

AASHTO's Subcommittee on Traffic Engineering (SCOTE)

2016 meeting – Savannah, GA

*Connected and automated vehicles
State and local agencies ramifications*

Abbas Mohaddes

CAVita



Giving life to transformational technology in transportation

Agenda

- Common understanding of connected and automated vehicles
- Technology trends, timing
- Key players
- Ramification to states and local communities
- Key barriers for deployment
- Plan for it?!



What are connected vehicles?

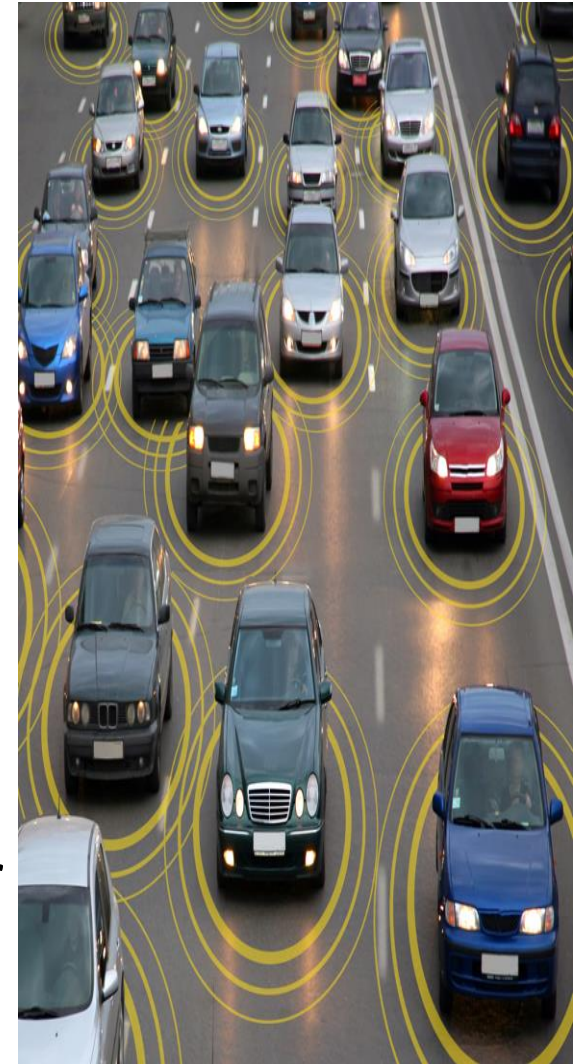
The term “connected vehicles” refers to both connecting vehicles and infrastructure, and to connection among all ground vehicle players: cars, freight trucks, buses, motorcycles, bicycles, and pedestrians.

- other modes such as BRT, heavy and light rail is included
- Connected refers to licensed wireless, Dedicated Short Range Communication (DSRC), other cellular technologies (i.e. 5G, etc.), satellite, internet, and all forms of telematics. **Often, connectivity is referred to as “V2X”**



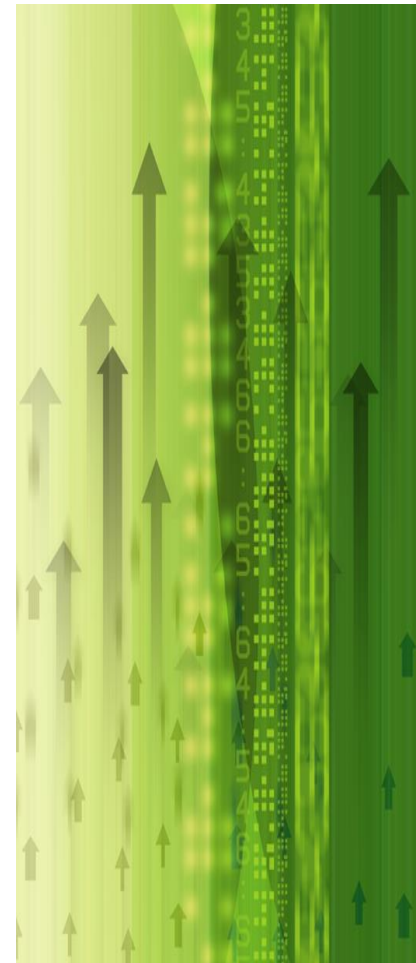
What are connected vehicles? (continued)

- “Connected” only becomes highly effective when the density of equipped vehicles in the traffic stream increases to a certain point.
 - Rate of deployment of V2X technology in vehicles and infrastructure is a key issue.
 - Requires consideration of “original equipment” fitment in both **vehicles and infrastructure**, as well as the **use of the aftermarket** for vehicles and **potentially for infrastructure** as well.



