
An Introduction to Automated Vehicles

Grant Zammit
Operations Team Manager
Office of Technical Services - Resource Center
Federal Highway Administration
at the
Purdue Road School - Purdue University
West Lafayette, Indiana



Topics

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1. What Are Automated Vehicles?
2. What Could This Mean for Our Nation's Roads?
3. What Are Transportation Agencies Doing to Prepare for Automated Vehicles?



What Are Automated Vehicles?



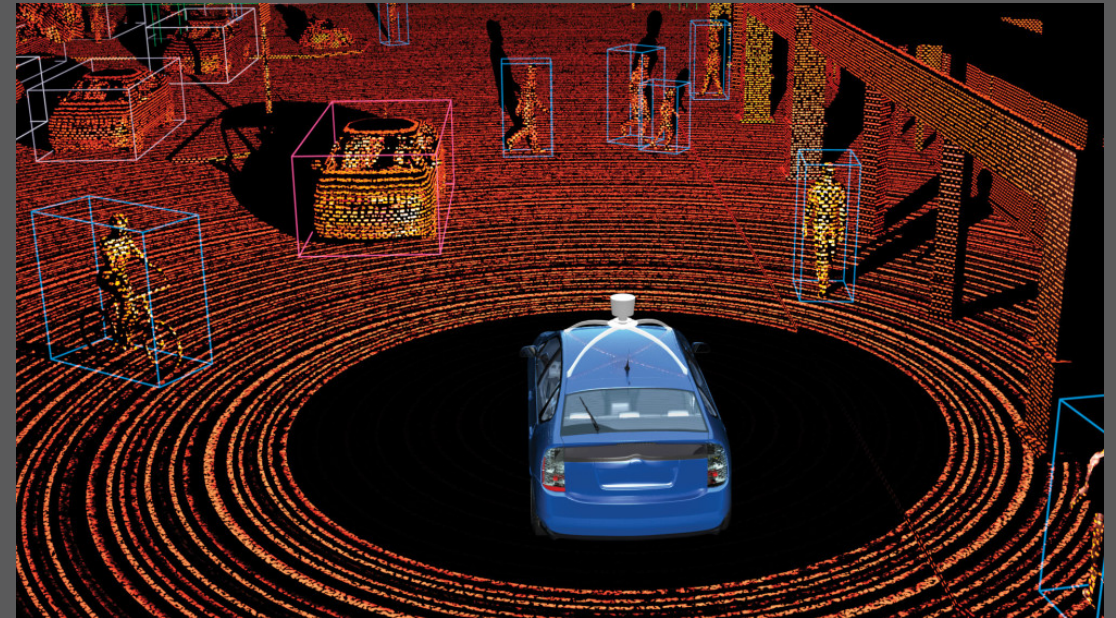
What Are Automated Vehicles?

- **Automated Vehicles (AVs)** are vehicles in which at least one element of vehicle control (e.g., steering, speed control) occurs without direct driver input.
- AVs work by gathering information from a suite of **sensors**:
 - Cameras.
 - Radar.
 - Light detection and ranging (LiDAR).
 - Ultrasonic.
 - Infrared.
- AVs may combine sensor data with other inputs (e.g. detailed map data & connected vehicle data.)



How Do Automated Vehicles Work?

- AVs may combine sensor and map data, can detect and classify objects in their surroundings, and may predict how they are likely to behave with:
 - Other moving vehicles.
 - Pedestrians and cyclists.
 - Stationary objects (e.g., signs, trees, traffic cones).
- Based on what an AV can “see” and what it predicts nearby objects are likely to do, it can make decisions about speed and steering inputs.



Source: Federal Highway Administration



Varying Levels of Automation (SAE J3016)

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SAE Level	SAE Name	Description*
0	No Automation	Full-time performance by the <i>human driver</i> of all aspects of <i>dynamic driving task</i> .
1	Driver Assistance	Driver assistance system controls either steering or speed while the <i>human driver</i> performs all remaining aspects of <i>dynamic driving task</i> .
2	Partial Automation	Driver assistance system(s) controls both steering and speed while the <i>human driver</i> performs all remaining aspects of <i>dynamic driving task</i> .
3	Conditional Automation	<i>Automated driving system</i> performs all aspects of <i>dynamic driving task</i> with the expectation that <i>human driver</i> will respond to a request to intervene.
4	High Automation	<i>Automated driving system</i> performs all aspects of <i>dynamic driving task</i> , even if a <i>human driver</i> does not respond to a request to intervene.
5	Full Automation	<i>Automated driving system</i> performs all aspects of <i>dynamic driving task</i> under all roadway and environmental conditions that can be managed by a <i>human driver</i> .

