Advanced Driver Assistance Systems (ADAS) & Automated Driving Systems (ADS) & Connected Vehicle Technologies

A Primer for Driver Education Professionals

ADTSEA Annual Conference
Burlington, VT
July 24, 2019
Overview

- Vehicle Technologies Overview
- Sensors Enabling Vehicle Safety Technologies
- Advanced Driver Assistance Systems (ADAS)
- Most Common ADAS Technologies
- Implications on Driver Education and Testing
- Automated Driving Systems (ADS)
- Connected Vehicle Technologies
- Commercial Transportation and ADS
Vehicle Technology Generally

- Vehicle technology not new but advancing rapidly

Advanced Driver Assistance Systems (ADAS) vs. Automated Driving Systems (ADS)
  - ADAS is here today
  - ADS under rapid development

- ADS and ADAS will NOT remove the need for driver education
  - will increase the need for driver training and ongoing training
  - ADAS/ADS training needed for ALL drivers
ADAS & ADS
You Can Only Avoid What You Can Detect: 3 Major Sensing Technologies

RADAR
Uses radio waveforms to determine distance and motion (velocity & angle).

CAMERA
Recognition & classification of images. Uses AI to “learn” about its environment.

LIDAR
Uses laser light pulses to provide 360 degree 3D view with high precision.
How It Works

- **LIDAR – Light Detection and Ranging**
  - Measures the distance to an object by calculating the time taken by a pulse of light to travel to an object and back to the sensor. It is used to build a 3D map and allow the car to “see”.

- **RADAR – Radio Detection and Ranging**
  - Uses radio waves to detect objects in the environment. Radars can determine the distance to a certain object as well as its speed and exact disposition.
How It Works

- **High-Powered Cameras**
  - The “eyes” of the ADAS / ADS. Overlapping fields of view can provide 360 degree view.

- **Positioning GPS**
  - Data and driving speed help accurately determine the precise position of each vehicle.

- **Sophisticated Software**
  - Processes all of the sensor data in real-time. While some programming is hard-coded into the car, other responses are “learned” using Artificial Intelligence.
    - AI requires significant use of simulation and on-road experience.
<table>
<thead>
<tr>
<th>Technology</th>
<th>Radar</th>
<th>Camera</th>
<th>LIDAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection</td>
<td>Detection – distance (range) and motion (velocity and angle) by radio waveforms</td>
<td>Recognition, classification by images</td>
<td>360-degree 3D view by laser light</td>
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<tr>
<td>Application</td>
<td>• Adaptive cruise control</td>
<td>• Traffic sign recognition</td>
<td>• Emergency brake assist for pedestrian, crash imminent braking, mapping</td>
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<tr>
<td></td>
<td>• Automatic emergency braking systems</td>
<td>• Lane keep systems</td>
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<tr>
<td></td>
<td>• Blind spot detection</td>
<td>• Parking assistance</td>
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<tr>
<td></td>
<td>• Parking assistance</td>
<td>• ACC, AEBS</td>
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<tr>
<td>Advantages</td>
<td>• Proven over decades</td>
<td>• Lower cost</td>
<td>• High accuracy</td>
</tr>
<tr>
<td></td>
<td>• Reliable in all environmental conditions</td>
<td>• Mass-market technology</td>
<td>• High resolution</td>
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<tr>
<td></td>
<td>• Small and lightweight</td>
<td>• Smaller sensor size</td>
<td>• Intelligent signal processing with a large amount of captured data</td>
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<tr>
<td></td>
<td>• Longer detection range</td>
<td>• High resolution</td>
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<td></td>
<td></td>
<td>• Color resolution</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Imaging processing</td>
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<tr>
<td>Limitations</td>
<td>• Limited information on detected objects (shape and movement only)</td>
<td>Performance varies with the environment (e.g. rain, snow, lighting)</td>
<td>• Unproven in massive deployments</td>
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<tr>
<td></td>
<td>• Lower resolution than LIDAR and Optical</td>
<td></td>
<td>• Expensive and large sensor</td>
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<td></td>
<td></td>
<td>• Expensive and complex signal/data management</td>
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<td>• Affected by weather (e.g. rain, snow, lighting)</td>
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Ante-Lock Braking System

- Helps prevent wheels from locking up – possibly allowing the driver to steer to safety.
Video – How ABS Works

ABS prevents brake lock-up
Most Common Technologies

**Traction Control**

- Helps your wheels gain traction on slippery surfaces.

