Tampa Bay Clean Cities Coalition

Autonomous Vehicles: State of Practice

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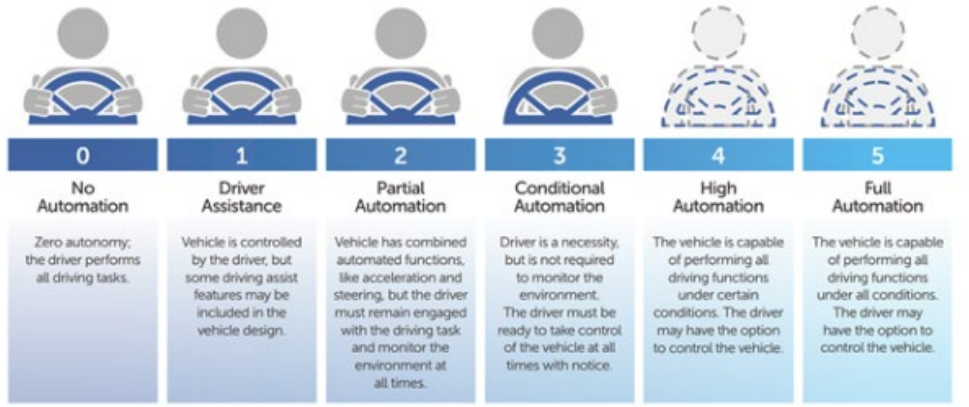
Key Issues

- **Very smart people have different opinions about AV/CAV:**
  - The state of AV technology and timeline
  - Legal aspects
  - Ability to make difficult decisions
  - Impact on transportation and planning
  - Connected vs. autonomous

Vehicle Automation

- **Advanced Driver Assistance Systems (ADAS):**
  - ❑ Collision avoidance/emergency braking
  - ❑ Lane assist
  - ❑ Traffic sign recognition
  - ❑ Precision docking (BRT), etc.



- **Potential Benefits:**
  - ❑ Can improve safety (reduce collisions) of both public transit and private LD vehicle
  - ❑ Improve on-time performance of transit
  - ❑ Reduce congestion
- **Challenges:**
  - ❑ Ability of technology to perform in all operating and weather conditions
  - ❑ Interaction with non-AV users on the road

Low-Speed Automated Vehicles

- **LSAV pilot projects in U.S.:**
  - 18 operating projects, 45 projects in planning
  - 7 completed projects
- **Notable shortcomings of LSAVs (TCRP study):**
  - Limited speed (11-20 mph)
  - Difficulty making left turn (use manual mode)
  - Weather impact on battery life (A/C, heat)
  - Poor performance in rain and snow
  - Interference with autonomous mode by light debris
  - Oversensitivity to unexpected objects on/near road (triggering abrupt stops)

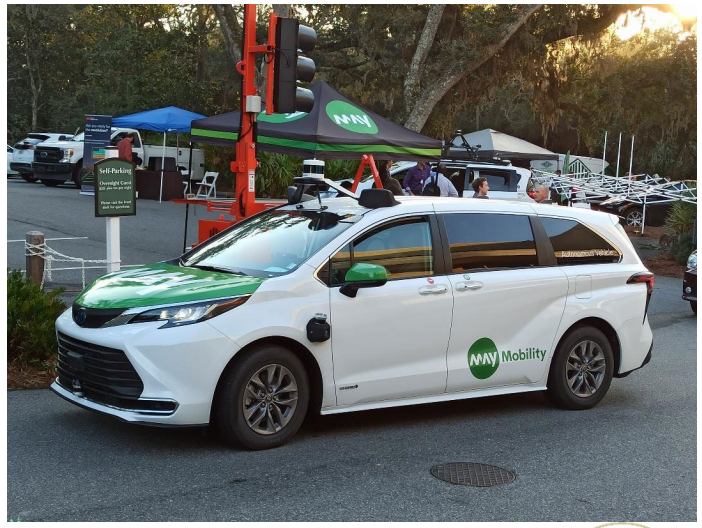
On-Road AV Testing

- Limited data on LSAV crash statistics – small number of transit AVs
- Vehicle manufacturers continue to test AV technologies on and collect data on incidents (Waymo, Uber, Tesla, etc.)
- Analysis of 53 traffic accidents involving AVs and 247 accidents with conventional vehicles in CA (2015-2017) demonstrate:
  - 64.0% of AV accidents – rear-end collisions
  - 28.3% of conventional car accidents – rear-end
  - Most accidents: conventional cars collided with AVs

- Potential reason:
  - Drivers of conventional vehicles are not accustomed to the way AVs drive
  - AVs are programmed to accelerate/decelerate gradually while conventional vehicles drive more aggressively

AV Testing Data

- AVs are less frequently involved in accidents involving pedestrian or broadside collisions
  - 5.7% of AV accidents were broadside or with pedestrians
  - 42.1% of conventional accidents were broadside or with pedestrian
- Likely because AVs are more careful approaching intersections
- No significant differences in types of maneuvers taken by conventional vehicles before collision with AV or conventional vehicle
- AVs on the road can reduce the share of accidents that involve injuries but increase the share of accidents involving only damage to vehicle
- Limitation: small data set