**Human Driver
Monitors
Driving
Environment**

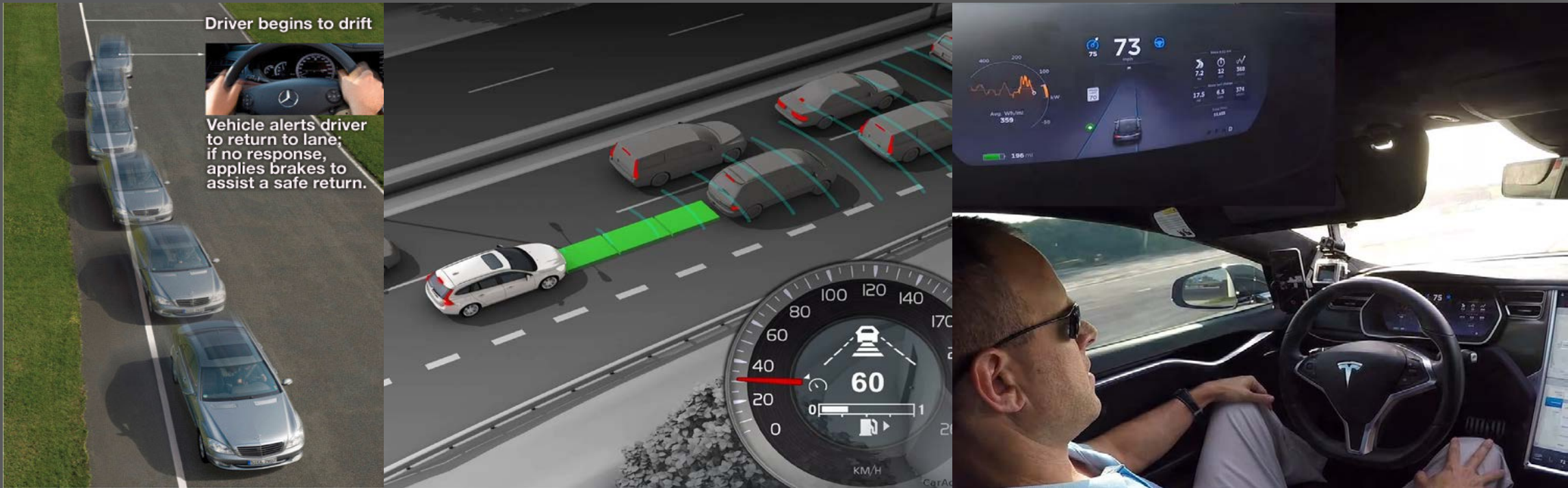
**Automated
Driving System
Monitors
Driving
Environment**

*Full definition available at: www.sae.org/misc/pdfs/automated_driving.pdf



Automated Vehicles Are...Here Today

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Source: Federal Highway Administration

Most major manufacturers currently offer Level 1 systems (e.g., lane keep assist, adaptive cruise control) and some offer Level 2 systems



Automated Vehicles Are...in Testing

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The Federal Highway Administration (FHWA) has conducted research into connected Level 1 applications, including:

- Cooperative Adaptive Cruise Control (CACC).
- GlidePath.
- Connected/Automated Truck Platooning.
- Lane Change/Merge.



