PARSONS

Automated and Connected Vehicles

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Agenda

- Survey
- Automated Vehicles
- Connected Vehicles
- Quick Hits
- Next Steps

Classroom Exercise: Question 1

- When it comes to riding in a car with no steering wheel, no gas or brake and no dashboard, and the car will drive anywhere, today I am inclined to:

  A) Not get in that car

  B) Not my first choice, but in a pinch I would ride in a fully automated vehicle

  C) Maybe use it occasionally as a taxi service

  D) Are you kidding, this is great, I would use it all the time

Classroom Exercise: Question 2

- Fully automated vehicles will be 25% of the installed vehicle base by:
  - A) 2030
  - B) 2035
  - C) 2040
  - D) 2045
  - E) 2050 or beyond

Classroom Exercise: Question 3

- Vehicle miles driven by ride-hailing service (Uber, Lyft) will be 25% of total miles driven by:

  A) 2030

  B) 2035

  C) 2040

  D) 2045

  E) 2050 or beyond

BCG Study

- By 2030, 25% of US miles driven could shift to
  - Ride-hailing Services (Uber, Lyft)
  - Which Use Fully Autonomous Vehicles
  - With most of the fleet electric
- Numbers to think about:
  - 260 million cars and light truck on the road
  - 17 million new unit sales per year

BCG

THE BOSTON CONSULTING GROUP

AAA Study

- AAA has conducted studies of attitudes towards Self Driving Vehicles
- ORLANDO, Fla. (January 24, 2018) The annual survey reveals that 63 percent of U.S. drivers report feeling afraid to ride in a fully self-driving vehicle, a significant decrease from 78 percent in early 2017.
- Millennial and male drivers are the most trusting of autonomous technologies, with only half reporting they would be afraid to ride in a self-driving car. To ensure that American drivers continue to be informed, prepared and comfortable with this shift in mobility, AAA urges automakers to prioritize consumer education.

MIT Study

Brand Name	Percent Correct By Respondents
Adaptive Cruise Control	50%
AutoPilot	26%
Drive Pilot	18%
Intelligent Cruise Control	30%
Pilot Assist	31%
SuperCruise	25%
Traffic Jam Assist	24%
Traffic Jam Pilot	22%

Massachusetts Institute of Technology

Automated and Connected Vehicles

Automated and Connected Vehicles

Connected Vehicles—Short Range

- On Board Systems which communicate with other vehicles and infrastructure using short range comms: V2V Safety

Automated Vehicles

- On Board Systems which automate the driving task
- Do not rely on Real-time Communications with other entities

Connected Vehicles—Wide Area Network (WAN)

- On Board Systems which communicate with other vehicles and infrastructure using Cellular Networks: OnStar, Apple Car, BMW Connect