![Diagram showing comparison between with and without Traction Control](image-url)
Most Common Technologies

- **Tire Pressure Monitoring System**
  - Lets you know if tire pressure has changed; common in change of seasons – especially from warmer to colder – or change of elevation.

![Diagram of Tire Pressure Monitoring System with Direct and Indirect Sensors]
Most Common Technologies

- Adaptive Cruise Control

  Can increase or decrease the vehicle’s speed to maintain a following distance set by the driver. Advanced versions can even slow and stop the vehicle in traffic jams, then accelerate automatically.
Video – Adaptive Cruise Control
Most Common Technologies

- **Blind Spot Detection**
  - Warns the driver of other vehicles driving in their blind spots through display of a symbol, sound or vibration. They may provide an additional warning if a driver uses their turn signal when there are other vehicles in another lane.
  - Use in conjunction with head-checks and mirrors.
Most Common Technologies

- **Lane Departure Warning**
  - Cameras read road markings and alert the driver with beeps or vibrations if they drift out of the lane.
**Most Common Technologies**

- **Lane Keeping Assist**
  - This feature can help return you to your lane if you drift out. This could help prevent a crash.
Most Common Technologies

- Automatic Emergency Braking
  - This feature can sense slow or stopped traffic ahead and urgently apply the brakes if the driver fails to respond.
Most Common Technologies

- **Back-Up Warning**
  - Uses radar sensors to scan for objects behind the vehicle and alerts the driver if an object is detected.
  - Use in conjunction with head-checks and mirrors.
Most Common Technologies

- **Back-Up Camera**
  - Helps see objects directly behind the vehicle by showing a wide view behind the vehicle while backing. Some cameras show a wider view than others.
Parking Sensors
Alerts the driver to the position of objects around the vehicle as they park. Some systems increase the rate of warning sounds as the vehicle gets closer – a constant tone means contact with the object is imminent.
Implications on Driver Education and Testing

- Educate drivers on new technology and to remain engaged in the driving task vs. complacency/dependency
- Continuous driver education and training for all drivers on new technologies
Driver education and training needs to adapt to the needs of drivers.

Current technologies assist the driver, they do not replace the driver.

A driver must be alert and attentive at all times, even with safety technology.
Teaching Vehicle Technologies

When teaching:

- Still teach to check mirrors when backing up.
- Parallel park assist, need to teach:
  - How to parallel park
  - How to use the technology
- Explain there are settings for the vehicle technologies:
  - Turn on and off
  - Sensitivity levels
  - Options to choose from
Technology and Driver Training

- Technology may make the job more challenging
  - Instructor must have knowledge on all technologies
  - Must also teach the implications on driver testing (convey to the student what they can and cannot use for driver testing)
  - Address complacency and dependency
  - Driver’s Education job is more critical because:
    - Technologies have varying sensitivities
    - Ultimately, any technology can fail
Technology and Driver Training

- EyeSight Driver Assist
- CoPilot 360
- Safety Sense
- Pro Pilot Assist
- Intelligent Drive
- Personal CoPilot
- Active Safety Technology
BLIS with Cross Traffic Alert = Blind Spot Information System
Safety Alert Seat = Anti-Fatigue
Road Sign Assist = Reads signs ahead and displays on monitor
DCC = Dynamic Cruise Control
Around View Monitor = 360 degree camera view
BAS = Brake Assist System
Attention Assist = Anti Fatigue System
Night Vision = Uses monitor to warn of animals crossing path
Auto Pilot = Integrated ADAS Suite
Examined ADAS Terminology Across 34 Brands

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<th>ADAS FEATURE</th>
<th># UNIQUE NAMES</th>
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<td>Automatic Emergency Braking</td>
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<td>Adaptive Cruise Control</td>
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<td>Surround View Camera</td>
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<td>Lane Keeping Assistance</td>
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<td>Forward Collision Warning</td>
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<td>Night Vision with Pedestrian Detect</td>
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AAMVA Assistance

- To assist jurisdictions prepare to incorporate ADAS into Driver Testing.
- Developed by the IDEC and TMS, in conjunction with AAMVA Autonomous Vehicles Working Group
- Expected Summer 2019
  - Under final review
1. **Vehicle Warning System Technologies**: notify the driver with a warning, by sound, light or vibration, that a crash is about to occur, or it provides an alert that there is a problem or malfunction.