5 SLOWDOWN: 30MPH
10/1/15

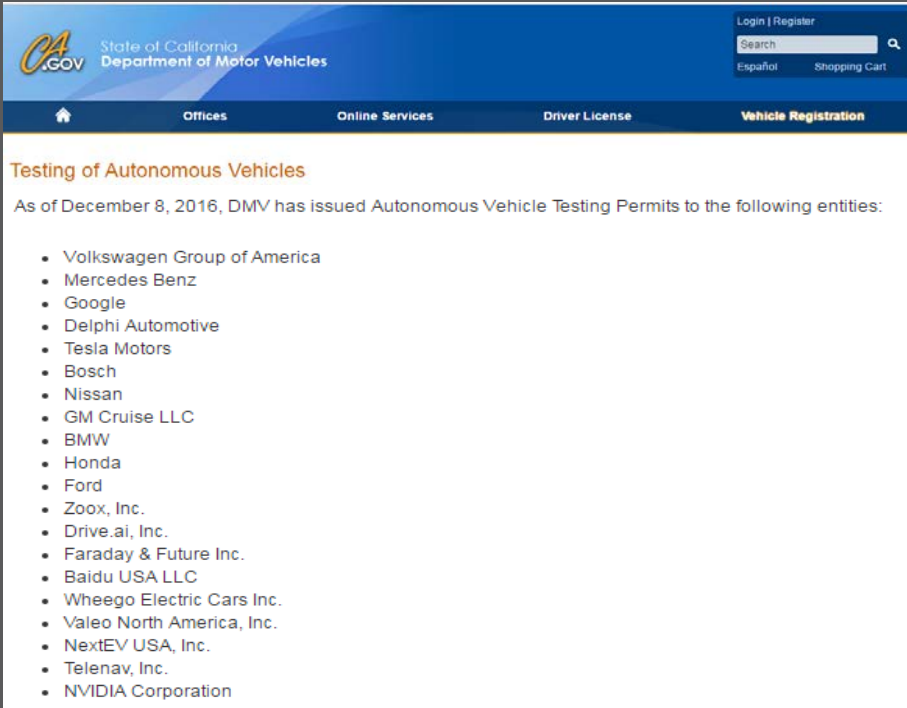


Source: Federal Highway Administration



Automated Vehicles Are...in Testing (cont.)

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Testing of Autonomous Vehicles

As of December 8, 2016, DMV has issued Autonomous Vehicle Testing Permits to the following entities:

- Volkswagen Group of America
- Mercedes Benz
- Google
- Delphi Automotive
- Tesla Motors
- Bosch
- Nissan
- GM Cruise LLC
- BMW
- Honda
- Ford
- Zoox, Inc.
- Drive.ai, Inc.
- Faraday & Future Inc.
- Baidu USA LLC
- Wheego Electric Cars Inc.
- Valeo North America, Inc.
- NextEV USA, Inc.
- Telenav, Inc.
- NVIDIA Corporation



Manufacturers and technology companies are also testing AVs, including passenger vehicles, heavy duty commercial and small transit-like vehicles.



Automated Vehicles Are...Coming Soon

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The New York Times

Ford Promises Fleets of Driverless Cars Within Five Years

By NEAL E. BOUDETTE AUG. 16, 2016

WIRED
Technology

Toyota to launch first driverless car in 2020

By BECCA CADDY

Thursday 8 October 2015

TESLA

All Tesla Cars Being Produced Now Have Full Self-Driving Hardware

The Tesla Team • October 19, 2016

MIT
Technology
Review

Robotics

2021 May Be the Year of the Fully Autonomous Car

BMW and Ford have each announced an aggressive time line for producing self-driving cars.