Vehicles may use one, two, or ALL three elements

Automated Vehicles

LIDAR and RADAR and AVs

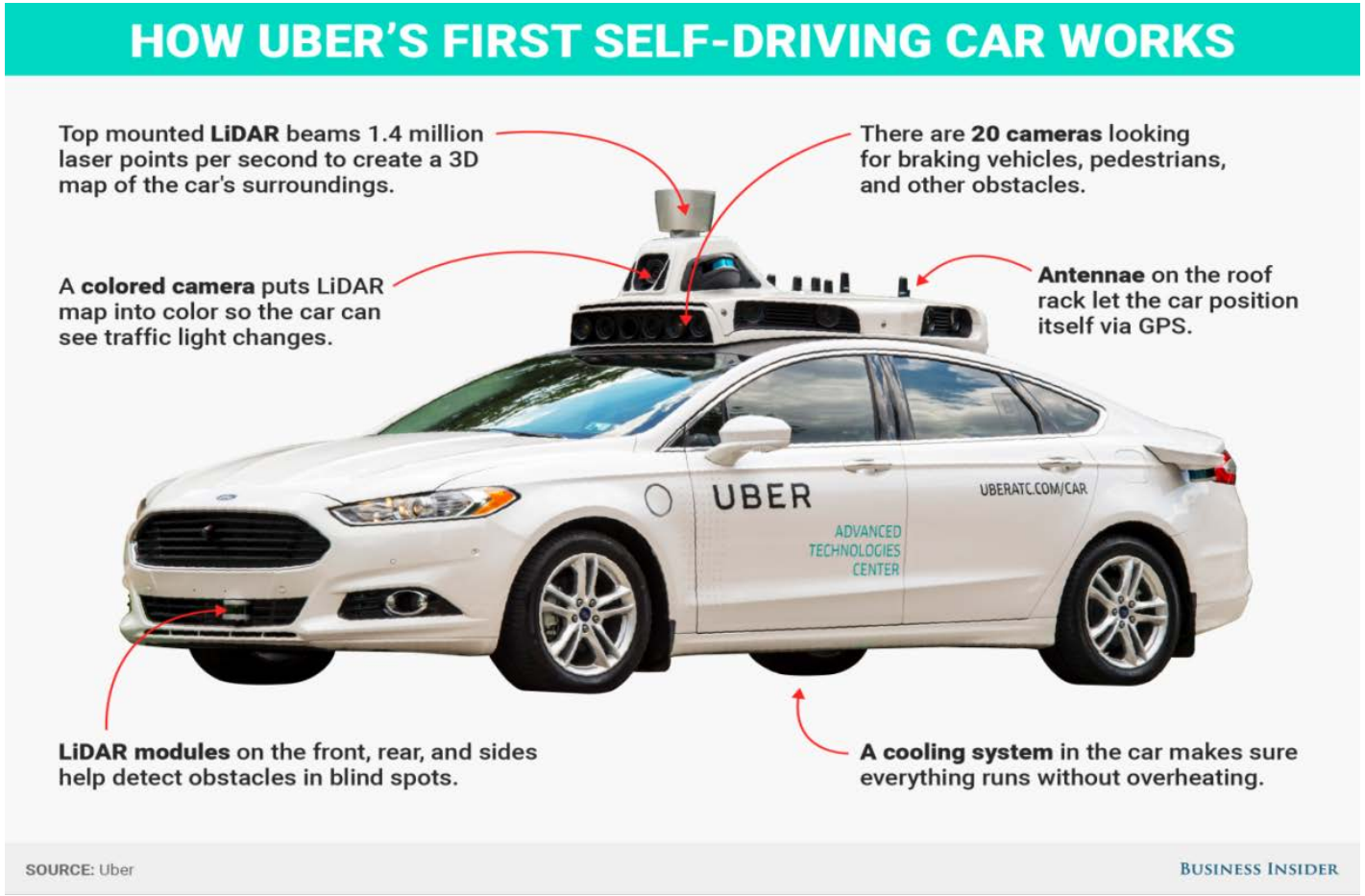
- RADAR = Radio Detecting and Ranging

- LIDAR = Light Detecting and Ranging

Elements of Automated Vehicles

Key Elements

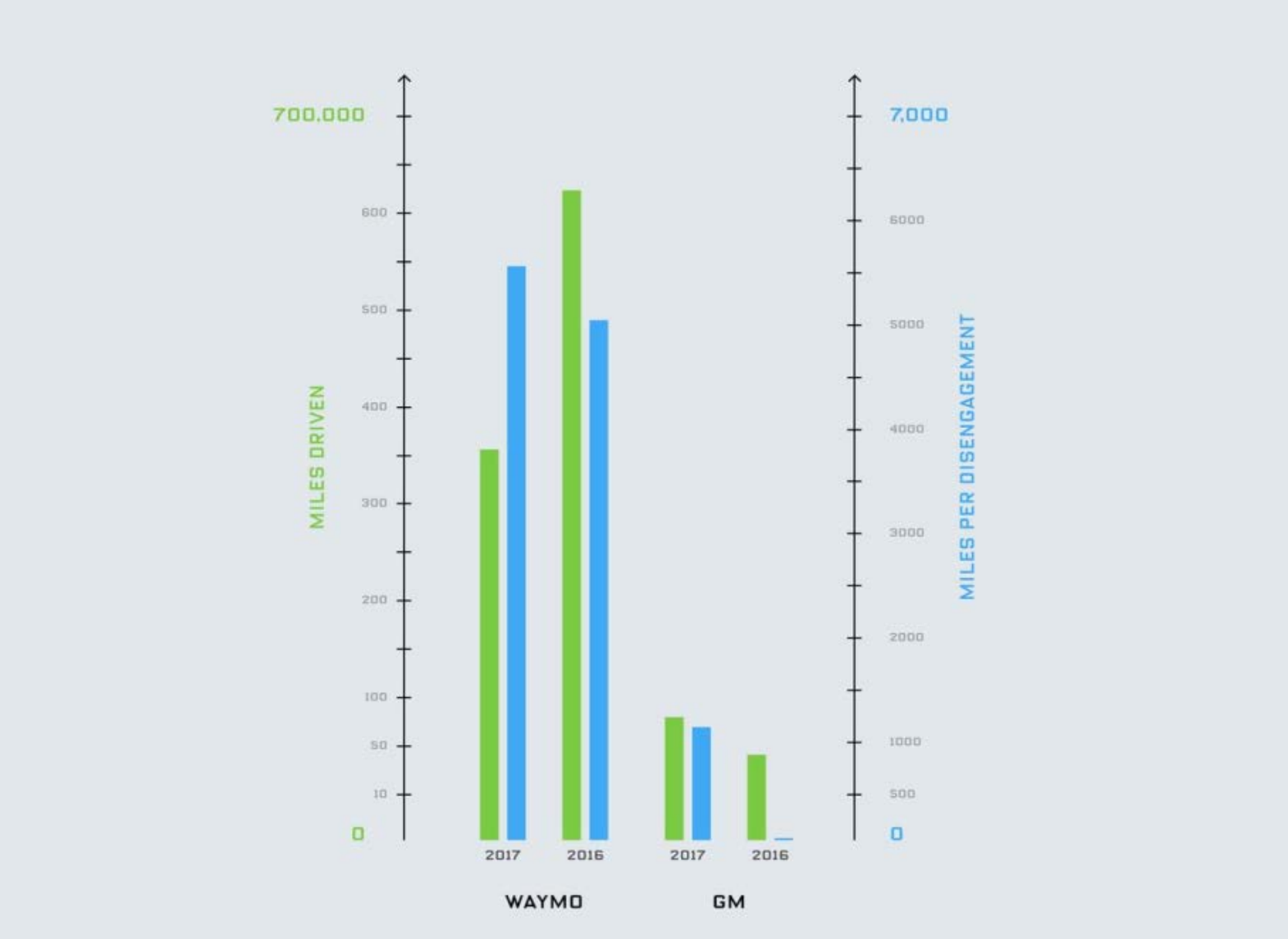
- Precise GPS for location
- Precise map database
- Cameras for traffic signal identification, reading signs, etc
- RADAR and/or LIDAR for lane keeping and obstacle detection