2. **Vehicle Assistance System Technologies**: assist the driver in avoiding a hazard or crash. Some automatically make adjustments to the operation of the vehicle and some assist the driver in making adjustments, such as braking or steering.
AAMVA Assistance

- In each of these sections the vehicle technologies are discussed and include:
  - a description of the technology,
  - how the technology works,
  - whether it is a safety or convenience technology,
  - considerations for testing,
  - guidance for skills testing and examiner training, and
  - considerations for driver’s manuals.
Automated Driving Systems (ADS)
Vehicle Technology Levels

**No Automation**
Zero autonomy; the driver performs all driving tasks.

**Driver Assistance**
Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.

**Partial Automation**
Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.

**Conditional Automation**
Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.

**High Automation**
The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.

**Full Automation**
The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.
Vehicle Technology Levels (L0)

- No Automation
  - Driver performs all driving tasks
  - Requires full situational awareness by driver.
  - Where we have been for over a century (birth of the automobile in 1886).
Vehicle Technology Levels (L1)

- Driver Assistance
  - Vehicle is controlled by the driver
    - Some driving assist features may be included in the vehicle design
  - Still requires full situational awareness by the driver.
  - Examples include: Cruise Control, Electronic Stability Control and various warning systems.
Vehicle Technology Levels (L2)

- Some systems today
- Partial Automation
  - Vehicle has combined automated functions like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.
  - May be able to remove hands from steering wheel at times, but still requires constant awareness and readiness of the driver.

Ex: Tesla Autopilot, GM SuperCruise
Conditional Automation

- Driver is a necessity for fall-back, but is not required to monitor the environment. Driver must be ready to take control at all times with notice.
- Requires situational awareness and constant readiness by the driver.
- Issue with driver complacency and dependency. Some OEMs have abandoned.
Vehicle Technology Levels (L4)

- **High Automation**
  - Vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.
  - Vehicle can operate without a driver in these conditions. Low speed automated shuttles.
  - No situational awareness required. Vehicle capable of achieving *minimal risk condition*.
  - Benefits for those unable to obtain a driver’s license.
Vehicle Technology Levels (L4)
Vehicle Technology Levels (L4)
Full Automation

- Vehicle is capable of performing all self-driving functions under all conditions.
- The driver may have the option to control the vehicle or the vehicle may operate without a human driver or occupants.
- No situational awareness needed.
- Mobility for those unable to obtain a driver’s license.
Video: How it Works
Uncertainties

Some level 4 and 5 may be completely driverless and may also have driver controls such as a brake or steering wheel.

And/Or

Level 4 and 5 vehicles may be completely driverless and have no driver controls such as a brake or steering wheel.
Video: How it Works
Autonomous VS Connected
Connected Vehicles

- Networked wireless communications among vehicles, the infrastructure, and personal communications devices.
Connected Vehicles

- 2 Main Platforms

DSRC vs 4G/5G

Dedicated Short Range Communications
Radio @ 5.9GHz
IEEE 802.11p

Cellular
**Connected Vehicles: DSRC**

**Pros**
- FCC Dedicated for auto safety
- Ready for Deployment now
- Fast/reliable: < 5ms latency
- Proven

**Cons**
- Will require access points and gateways = cost & time
- No clear path for evolution
Connected Vehicles: Cellular

Pros
- Can use existing infrastructure
- 5G very fast: 1ms latency
- Broader interfaces, i.e. with pedestrians, the grid, etc.
- Limitless path for evolution

Cons
- 4G LTE latency Issues (40ms)
- Path needed 4G – 5G
- Not immediately available
Connected Vehicles
Vehicle to Vehicle (V2V)

Ambulance Following
193 FT behind
Moving at 8mph
Connected Vehicles
Vehicle to Vehicle (V2V)
Connected Vehicles
Vehicle to Infrastructure (V2I)
Connected Vehicles
Vehicle to Infrastructure (V2I)
Connected Vehicles
Vehicle to Everything (V2X)

V2V – Vehicle to Vehicle
Alerts one vehicle to the presence of another. Cars “talk” via DSRC technology.

V2D – Vehicle to Device
Vehicles communicate with cyclists/others & vice versa.

V2P – Vehicle to Pedestrian
Communication with pedestrians via cellular link.

V2H – Vehicle to Home
Vehicles act as supplemental power source for the home.

V2G – Vehicle to the Grid
Smart Grid controls vehicle charging infrastructure and returns electricity to the grid.