CV technologies and trends

- Connected vehicles (and infrastructure) rely on wireless communication
 - The selected wireless regime provides a *platform* upon which a rich variety of *applications* may be placed and operated.
 - The requirements of the application – its purpose and scope – largely determine the necessary capabilities of the assigned wireless communication method.
 - In the United States, connected vehicles have been developed primarily for the purpose of deploying ***safety applications***. While safety applications may cover a wide field in terms of specificity for avoiding crashes, the adopted wireless method must accommodate the most demanding applications.

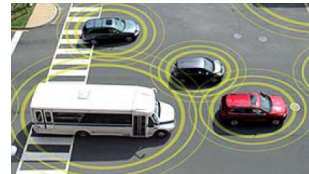


CV technologies and trends (continued)

- The platform development that was largely funded by the USDOT uses Dedicated Short Range Communication (DSRC)
 - uses part of a 75 MHz slice of licensed spectrum at 5.9 GHz.
 - Signal reliability and short latency of this wireless regime are *suitable for highly specific safety applications* like forward collision warning, or automatic braking system.
 - It is possible that future versions of cellular technology, such as 5G, will have adequate technical performance – similar to DSRC – and will need to be considered.
 - The DSRC platform is used to send *Basic Safety Messages* (BSMs) that contain vehicle position, speed and heading, as a minimum. ***BSMs are sent ten times per second*** and are received by equipped vehicles and infrastructure equipment in the immediate vicinity.

CV technologies and trends (continued)

- The deployment of DSRC roadside equipment in the infrastructure – especially at intersections and on curves – is a necessary development, along with a sufficient density of equipped vehicles in a given traffic stream.
 - Typically housed in traffic control cabinets, with transmission equipment high-mounted on signal arms, poles and gantries.
- While equipment vendors and the traffic control industry have the necessary technology, the business case for paying for the installation, operation, and maintenance of the roadside equipment is not at all clear.
- A minimum level of roadside equipment is needed for connected vehicle support functions - such as the operation of security systems – and higher levels of deployment will provide important V2I advantages for traffic operations and safety (beyond those which V2V has to offer).
- In addition to the roadside equipment, it is necessary to have a “data backhaul” (getting data to a point from which it can be distributed over a network) to centralized locations.



What are automated vehicles?

- AVs cover a very broad range of functions, from driver-assist interventions to full driverless capability
 - The term “automated vehicle” includes “autonomous vehicle” (having more reliance on on-board technologies)
- The common feature of all AVs is the replacement of one or more human control functions with machine functions
- In order to describe an AV, it is necessary to consider:
 - The intended role of the driver
 - The intended operating environment
- The AV value proposition has a short-term focus on convenience and efficiency, and a long-term focus on shared mobility services
 - Safety is a major criterion: starting with the safe introduction of automated features, and ending with a mobility system free of crashes

Elements of automation

- Sensing of the vehicle location and immediate environment of roadway, roadside and traffic
- Determination of “situation awareness”
- Recognition of traffic conflicts
- Determination of control actions
 - Subject to driving norms and road rules
- Effecting and monitoring control

Examples of AV features

- Automated Emergency Braking (AEB) to apply a car's brakes in an imminent collision when the driver has failed to act
 - To be deployed voluntarily in 2022 subject to 2016 NHTSA agreement with 20 automakers
- Advanced multi-function cruise control that drives the car on a freeway
 - Super Cruise on 2017 Cadillac
- Platooning of long-distance freight trucks on major highways
 - Following vehicles automatically travel behind the lead vehicle at short headways
 - Significant gains in fuel economy
- The vehicle takes over control traveling at very low speed in a traffic congestion
 - Applicable to long-distance freight trucks when encountering a zone of intense congestion
 - Provides fatigue relief for the driver