SAE Levels of Automation (SAE = Society of Automotive Engineers)

Level	Label	Description	Functionality/Example
0	No Automation	Warnings Only	Blind Spot Detection
1	Drive Assistance	Control of either steering or acceleration/deceleration	Adaptive Cruise Control
2	Partial Automation	Control of both steering and acceleration/deceleration	Adaptive Cruise Control plus Lane Keeping
3	Conditional Automation—human intervention in some time frame	Complete control by vehicle with expectation that driver will intervene when requested	All of 2 PLUS Cameras to read/interpret Traffic Signs/Signals and with Built In Navigation Control
4	High Automation---defined geographies	Complete control by vehicle for defined geographies	All of 3 PLUS no expectation of human intervention in defined geography
5	Full Automation---all modes, all geographies	No steering wheel, no brakes, no gas pedal	No human intervention needed

Automated Vehicles 2017 Miles Driven and Miles Per Disengagement



Connected Vehicles

Notice of Proposed Rulemaking (NPRM)

- In December, 2016, NHTSA announced plans for a rulemaking on V2V communications
- NHTSA proposes to amend Federal Motor Vehicle Safety Standards (FMVSS) No. 150:
  - "to require all new light vehicles to be capable of Vehicle-to-Vehicle ('V2V") communications, such that they will send and receive Basic Safety Messages to and from other vehicles"

