Pathway to Automation: Transition from CAS

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Overview

• Investigate then make recommendations … follow-up on the implementation

• Path to Autonomous Vehicles

  Crash Investigation

  Perspective

  • Level 2 AV (Williston, FL)
  • Testing of AV (Tempe, AZ)
# Path to Autonomous Vehicles

<table>
<thead>
<tr>
<th>SAE Level</th>
<th>Name</th>
<th>Narrative Definition</th>
<th>Execution of Steering and Acceleration/Deceleration</th>
<th>Monitoring of Driving Environment</th>
<th>Fallback Performance of Dynamic Driving Task</th>
<th>System Capability (Driving Modes)</th>
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<td>The driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.</td>
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<td>4</td>
<td>High Automation</td>
<td>The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene.</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Some driving modes</td>
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<tr>
<td>5</td>
<td>Full Automation</td>
<td>The full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver.</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>All driving modes</td>
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# Path to AV: Where We Were

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Collision Avoidance Systems (CAS)

- **1995** - Examining the effectiveness of collision warning (CW) in heavy vehicles
- **2001** - Development of performance standards for CW and adaptive cruise control (ACC) in passenger and heavy vehicles
- **2008** - Examining the effectiveness of automatic emergency braking (AEB) in heavy vehicles
- **2015** - Installing CW and AEB as standard equipment in all vehicles; expanding NCAP to rate CAS
Today: Transitioning from CAS to Automation

- CAS assist a driver in the performance of a driving task
  - Safety benefits by overcoming environmental factors
  - Safety benefits by reducing deficits in driver performance
- Level 2 automated vehicle systems
  - Possible additional safety benefits, but also
  - Potential cost due to reliance on driver monitoring
  - Retaining the safety benefits of CAS
Path to AV: Public View

Autonomous features we have today

Automatic Emergency Braking

Adaptive Cruise Control

Auto Steering

…
Path to AV: Public View

What is arriving tomorrow
Path to AV: Public View

**Today** (level 0 – 2)
- Data availability
- Driver engagement
- Takeover time
- Defining disengagement
- Phased testing: roadways
- Enforcing driver engagement

**Tomorrow** (level 4 – 5)
- Operational domain
- Maximum hands off time
- Disengagement frequency
- Bullying of an AV system
- Testing of AV systems
- Enforcement: who is at fault
- Phased testing: human operator
- Recording AV-related data
Path to AV: Public View

Today (level 0 – 2)

Operational domain

Data availability
Takeover time
Defining disengagement
Phased testing: roadways
Enforcing driver engagement

Driver engagement

Tomorrow (level 4 – 5)

Operational domain

Takeover time
Maximum hands off time
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Phased testing: roadways
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Recording AV-related data
Williston, FL – Crash Overview

- May 7, 2016 ~4:36 p.m.
- 2014 Truck-tractor combination vehicle
- 2015 Tesla, Model S
  - Level 2 automation
- Daytime, dry roadway, no sun glare
Operational Domain: Roadway

US-27A

- 4-lane roadway
- With central median divider
- Not limited access
- Cruise speed limited to 90 mph
Operational Domain: Roadway

SR-24

- 2-lane roadway
- No central median divider
- Not limited access
- Cruise speed limited to 5 mph over the speed limit
Driver Engagement

- Tesla monitored driver engagement through driver-applied changes to steering wheel torque
- Timing of the alerts after hands-free operation in Autopilot mode
  - Initial visual alert after 3-5 minutes when traveling above 45 mph
  - Additional 2 auditory alerts and a final auditory alert with a slowdown
  - No alert when traveling less than 45 mph
Driver Engagement During the Crash Trip

- Crash trip lasted 41 minutes
- Autopilot was engaged for 37 minutes
- Hands on the steering wheel for 25 seconds
Conclusions and Recommendations

Autopilot operated within its limited functional capabilities, but outside its operational domain

- Driver-based adherence or system-based implementation
  - **Recommendation**: System-based restriction to its operational domain

Driver’s lack of responsiveness indicated overreliance on automation

- Steering wheel torque a poor surrogate measure
  - **Recommendation**: Improved means of monitoring driver engagement

Other recommendations: AV data parameters and availability
Path to AV: Safety Issues

Today (level 0 – 2)

- Availability of AV data
- Takeover time
- Operational domain
- Defining disengagement
- Phased testing: roadways
- Enforcing driver engagement

Future (level 4 – 5)

- Testing of AV systems
- Maximum hands-off time
- Disengagement frequency
- Bullying of an AV system
- Phased testing: human operator
- Enforcement: who is at fault
- Recording AV-related data
Tempe, AZ – Crash Overview

- March 18, 2018 ~10 p.m.
- Uber test vehicle
  - Operated in autonomous mode
- Pedestrian walking a bicycle
- Nighttime conditions
- Roadside lighting present
Uber Test Vehicle

- Built on Volvo XC90
  - Includes CAS with CWS and AEB
- Uber’s autonomous system
  - LiDAR, radars, cameras
  - Disables Volvo’s CAS
Crash Detection Sequence

- A hazard (pedestrian) detected 6 sec TTC
- The hazard changed to an unknown object, a vehicle and finally a bicycle
- Image at 1.3 s TTC
  - Speed of 43 mph
- Driver steered < 1 s
System and Driver Tasks

- **AV system task**
  - Follow the path; speed and lane position determined by the system
  - Does NOT engage emergency braking
- **Driver task**
  - Take over in case of emergency
  - Report events of interest (e.g., system disengagement)
All Issues Are Being Examined

- Highway design, pedestrian safety, …
- Testing of AV systems (not investigation-specific)
  - NHTSA and State requirements for public roads
  - Requirements dependent on an AV level
  - Phased complexity
- Driver monitoring
  - Necessary or optional
  - In-vehicle or remote
Conclusion and Near Future

- The safety promise of AV systems
  - Retaining the safety benefits of CAS while progressing toward a fully autonomous vehicle
- Modulating public expectations
- Determining parameters or requirements for testing