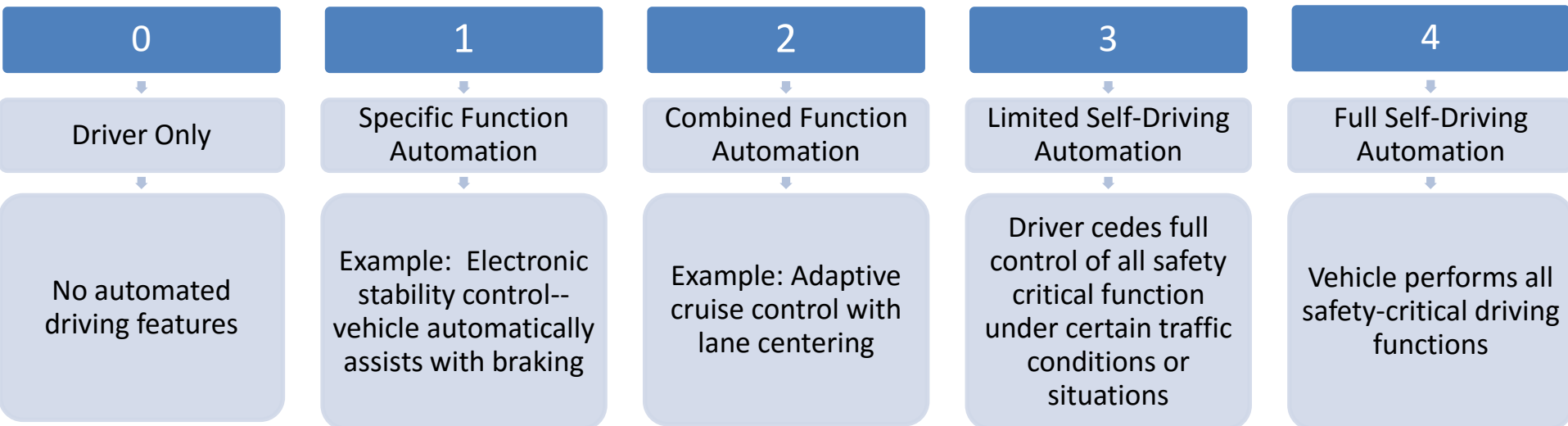
How do automated vehicles differ from connected vehicles?

- Connected vehicles provide drivers with warnings related to the behavior of other vehicles, or infrastructure factors such as curves
 - The driver still has to take the control action
 - V2V-V2I connectivity relies on a highly-effective sensor and does not replace the driver
- *Connected vehicles are not necessarily automated; automated vehicles will eventually be connected*

Role of the driver

- Both NHTSA and SAE have defined levels of automation from the perspective of the required role of the driver
- The driver's role is viewed in terms of:
 - Eyes on/off the road
 - Hands on/off the wheel
 - Feet on/off the pedals
- Distinction is made between the machine or driver monitoring operating conditions (and the need for the driver to regain control)
- *The time available for the driver to regain control is important*
 - Some companies and experts are opposed to technologies that require such monitoring and sudden reinsertion of driver control

NHTSA Automation definition



How do AVs relate to the infrastructure and traffic environment?

- The sensors on AVs recognize certain infrastructure features such as lane markings, signs and signals
- A future state with high penetration of AVs may allow roadway geometry to change
 - eg. Narrower lanes
- AVs need to co-exist with conventional vehicles
 - Both need to follow the same “rules of the road”
 - Machines currently drive conservatively and many drivers are the opposite
- Driverless vehicles will be introduced in certain contained and controlled environments, as part of public-private mobility schemes
 - Important element of Smart Cities programs
 - Such schemes will be place-based and may bundle other technologies such as electrification

*CV and AV can proceed
independently on parallel paths but
will converge to produce
“connected automation”*