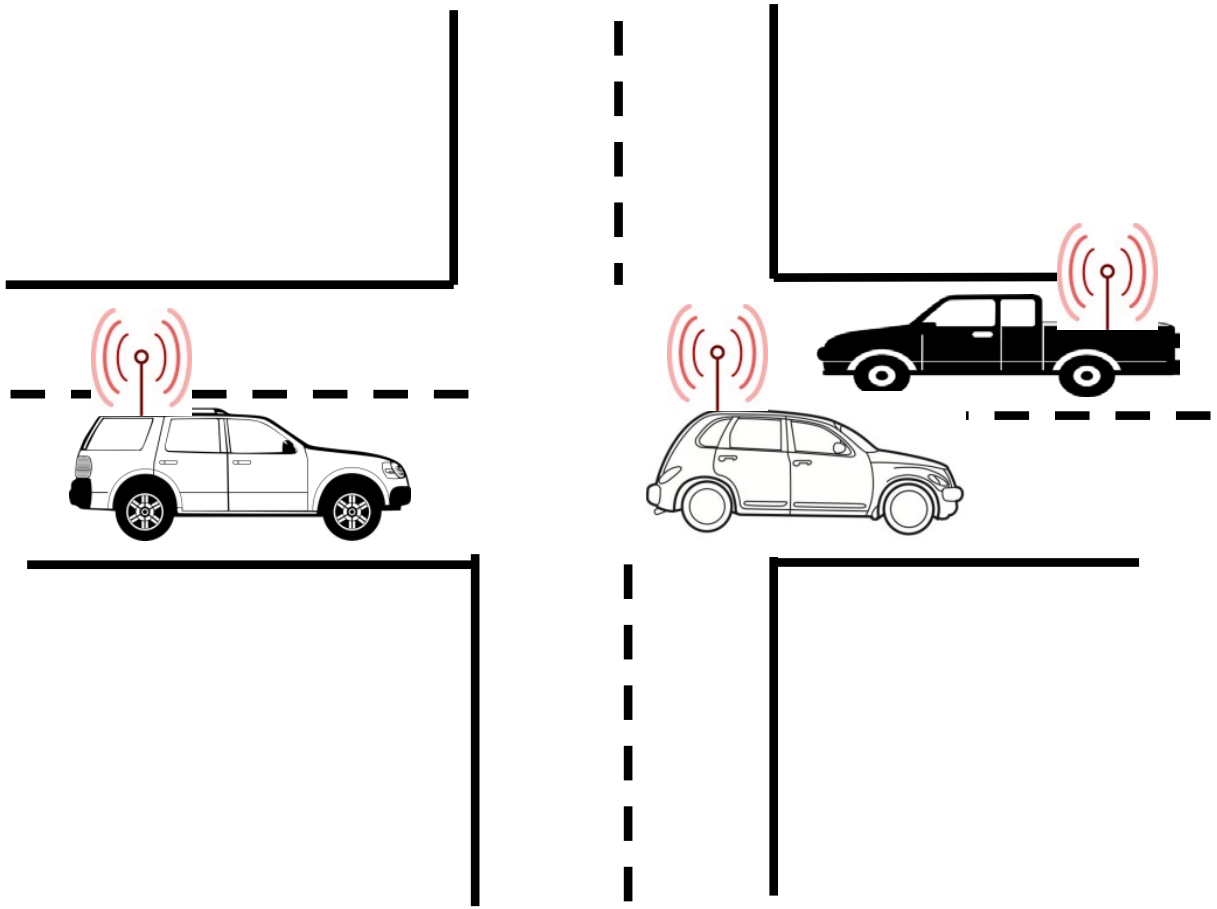
Notice of Proposed Rulemaking

- January 12, 2017: Publication in Federal Registry
- April 12, 2017: Comments Due Regarding NPRM
- 2019: Assume Rule is planned to become effective
- 2021: Begin phase in on all light trucks and cars sold
- 2023: All cars and light trucks required to install V2V Communications
- Current Administration is not pushing the NPRM forward but some automakers are moving forward anyway to implement---more in a few slides

How do they plan to prevent “hacking and tracking”?

- Will the system be anonymous?
- Will the system be able to track my movements?
- How do we reduce the likelihood of hacking?

How Does V2V for Safety Work?