by Jamie Condliffe August 17, 2016

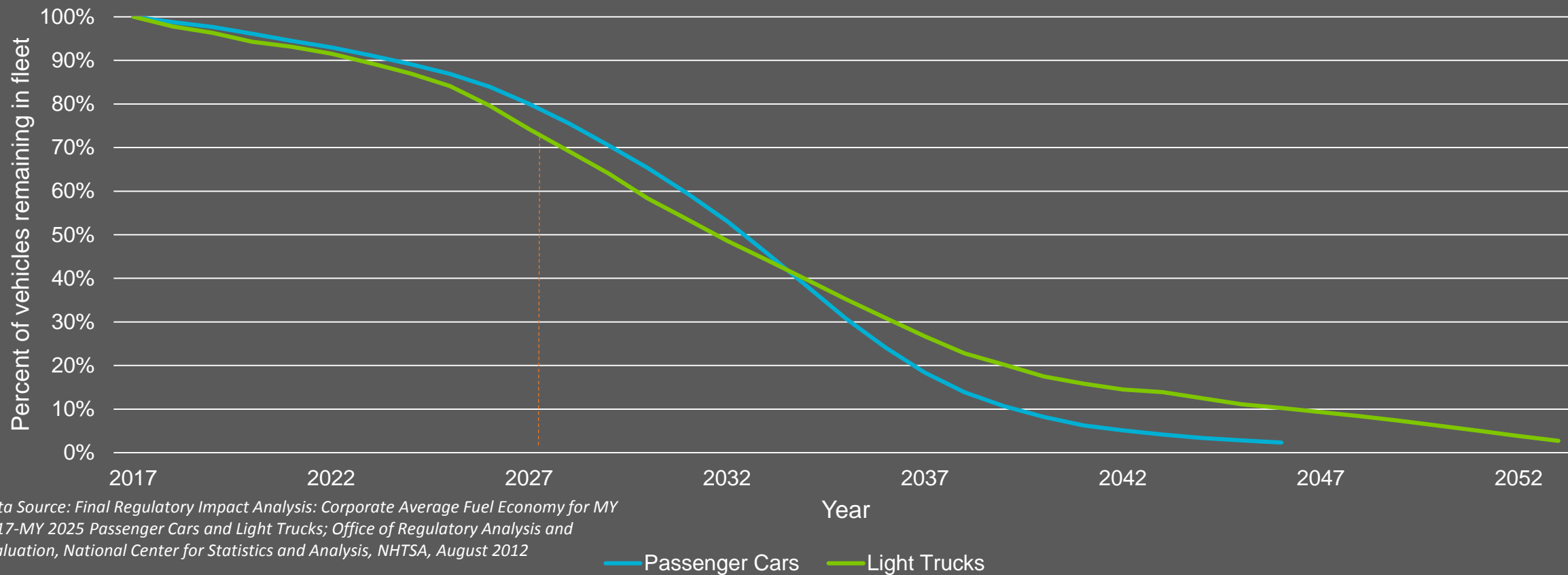
Mark your calendars: automakers plan to put truly autonomous cars on our roads in the next five years.

Many manufacturers are targeting 2020 (or potentially sooner) to introduce Level 3 and 4 automated vehicles...



Vehicle Fleet Turnover

Expected Survival Rate of Model Year 2017 Vehicles



Data Source: Final Regulatory Impact Analysis: Corporate Average Fuel Economy for MY 2017-MY 2025 Passenger Cars and Light Trucks; Office of Regulatory Analysis and Evaluation, National Center for Statistics and Analysis, NHTSA, August 2012



AVs Could Introduce Significant Benefits

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Potential Benefits

- Reduction in vehicle crashes.
- Improved mobility for elderly, disabled and those unable to drive.
- Improved convenience of travel.

Potential Challenges

- Less efficient operations of the highway system.
- Increases in VMT and congestion.
- Land use implications and increased sprawl.



Connectivity May Enhance Automated Vehicle Benefits

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Connectivity may enhance the safety and efficiency of AVs by providing greater situational awareness and efficiency.

What is Connectivity?

- The ability to transmit data and information to and from the vehicle.
- May include the ability for a vehicle or driver to receive and use broadcasted information about traffic, travel, roadway condition, and other information. (Example: vehicle is aware of work zone in advance.)
- May include the transmission of critical information from the vehicle. (Example: crash notification.)



Connectivity May Enhance Automated Vehicle Benefits (cont.)

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What is Connectivity? (continued)

- May include the exchange of safety-critical information between vehicles or between vehicles and infrastructure.

Examples:

- An equipped vehicle sends a defined message packet with vehicle location, heading and speed - *transmitted ~10 times per second.*
- Other nearby vehicles and roadside equipment receive and process the messages.

- Drivers receive warnings and information to avoid potential crashes.
- May also enhance mobility and efficiency.

Examples:

- Facilitate vehicle platoons.
- Enable vehicle to travel at ideal speed to minimize stopping at signalized intersections.



What Could This Mean for Our Nation's Roads?



Physical Infrastructure

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- Unclear infrastructure requirements for AVs (signs, signals, markings).
- Possible need for adaptations to design standards for greater consistency.
- Implications for maintenance and investment.