Connected Automation for Greatest Benefits

Autonomous Vehicle

Operates in isolation from other vehicles using internal sensors



Connected Vehicle

Communicates with nearby vehicles and infrastructure

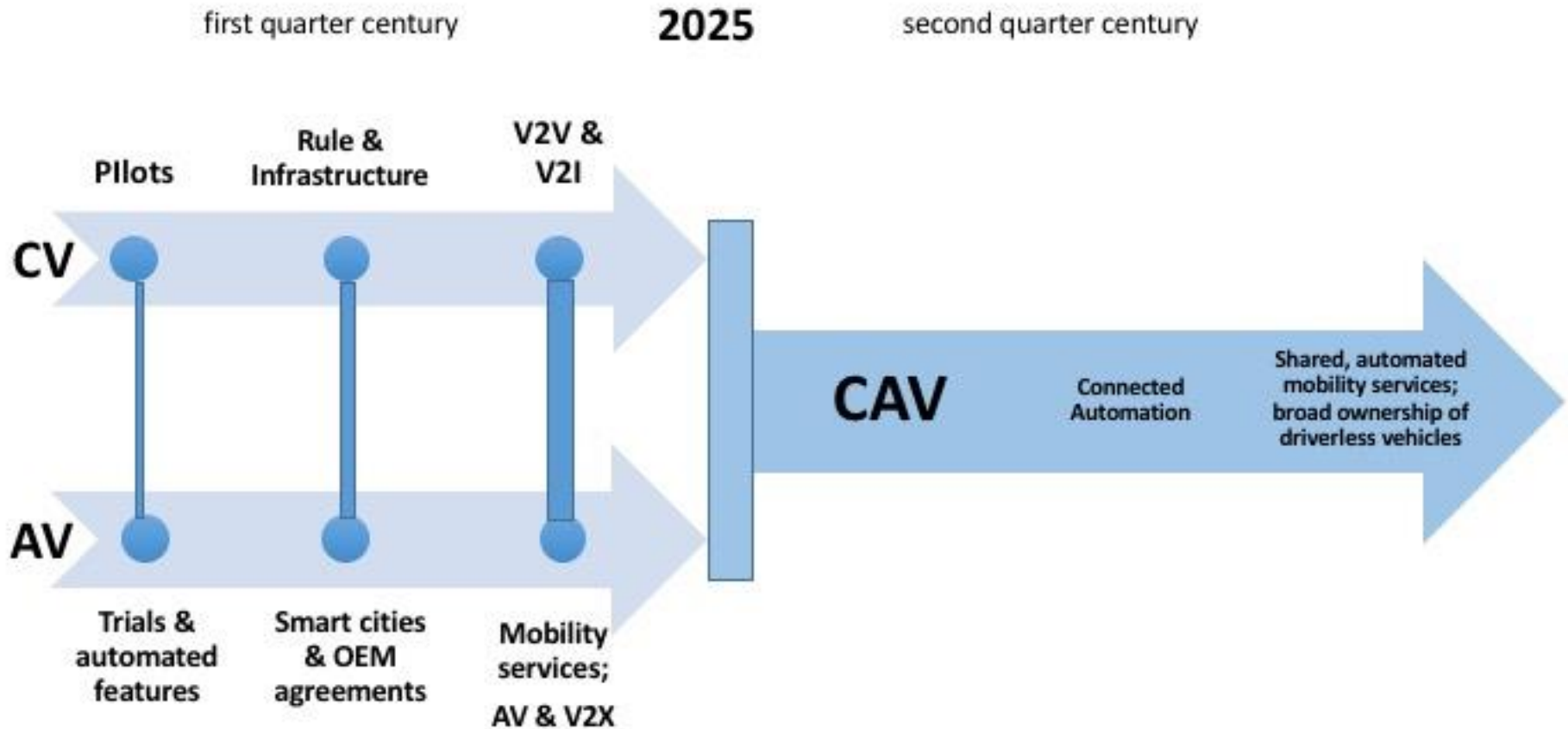


Connected Automated Vehicle

Leverages autonomous and connected vehicle capabilities

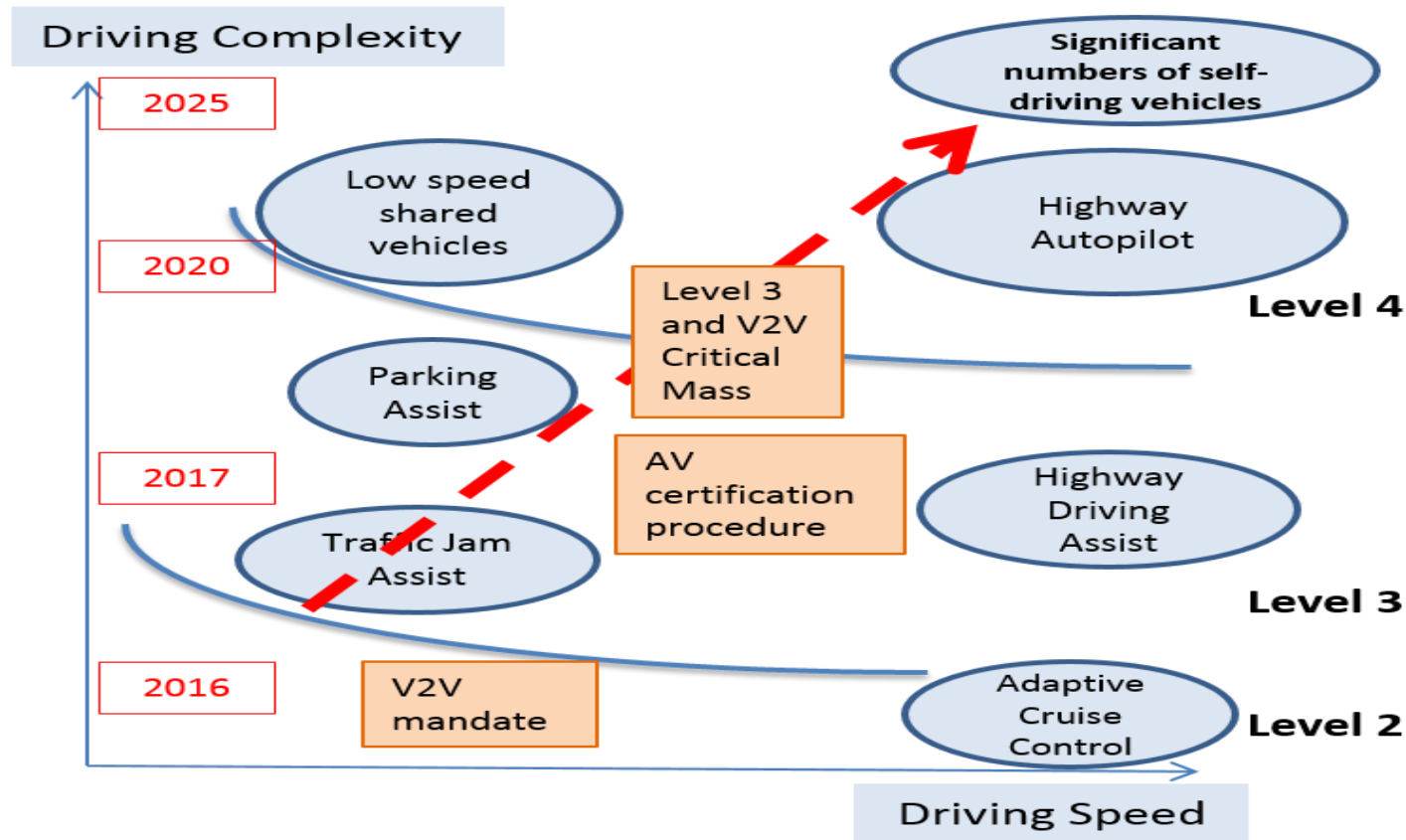


Convergence of CV and AV paths



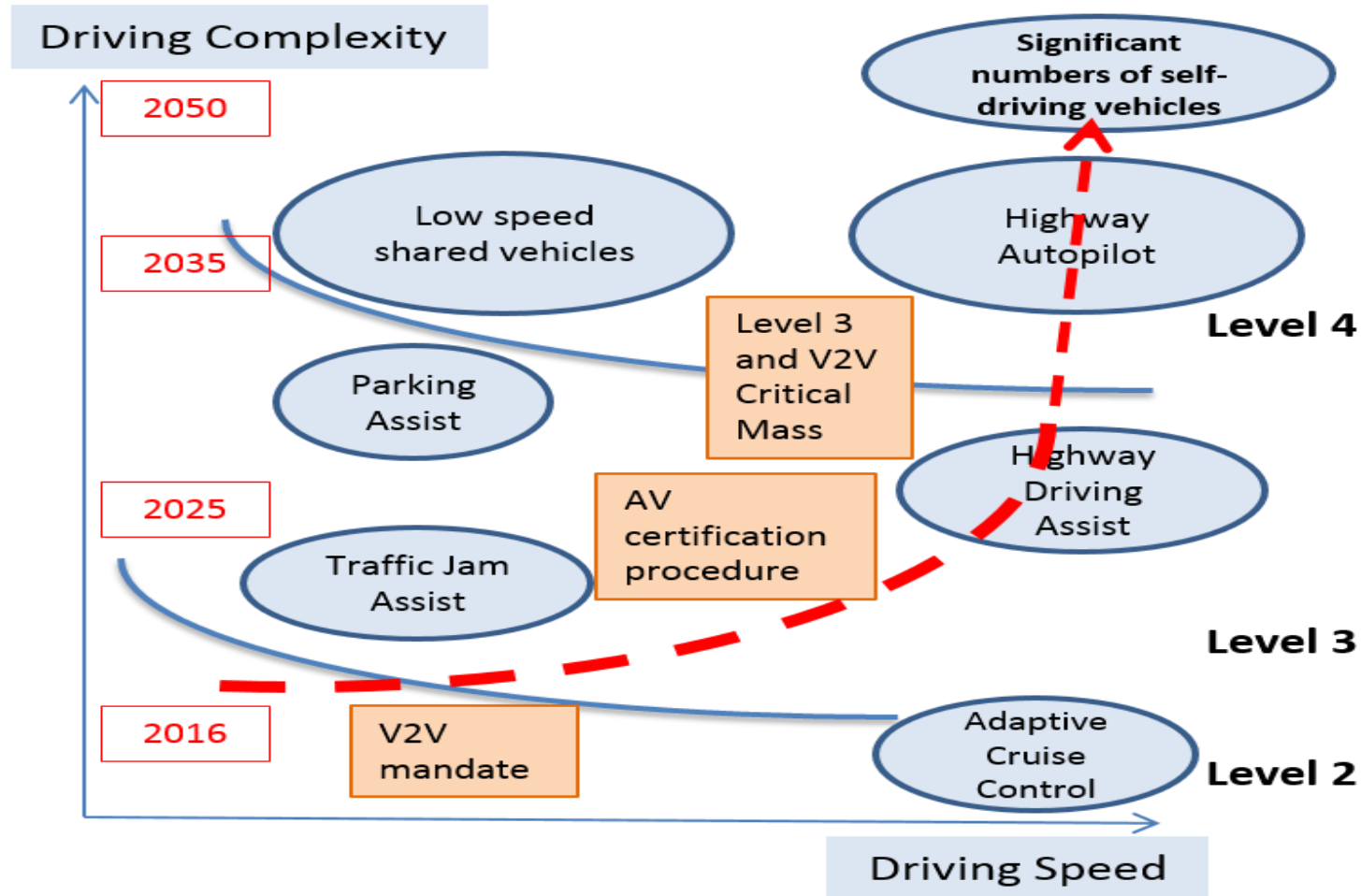
Disruptive (Revolutionary) path of deployment

- OEM's, and Suppliers aggressively develop, Federal and States policies facilitate development to reach a significant number on roads by 2025



Source: Adapted from European Technology Platform on Smart Systems Integration

Evolutionary path to deployment



Source: Adapted from European Technology Platform on Smart Systems Integration

The tipping point for CAV

2025 – 2030 timeframe

- V2V and V2I are widely deployed
 - Cybersecurity and privacy issues are settled
- Privately-owned vehicles with automated features (such as AEB) are widely used
 - Many of these vehicles have the additional benefit of V2V and V2I connectivity
- Driverless vehicle standards and operating rules are available
 - Cybersecurity & privacy measures are proven adequate for AVs on a large scale
 - Experience with mobility services using tailored driverless vehicles
 - Sufficient connected infrastructure is available

What are key policy and technical ramifications of CV deployment for States and cities?