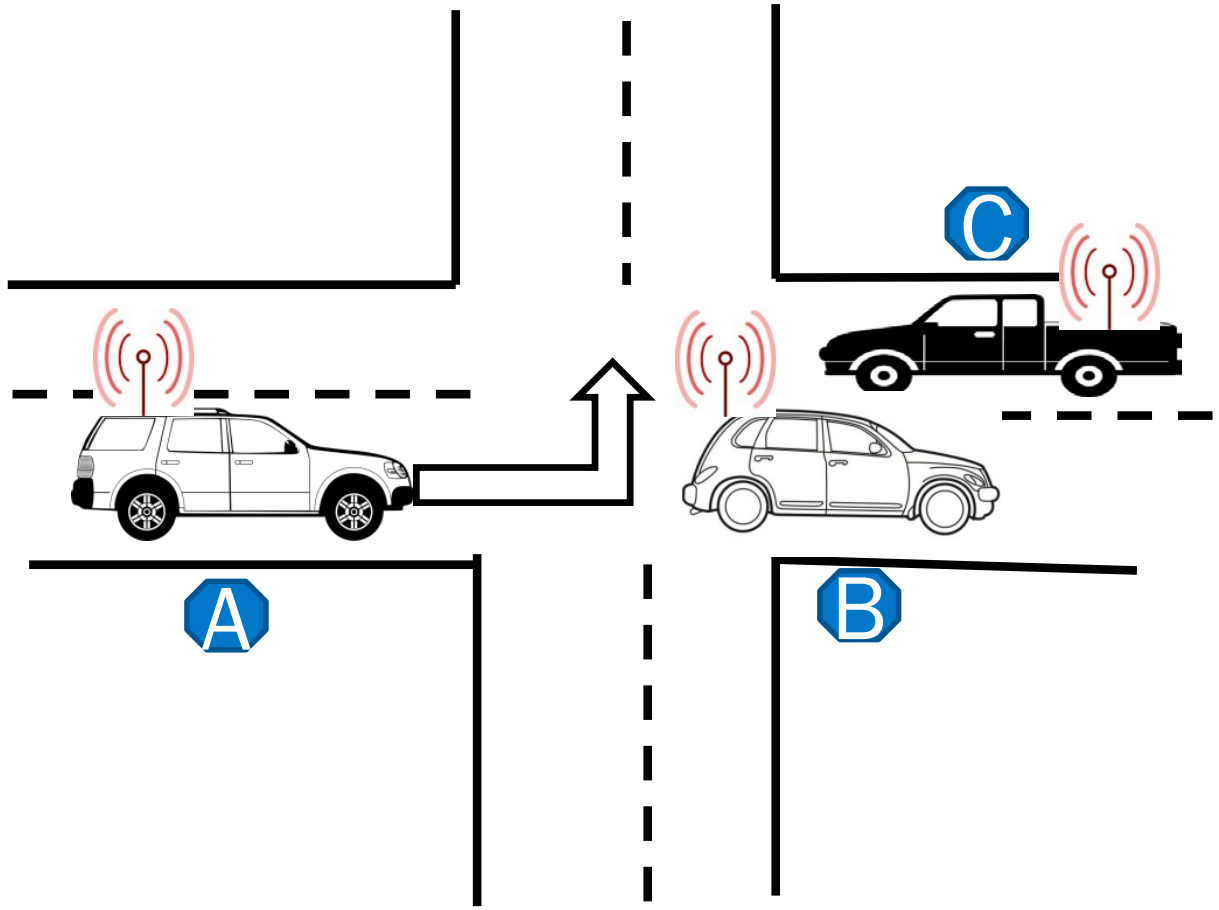


- Vehicles Equipped with DSRC for V2V Safety broadcast a Basic Safety Message (BSM)10 times per second
  - DSRC range ~ 300 meters
- BSM includes:
  - Location
  - Direction of Travel
  - Speed
  - Security Credentials
  - AND is Anonymous—no VIN or Account ID is broadcast
- Other vehicles receive the BSM and decide:
  - Given other vehicle's trajectory "Is a crash likely or imminent?"
  - Should the vehicle alert the driver?

V2V Safety: Some Applications

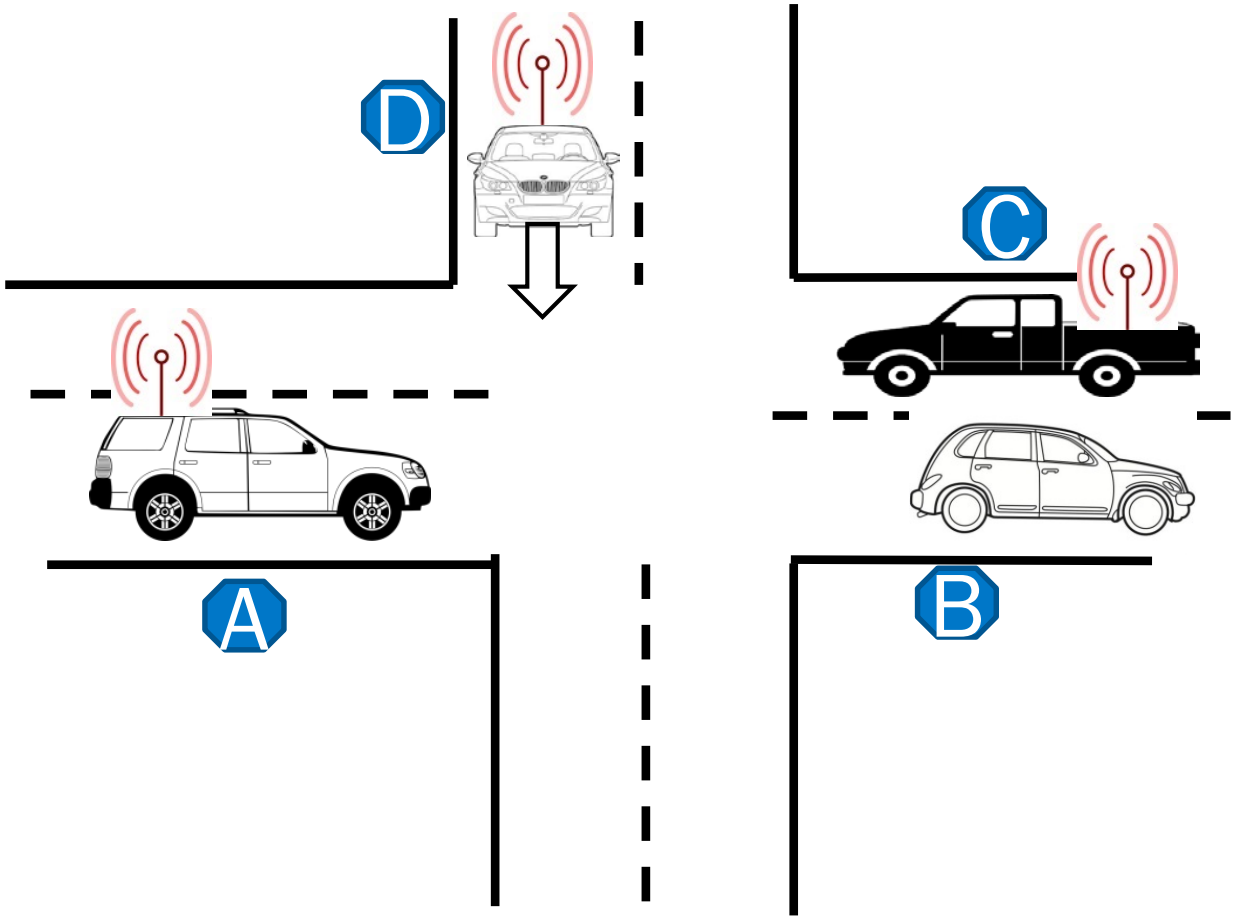
- **Forward Collision Warning:** Warns of stopped, stalled vehicles ahead
- **Do Not Pass Warning:** Warns of oncoming traffic in opposing lane when attempting to pass
- **Left Turn Assist:** Warns of vehicles crossing the path of a left turn
- **Intersection Movement Assist:** Warns of lateral crossing vehicles at an intersection
- **Approximately 30 others**

Application: Left Turn Assist



- White SUV (A) approaches intersection and signals left turn
- Black pick up truck (C)
  - Approaching intersection at 60 mph (88 feet/sec)
  - Separation distance is 80 feet
- Vehicle A's speed is 15 mph (22 feet/sec)
- Vehicle A will ALERT THE DRIVER!
- Vehicle C will ALERT THE DRVER!