Source: Federal Highway Administration

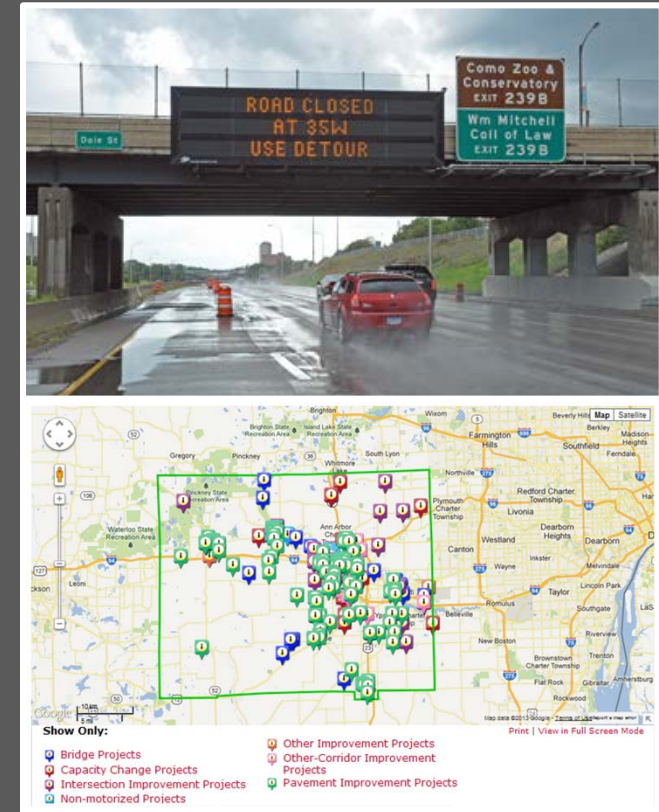


Digital Infrastructure

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- AVs as potential sources of roadway data.
- Data updates on construction and road closures.
- Maintenance of digital infrastructure.



Source: Federal Highway Administration

Roadway Operations

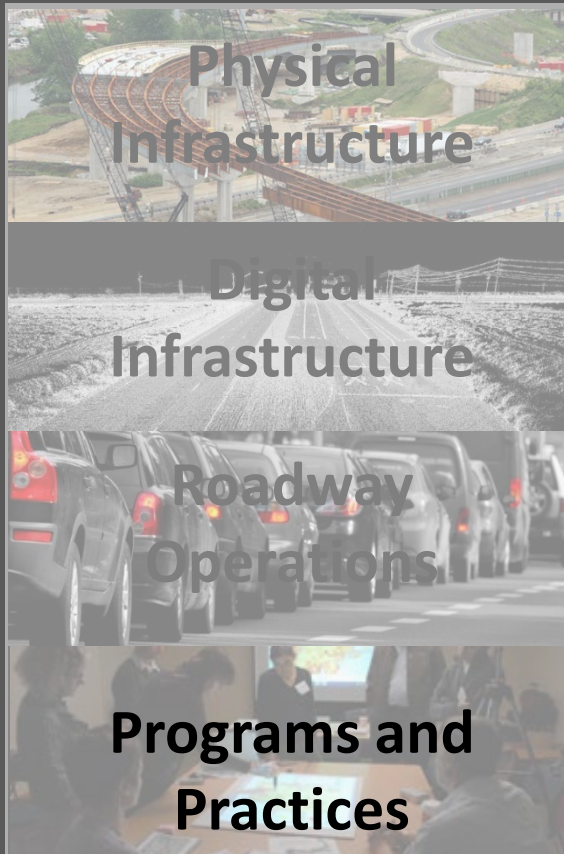
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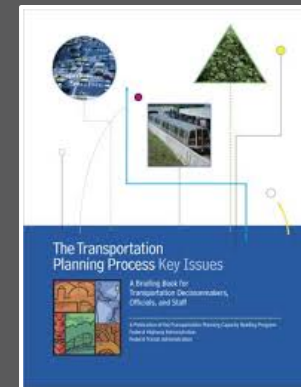
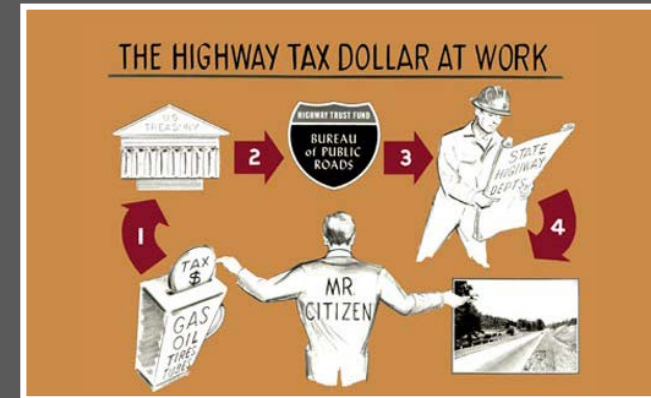
- Short-term challenges of managing a mixed traffic environment (AVs, CVs, non-AVs, bike/ped and other road users).
- New challenges in harmonizing traffic flow.
- Potential travel demand changes.
- Likely long-term efficiency and congestion benefits.