- **Standards**
 - Guidance V2I from FHWA and Consistent V2I standards development (by national Associations) is promising
- **Communication** – Accommodate seamless implementation from state to state
 - DSRC, Wi-Fi and other means
- **Roadway readiness**
 - Geometric ramifications
 - Dedicated CV lanes at certain deployment scale?
- **Roadside communication units (RSU's)**
 - Significant testing required – Pilot and demonstration projects
 - How to fund it?
- **Pavement marking/signing**
 - More consistency and maintenance might be required

What are key policy and technical ramifications of CV deployment for States and cities? (continued)

- Roadway sensors
 - Capital improvement and Maintenance might be required
- Operational
 - Shorter headway will be helpful for traffic throughput
 - Real time Bottleneck warning will help traffic flow
 - Weaving issues due to shorter headways
- Truck platooning
 - Potential early deployment
 - Standards
 - Multi-state pilots
 - Geometric ramifications? Possible dedicated lane at scale

What are key policy and technical ramifications of CV deployment for States and cities? (continued)

- *At what scale of deployment we need to do what?*
- Business models – Affording to absorb the cost of installing and maintaining the system?
 - CV provides a significant ROI in safety and traffic operations benefits
- Consumer demand – will drive the deployment
- Consumer outreach and education
 - Need for harmonization and common approach

What are key policy and technical ramifications of AV deployment for States and cities?

- Vehicle Code modifications
- Standards
 - Uniformity in all states
 - Set too early might stifle innovation
 - Guidance V2I from FHWA and Consistent V2I standards development (by national Associations?)
- Communication and sensors
- RSU's and intersection readiness
- Operational and geometric ramifications

What are key policy and technical ramifications of AV deployment for States and cities?

- Pavement marking/signing
- At what scale of deployment we need to do what?
- Business models – Who can afford to absorb the cost of installing and maintaining the system?
- Consumer demand
 - Consumer acceptance
 - Consumer outreach and education
- Shared use economy
- State, local jurisdictions and national responsibilities

What are key policy and technical ramifications of **AV** deployment for States and cities? (Continued)

- Would the insurance system change to be more uniform across states or OEM's should be required to accept more responsibility for damages and injuries?
- Settling in on a process for deciding whether a specific vehicle automation system is "safe enough" to operate on public roads, across 50 states, is extremely cumbersome and takes time.

What are additional considerations for *Driverless* deployment for States and cities?

- Reliability
- At what scale of deployment we need to do what?
- Consumer demand
 - Consumer outreach and education
- Shared use economy
 - Business models and fees
- Land use, parking

Readiness timing

- **Consumer demand for vehicle level 3** and V2V capabilities would be strong
 - Young adults seek technologically advanced eco-friendly vehicles with high level of automation
- **Promising safety improvement of CV** will help accelerate deployment
- From 2018 – 2025 the demand will increase and self-driving vehicles are expected to be present at regional scale.
- 2025 – 2030 is the convergence of Automated and Connected vehicles

Key policy and technical readiness on demand within 10 years

What are the drivers and barriers of wide deployment of CAV?

- Requires a highly strategic and coordinated public-private effort
 - Strong decision making by a range of companies from the automotive, traffic control, infrastructure, and the technology industry.
 - Public agency support at all levels
- More *demanding institutionally than technologically*
 - Consumers will demand and drive it!
 - Infrastructure guidelines, connectivity and funding
 - Legal, privacy and liability issues
 - Cybersecurity



Planning for it !?

- Long range transportation planning process:
 - *Inclusion of CV/AV assumptions in the State Long –Range Plan*
 - *Typically a 25 year plan in many states*
 - *Inclusion of educational materials in public involvement millstones*
 - *Inclusion of modified assumptions in the State freight plan (when a separate document)*
 - **Scenario planning**
 - *Modification of assumptions in travel demand forecasting process*
 - *Modified travel characteristics, behavior and data*
- Short range transportation plans and programs
 - *Maintenance budget for signing and striping requirements*
 - *Funding estimate for roadside and intersection communication and data interface units.*
- *Communication requirements*
 - *Short range, and backhaul*
- *Parking requirements*
- *Public outreach and education*
 - *SBD consumer report on ADAS use – trust, emotion, expectation, etc.*