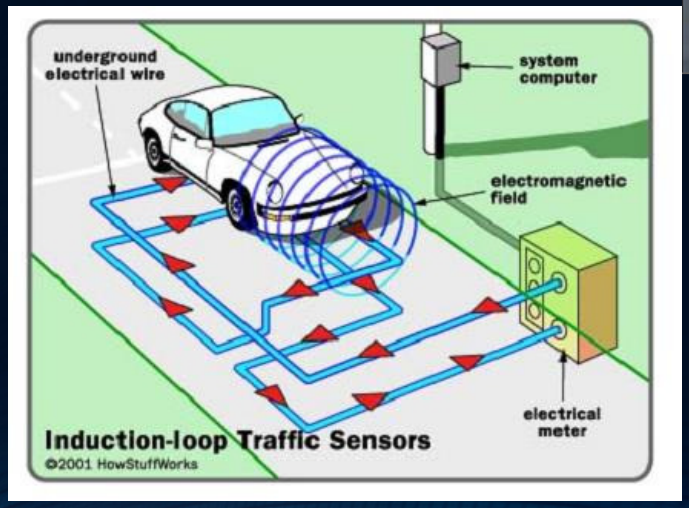
Basic infrastructure to implement CV

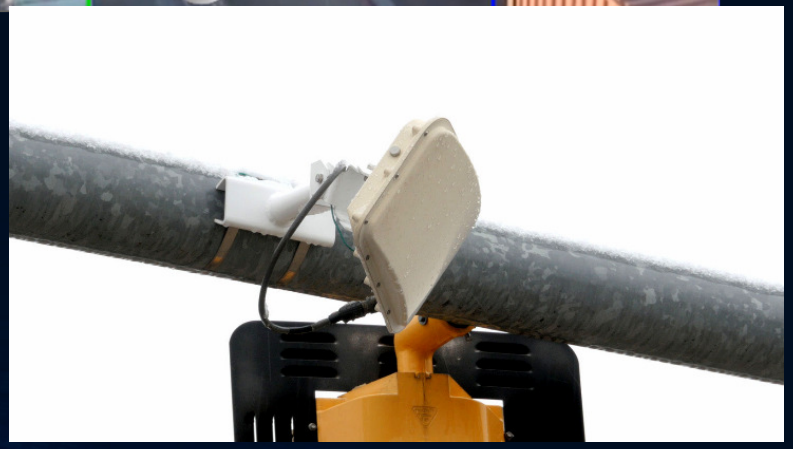
- Signal System Integration
  - Broadcast static message of crossing in open state
  - Broadcast new message when crossing closed
  - Use existing messaging at signal controller
  - Can use cellular for long-range messaging
  - DSRC used for localized communication at highway-rail intersection

Basic infrastructure to implement CV

- Passive System
  - Make use of other train detection means
    - Video detection
    - "Traditional" inductive loops or "side fire"
    - Placed off railroad right-of-way
    - Maintained by local DOT jurisdiction
  - Can be used as failsafe to active signal system integration







3 takeaways

1. Safety opportunities are tremendous
   - Capitalize on machine learning strengths for AVs
   - Advocate for OEM adoption of standards
   - Capitalize on ability to speak to driver and the car directly
2. CAV will be here
   - AVs will need standardized method of recognition
   - CVs will be able to communicate with rail infrastructure one way or another – (cellular or DSRC)
3. What to do now
   - Should be preparing for this now in long-term capital improvement plans
   - More pilots needed for CV solutions at highway-roadway intersections

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