



# The Future is Already Here: Connected and Autonomous Vehicles



## Autonomous Vehicles in California

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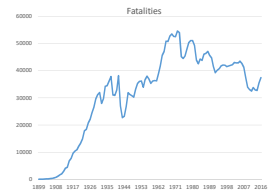
## Why Autonomous Vehicles?

### Safety

- o 37,133 people killed in crashes on U.S. roadways (2017)
  - 30% of fatalities attributed to alcohol-impaired driving
  - 10% because of distracted driving
  - 27% due to speeding-related crashes
  - 18% were non-occupants (pedestrians, cyclists, etc.)
- o Estimated that 94% of fatalities due to human choice
- o ~7K injured per day

### Mobility

Efficiency (Time, resources, traffic flow, land use, etc.)



Source: NHTSA National Center for Statistics and Analysis

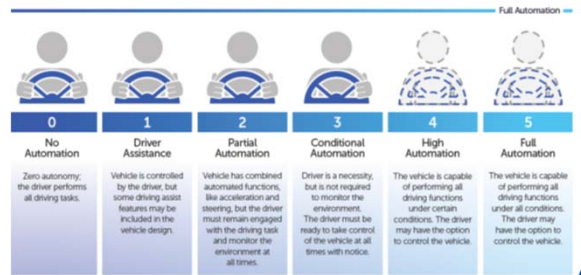


## Important Distinction

- The federal government, through the National Highway Traffic Safety Administration (NHTSA), is responsible for ensuring the **safety of vehicles**.
- State governments, in contrast, are responsible for ensuring the **safe operation of vehicles on public roads**.



### SAE AUTOMATION LEVELS



Source: NHTSA Automated Driving Systems 2.0: A Vision For Safety



## California Vehicle Code

### VC Section 38750:

- Defines key terms
- Develops regulations for the testing and operation of autonomous vehicles on public roadways
- Outlines requirements the department concludes are necessary to ensure the safe operation of autonomous vehicles.



## California's Definition of Autonomous Vehicle

**"Autonomous technology"**: technology that has the capability to drive a vehicle without the active physical control or monitoring by a human operator.

**"Autonomous vehicle"**: any vehicle equipped with autonomous technology that has been integrated into that vehicle.





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## A (Very) Brief History of California AV Regulation



- **September 25, 2012:** Senate Bill 1298 authorizes the DMV to adopt regulations for the operation of autonomous vehicles in California.
- **September 16, 2014:** First set of regulations governing how manufacturers could test autonomous vehicles (with a driver) on California roads went into effect.
- **April 2, 2018:** DMV can begin approving applications for autonomous vehicle testing without a driver and deployment (public use).



## Title 13, Division 1, Chapter 1 Article 3.7 – Testing of Autonomous Vehicles

- Testing with a driver
- Testing without a driver
- Deployment (public use)



## Regulations Summary: Testing with a Driver



- \$5 million in insurance, bond, or self-insurance
- Test driver requirements:
  - No DUI, not an at-fault driver, and no more than 1 point
  - Successful completion of test driver training program
  - Employee, contractor, or designee of manufacturer
- Test driver must be seated in driver seat during testing
- Report any accident within 10 days
- Report unanticipated disengagements of autonomous technology annually
- Testing permit valid for one year
- Vehicles excluded from testing:
  - Commercial vehicles
  - > 10,000 lbs GVW
  - Motorcycles



## Regulations Summary: Testing Without a Driver

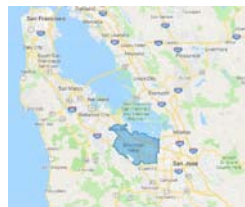
- \$5 million insurance, bond, or self-insurance
- Communication link with the remote operator.
- Process to display or communicate vehicle owner or operator information to a law enforcement officer.
- AV complies with all FMVSS and CVC Div. 12 (Equipment of Vehicles), or NHTSA has approved an exemption.
- Meets the description of level 4 or 5 automated driving system.
- Law enforcement interaction plan
- Remote operators + training program
- Passengers that are not employees/contractors will be notified what personal information, if any, may be collected and how it will be used.
- Annual report of disengagements to the DMV.
- Report collision resulting in damage of property, bodily injury, or death to DMV within 10 days.
- No charging of a fee or receiving other compensation for providing a ride to members of the public.