V2I – Vehicle to Infrastructure
Alerts for traffic congestion, signals, road construction, parking, etc.
For the full potential to be realized, all vehicles may need some form of and V2V and V2I technology.

- New vehicle manufacturers
- After market manufacturers
- App producers
Challenges for ADS Vehicles

- Pedestrians, Bicyclists & Motorcyclists
- Law enforcement and EMS (traffic police/hand signals/directions/lights)
- Construction (directions/signs/lights/hand signals)
- ADS vehicles expect other road users to follow laws
- Sensors must remain clean to function
- Software updates
- Standardization of definitions & terms
**Benefits of ADAS/ADS**

- Save lives and prevent injuries
  - NHTSA – 94% of crashes are caused by human behavior
- Societal and Economic benefits by eliminating crashes and associated costs
- Reduce driver fatigue and inattention
- Potential for Smoother traffic flow and reduced traffic congestion (vehicle sharing models)
- Increase in technology jobs/New industries
Opportunities of ADS

Mobility options for:
- senior drivers
- passenger under driving age
- vision impaired
- individuals with mental/physical disabilities
- ride sharing services
- deliveries / transporting goods
Implications of ADAS/ADS

- Dependency / complacency on technology
- Distractions from technology
- Rental cars – unfamiliar with technology onboard
- Liability for automated vehicle crashes
- Legal responsibility for traffic violations
- Cyber security
  - Hijacking vehicle
  - Data Privacy
- Workforce Displacement – taxi, bus and truck drivers – New industries & services evolve
AAMVA Guidelines

- Voluntary recommended guidelines for the safe testing and deployment for highly automated vehicles
- Need for driver training
- Need for manufacturer or dealer incentives
5.3.1. Promote consumer training on the use of HAV functions.

5.3.2. Encourage communication between dealers and consumers including, but not limited to, acknowledgement of the sections in the vehicle “owner’s manual” that relate to the HAV functions.

5.3.3. Encourage manufacturers, dealers and insurance companies to provide incentives for consumers to receive proper training on the use of HAV functions.
5.4.2. Require driver education curricula to contain information on HAVs and to provide hands-on training in the utilization of HAV technologies.

5.4.3. Establish standards for the conduct and training of driver educators and private instructors for the training of drivers on the use of HAVs.
Upcoming AAMVA Documents

- Summer 2019 – Guidelines for Testing Drivers in Vehicles with Advanced Driver Assistance Systems
Explains today’s safety features: https://mycardoeswhat.org/

Learn more about automated vehicles: https://www.sae.org/

Learn more about connectivity products through Bosch: https://www.bosch-mobility-solutions.com/en/

Fully autonomous vehicles, L5, likely 10 years out, although we have ADAS today. Initial ADS may be used as inner-city/institutional, low speed passenger transports. However, manufacturers in the commercial vehicle industry will more than likely be the sector to rapidly advance ADS technology.

Major automobile manufacturers want to sell vehicles that provide both the “driving experience” and the option to engage ADS. Opportunity to partner with local dealers.
Vehicle use will most likely be as follows:

- Metropolitan areas / institutional campuses – low speed shuttles
- Urban areas – mix of ADS and ADAS
- Rural – Slower to move towards ADS although used in some form by agriculture

There will be a mix of level 0 – 5 vehicles. This will create a challenge for traffic safety.
People still like to drive, ride in and work on cars. Therefore, automobile manufacturers are still going to manufacture cars for the driving experience with the ability to switch into auto mode.

- Model –T Fords are still in circulation.
- People like to ride motorcycles / trikes.
- We will not give up the pleasure of driving easily but will be embraced by younger generations.
Autonomous Motorcycles

- ABS
- Motorcycle stability control
- Assistance systems
  - Adaptive cruise control
  - Forward collision warning
  - Blind spot detection
- Increase safety
- Enhance enjoyment and convenience, making life easier for riders

Autonomous Commercial Vehicles

- Tremendous Economic Incentive
- Platooning – V2V connection / SAE Level 2
  - Saves Fuel by Drafting
  - Accelerator & Brake Link
Trucking
Opportunities for Driver Educators

- Many opportunities for driver educators
- Enhanced training for novice teen drivers
- Partner with dealers to train consumers
  - Or train dealers salespersons
- Partner with insurance companies
- Partner with companies/organizations with fleets of vehicles to train their drivers
- Offer courses to families with ADAS vehicles
- Offer courses for travelers who drive many different vehicles per year
- Life-long learning for all drivers…