Programs and Practices



- Accounting for AVs and potential land use impacts as well as uncertainty in long-range planning process.
- Implications of shared vehicle fleets and new mobility models on travel demand modeling/forecasting.
- Revenue and budget implications.



Source: Federal Highway Administration

What Are Transportation Agencies Doing to Prepare for Automated Vehicles?



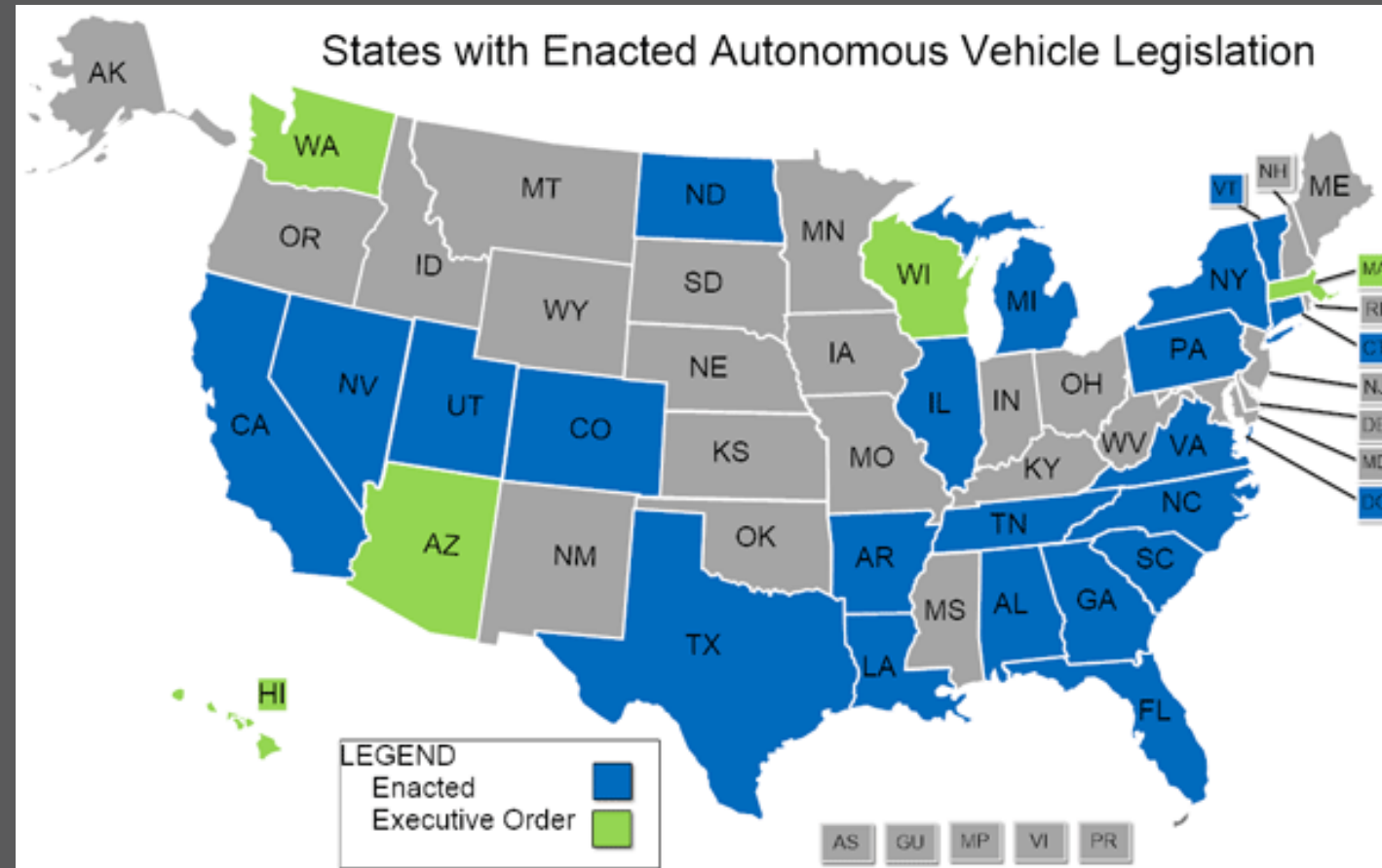
States Are Supporting Testing of AVs

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Arizona and **Massachusetts** governors signed executive orders supporting AV testing.

Virginia's governor endorsed the Virginia Automated Corridors Initiative through a proclamation.

Texas has welcomed AV testing to Austin without specific legislative action.



Executive Order

Enacted

Source: National Conference of State Legislatures, March 1, 2018



National Associations

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- Numerous activities by national associations to assess issues and support their memberships.
- Coordination events held in January 2017 and 2018, hosted by American Association of State Highway and Transportation Officials (AASHTO) and American Association of Motor Vehicle Manufacturers (AAMVM).



U.S. Department of Transportation (US DOT) Automated Vehicle Initiatives

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- Federal Automated Vehicle Policy (FAVP) 1.0 and 2.0.
- FAVP 3.0 anticipated in 2018.
- Automated Vehicle 3.0 Public Meeting - March 1, 2018.
- Roundtable on Data for Automated Vehicle Safety - December 2017.
- Requests for information and comments.
- Ongoing outreach and engagement.



USDOT Automated Vehicle Initiatives

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- *Automated Driving Systems 2.0: A Vision for Safety* released in September 2017.
- Replaces 2016 Federal Automated Vehicles Policy with...
 - Section I: Voluntary Guidance for Automated Driving Systems.
 - Section II: Technical Assistance to States.
- More information available on NHTSA website: <https://www.nhtsa.gov/technology-innovation/automated-vehicles>



USDOT Automated Vehicle Initiatives (cont.)

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- Requests for Information/Comments (RFI/RFC):