Application: Intersection Movement Assist



- White SUV (A) and Black pick up truck (C) have green light
- Vehicle D approaches at high speed and is on a trajectory to run the red light
- Vehicles A and C receive BSMs from Vehicle D and determine a collision is imminent (Vehicles are always receiving BSMs)
- Vehicle A will ALERT THE DRIVER!
- Vehicle C will ALERT THE DRVER!

NHTSA Cost-Benefit Analysis

- USDOT conducted a series of studies:
  - Safety Pilot Model Deployment & Driver Clinics
  - Worked with automakers in Collision Avoidance Metrics Partnership (CAMP)
- NHTSA/USDOT Created Cost-Benefit Based Upon ONLY **Left Turn Assist** and **Intersection Movement Assist**

Table I-1 From NPRM	All Stats per year		
Total Annual Costs	Per Vehicle Costs	**Crashes Prevented and Lives Saved**	**Monetary Benefits**
$2.2 B - $5.0 B	$135 - $301	Crashes: 424,901-594,569 Lives Saved: 955- 1,321	$53 B - $71 B

*Year 30 after ruling takes effect

Accelerating Adoption of V2V/V2I Safety

COALITION FOR SAFETY SOONER

January 23, 2018

The Honorable Elaine L. Chao
Secretary
United States Department of Transportation
1200 New Jersey Avenue, S.E.
Washington, D.C. 20590

The Honorable Mick Mulvaney
Director
Office of Management and Budget
725 17th Street, N.W.
Washington, D.C. 20503

The Honorable Ajit Pai
Chairman
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

How do they plan to prevent “hacking and tracking”?

- Will the system be anonymous?
  - Yes, data is broadcast without identifying the broadcaster
- Will the system be able to track my movements?
  - No, because of anonymity the system has protections in place to not track your travel
  - Most people carry 1-2 cell phones and are allowing their location to be discovered by Facebook, Google, Waze, Uber, WhatsApp, etc….
- How do we reduce the likelihood of hacking?
  - Automakers are working together under the Collision Avoidance Metrics Partnership (CAMP) to create security system
  - Creating a Security Credential Management System (SCMS) which includes a Public Key Infrastructure (PKI)-- a security approach.

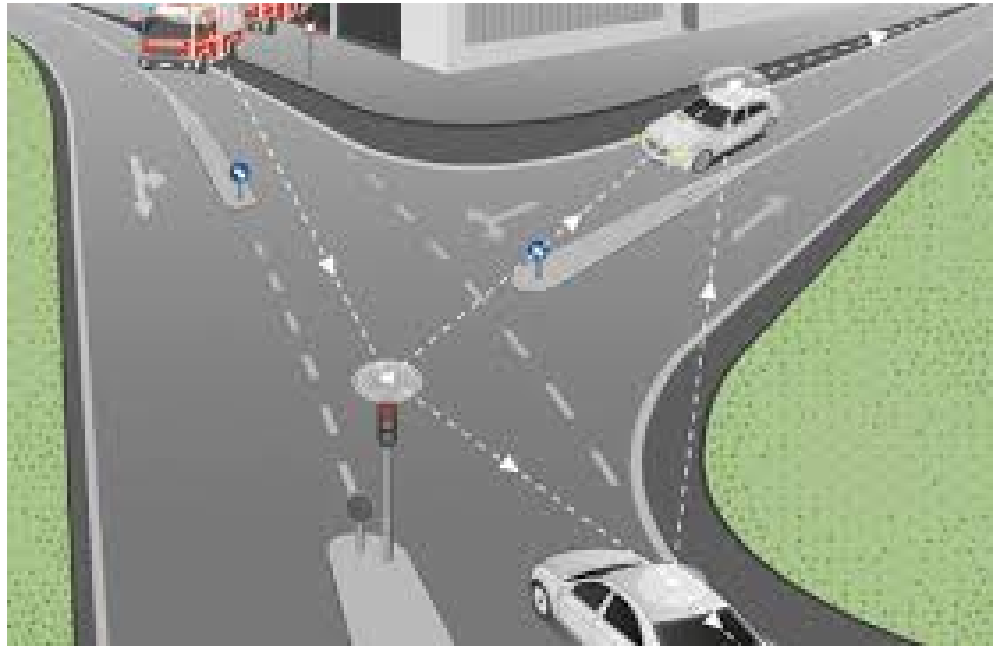
Shifting Gears: Cooperative Automated Transportation (CAT) Coalition

Vehicle-To-Infrastructure

- Given that FHWA will not issue a rule for DSRC but is looking to states to create guidelines for V2I deployment
- Cooperative Automated Transportation (CAT) Coalition was formed by:
  - American Association of State Highway Transportation Officials (AASHTO)
  - ITS America
  - Institute of Transportation Engineers (ITE)