## Approved Testing Permits Today (63)



## Approved Driverless Testing Permits (1)



- Fleet – 39
- Operational Design Domain
  - Level 4 Automation
    - Minimal Risk Condition
    - Freeways, highways, city streets, rural roads, and parking lots
    - Up to 65 mph
    - Inclement weather
    - All times of day and night





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## California by the Numbers

- 60** active permits to test with a driver
- 626** autonomous vehicles permitted for operation on public roads
- 2073** test drivers
- 1.6 million+** autonomous miles driven
- 107** crashes



## Current state of AV testing in California: Disengagements

Manufacturers required to submit an annual report to DMV

- Circumstances or testing conditions
- Location
- Description of the facts causing the Disengagement
- Party that initiated the Disengagement (Autonomous Technology, Test Driver, Remote Operator)

2017: 2309 disengagements reported\*

\*these numbers do not include testing by companies that did not submit disengagement reports

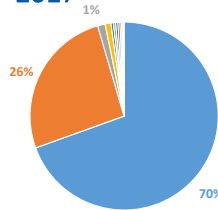


## Autonomous Miles Reported- 2017

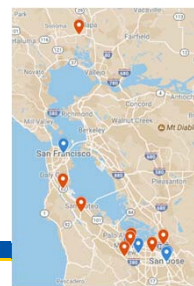
Total: 507,271 miles

Top Three in 2017:

1. Waymo = 352,545 miles
2. GM Cruise = 131,675
3. Drive.AI = 6,572 miles



## Where Disengagements Occur

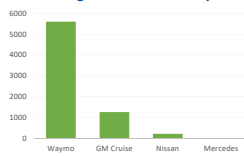


Cities & Highways

- Sunnyvale
- San Francisco
- San Jose
- Mountain View
- Santa Clara County
- U.S. 101
- Central Expressway
- Interstate 280
- Montague Expressway
- Cameros Highway
- San Tomas Expressway
- California 92
- Interstate 380

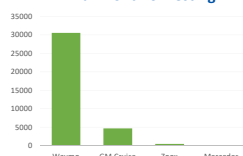


MPD Averaged Over Entire Reporting Period



1. Waymo = 5,596 MPD
2. GM Cruise = 1,254 MPD
3. Nissan = 209 MPD

MPD Final Month of Testing

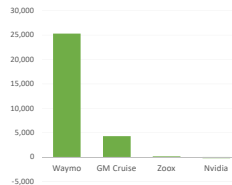


1. Waymo = 30,517 MPD
2. GM Cruise = 4,630 MPD
3. Zoox = 430 MPD



## Greatest Increase in MPD over the 2017 Reporting Period

Change in MPD Over Reporting Period



1. Waymo = Increase of 25,279 MPD over 12 months
2. GM Cruise = Increase of 4,261 MPD over 12 months
3. Zoox = Increase of 149 MPD over 9 months





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## Top Causes of Disengagement: 2017

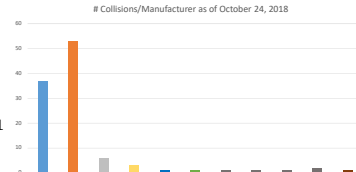
- Perception discrepancy
- Other road user behaving poorly
- Traffic light detection; Pedestrian traffic
- Undesired motion planning behavior
- AV system fails and requires driver to take over
- Distance keeping problem
- Unwanted maneuver of the vehicle



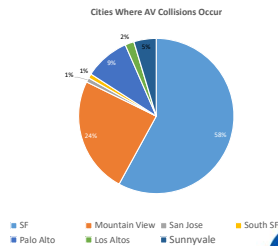
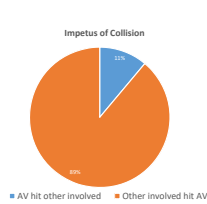
## Current state of AV testing in California: Collisions

107 total collisions since testing regulations in effect.

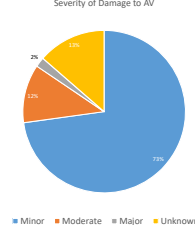
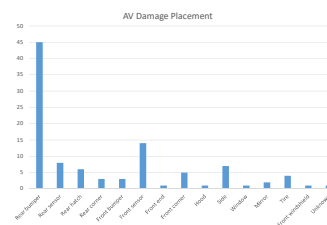
- GM Cruise – 53
- Waymo (Google) – 37
- Zoox – 6
- Nissan – 1
- Delphi Automotive – 1
- Apple Inc. – 2
- Drive.ai – 1
- Uber – 3



## Current state of AV testing in California: Collisions



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