 - Federal Highway Administration
 - RFI on Integration of Automated Driving Systems (ADS) into the Highway Transportation System (Closed 3/5/18).
 - Federal Transit Administration
 - RFC on Automated Transit Buses Research Program (Closed 3/2/18).
 - RFC on Removing Barriers to Transit Bus Automation (Closed 3/2/18).
 - National Highway Traffic Safety Administration
 - RFC on Removing Regulatory Barriers for Automated Driving Systems (Closed 3/5/2018).



FAVP 3.0 FHWA RFI Topics

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1. Roadway characteristics.
2. Non-uniformity in traffic control.
3. State of good repair.
4. Nature of industry engagement.
5. Role of digital infrastructure and data.

<https://www.transportation.gov/AV>



FAVP 3.0 FHWA RFI Topics (cont.)

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6. Concerns of state and local agencies.
7. Current research and activities on infrastructure-vehicle interface.
8. Priority issues for road owner/operators.
9. Traffic information needed by ADS.
10. Issues during mixed fleet transition.

<https://www.transportation.gov/AV>



National Dialogue on Highway Automation

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- Stakeholder engagement activities to discuss the role of FHWA in automation and explore issues of concern to FHWA and its stakeholders.
- Focus on topics related to highway infrastructure systems, highway information systems, planning, traffic operations, and other provisions to be ready for the safe and efficient integration of automation.
- Inform research, policy support, implementation assistance, and national transportation community development.



Stakeholders of the National Dialogue

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- State and local agencies.
- Automotive industry and new developers.
- ADS hardware and software developers.
- Road hardware and ITS industry.
- National transportation organizations.
- Telecommunications industry.
- Data and analytics companies.
- User groups and the general public.



Disclaimer

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Questions?



For More Information Please Contact:

<https://www.transportation.gov/AV>

and

Indiana Division of the Federal Highway Administration

indiana.fhwa@dot.gov

Phone: (317) 226-7475