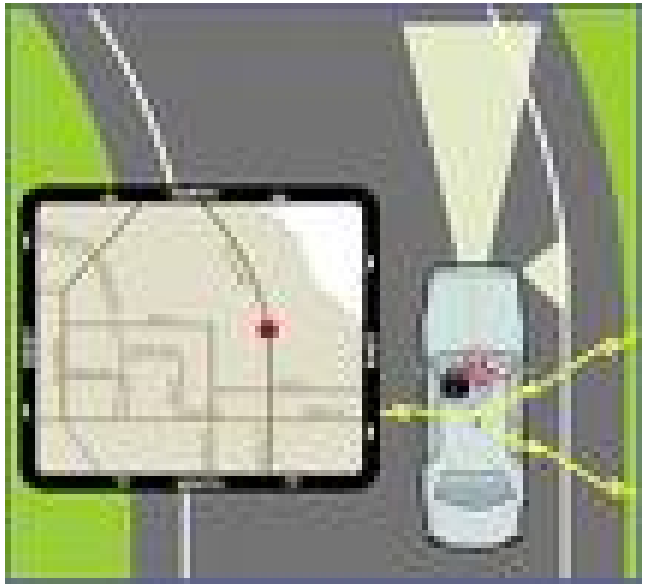
CAT Coalition

- Approach is to create a single point of reference for stakeholders to meet and discuss V2I deployment related issues
- Create guidance for Infrastructure Operators
- Foster cooperation between:
  - Infrastructure Operators
  - Automakers
- Initiatives Working Group:
  - Greg Larson, Caltrans, Chair
  - Joe Averkamp, Parsons, Co-Chair



Vehicle-To-Infrastructure

- Initiatives Working Group-Four Key Applications:
  - Intersection Safety: Signal Phase and Timing
  - Work Zone Safety—a critical area for Traffic Management Authorities
  - Curve Overspeed Warning
  - Approaching End of Queue Alerts



Signal Phase and Timing Challenge

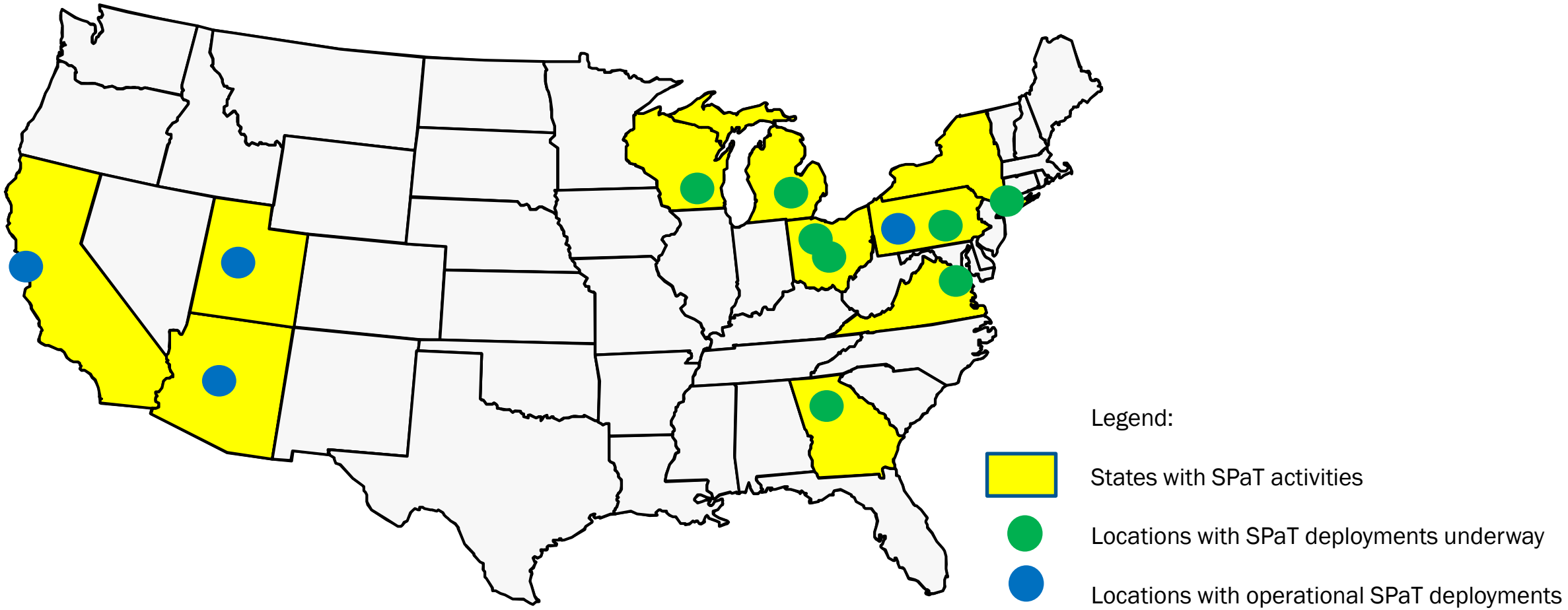
The National Connected Vehicle Deployment Challenge

20 SPaT Intersections in 50 States by 2020

The Challenge:

To Challenge state and local public sector transportation infrastructure owners and operators to cooperate together to achieve deployment of DSRC infrastructure with SPaT broadcasts in at least one corridor or network (approximately 20 signalized intersections) in each state by January 2020.

Tracking SPaT Challenge Activities



More details at:
www.transportationops.org/spatchallenge

Quick Hits

Quick Hits: Automakers

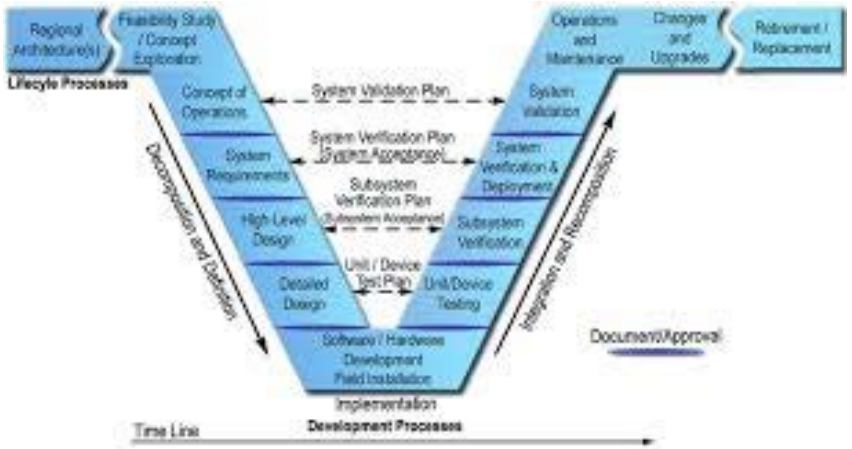
Toyota Announces Plans to Install DSRC in Vehicles Starting in 2021; All New Sales by mid-2020s—Announced April 16, 2018

GM announces DSRC as part of 2018 Cadillac STS Supercruise—Mar 9, 2017

Ford and Qualcomm announce Cellular V2X Trial—January 9, 2018

Quick Hits

Ohio DOT announces plan to conduct System Engineering Analysis on Automated and Connected Vehicles—April 12, 2018



Quick Hits

Michigan Mcity launched in 2015

Columbus Wins USDOT Smart City Challenge

Truck Platooning trials in several locations

Automated Vehicle Shuttles for Transit Systems

Developing an ACV Plan: Some Approaches

- Needs
  - Determine regional needs from a transit, tolling, intelligent transportation management perspective
    - What are pain points? What do we aspire to be?
    - How do we foster mobility and safety?
    - How do we encourage Economic Development for the region?
    - How do we engage the citizenry; what are their preferences?
  - Evaluate infrastructure readiness and ability to support Connected Vehicles environment.
    - How extensive is fiber optic deployment? How well instrumented is the road network?
    - How extensive is signal system deployment, ramp metering, DMS deployment---system inventory?
  - Human factors—consider the social elements
    - Professional workforce development
    - Commerce/Businesses
    - Citizens/Universities/Social Organizations
  - Devise and deploy pilots and plan

- Approaches
  - Conduct a Systems Engineering Analysis of the region's needs, readiness, and ability to upgrade infrastructure for ACV vehicles. Determine users needs, create high level and detailed design.
  - Deploy elements from the Smart Cities proposal
  - Participate in SPAT Challenge; develop competency around V2I
  - Conduct/encourage AV testing on freeways and arterials
  - Evaluate use of ride-hailing services to support paratransit
  - Conduct pilots to evaluate use of Automated Shuttles for transit
  - Revise modify ITS plan

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Dictionary of Terms

- DSRC: Dedicated Short-Range Communications; wireless protocol at 5.9 Ghz based on 802.11p, and WAVE1609
- V2V: Vehicle-to-Vehicle; communication which enables messaging between vehicles over wireless data channels
- V2I: Vehicle-to-Infrastructure; communications between vehicles and infrastructure
- V2X: Vehicle-to-Everything; communications between vehicles and their environment
- CV2X: Cellular-Vehicle-to-Everything: protocol based upon LTE which Qualcomm is leading
- LIDAR: Light detection and ranging; Automated Vehicle technology for detecting objects and vehicles around the AV
- RADAR: Radio Detection and Ranging; Automated Vehicle technology for detecting objects and vehicles around the AV
- SCMS: Security Credential Management System; management structure for managing security in the V2V environment
- PKI: Public Key Infrastructure: security credential approach---set of roles, policies and procedures to create, manage, distribute, use, store, and revoke digital certificates
- CAMP: Collision Avoidance Metrics Partnership; organization created by automakers to manage cooperation for V2V elements; Participants includes GM, Ford, Honda, Toyota, Nissan, VW, Mercedes Benz