Waymo Disengagement Report

- Reporting disengagement data is mandated by state of California
- Data covers 153 cars and 268 drivers in California
- Disengagement rates dropped:
  - From one per 11,017 miles (0.09 per 1,000 miles)
  - To one per 13,219 miles (0.076 per 1,000 miles)

Waymo Crash Data

- **Low-impact accidents**
  - 1 actual and 2 simulated accidents with pedestrians/cyclists
  - 1 actual and 1 simulated reversing collisions (rear to front)
  - 1 actual an 8 simulated sideswipes
  - 11 actual and 1 simulated rear-end collisions (8 actual accidents when another car struck Waymo car when it was stopped)
- **Higher-impact accidents**
  - 1 actual and 1 simulated rear-end collision
  - 2 actual rear-end collision that triggered airbag deployment
  - One accident when Waymo car struck another car (that swerved and braked hard)

UBER Crash Data

- First fatal crash – AV struck/killed pedestrian (Tempe, AZ, 2018)
- Uber suspended on-road testing for almost 2 years
- CA allowed to resume testing in 2020 with backup driver inside
- Prior to fatal crash, Uber self-driving vehicles were involved in at least 37 minor accidents

Tesla Crash Data

- Tesla vehicles are more likely to crash with an emergency vehicle when on Autopilot
- 12 incidents of Teslas colliding with emergency vehicles when using ADAS (NHTSA data)
- One death, 17 injuries
- Last incident in Orlando – Tesla hit trooper car stopped on I-4
- Most incidents occurred after dark
- Overall crash rate:
  - 9.1 crashes per million miles – AVs
  - 4.1 crashes per million miles – conventional vehicles
  - Lower injury rates for AV accidents

Battery Fires

- Lithium-Ion batteries are highly combustible
- Lithium burns generating temperature of 3,632 degrees F (2,000 C)
- Li-ion cells tend to re-ignite long after initial fire is extinguished
- NTSB Investigation of EV battery fires:
  - 3 out of 4 investigated fires reignited in towing storage facility
  - Damaged batteries reignited multiple times even days after a crash

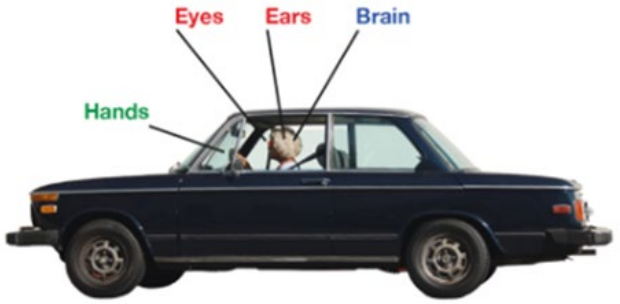
- Notable case of EV battery fire
  - Chevy Volt caught fire 3 weeks after crash test in 2011
- NFPA recommends leaving 50-foot clearance around stored, damaged EVs
- Alternative solution – Isolate damaged EV by steel/concrete barrier (SAE J2990)

Battery Fires Due to Flooding

- Hurricane Ian - September 2022
  - At least 11 cases of EVs catching fire (SW Florida)
  - Vehicles were flooded before catching fire
  - Likely cause – corrosion caused by saltwater
- Exact circumstances are not known yet
- NHTSA investigation is pending
- Florida has second highest numbers of EVs in the nations

AV Challenges and Limitations

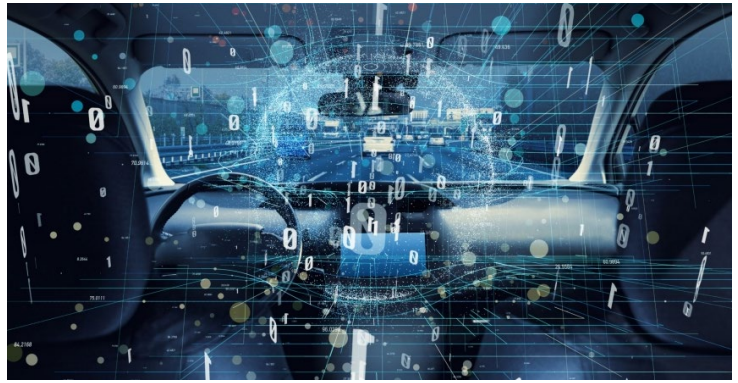
- Challenges:
  - Ability to perform in all operating and weather conditions
  - Interaction with non-AV users
- Types of AV technology malfunctions:
  - Perception errors
  - Decision errors
  - Action errors



- Disengagement frequencies vary (CA data):
  - 0.0002 to 3 disengagement per mile for different manufacturers
- Majority of AV-related accidents (93.7%) are caused by other road users behaving abnormally on the road

Inherent Hazards of AVs

- False Sense of Security
  - Misuse of ADAS by drivers, despite system imperfection
  - Engagement in secondary tasks
- Imperfect Technology
  - ADAS experience some type of issue every 8 miles in real-world driving (2020 AAA study)
- Cyber Attacks
  - Jamming, spoofing, interference
- Complex Real-Life Driving Conditions
- Misrepresentation of Crash Data



Willingness to Rely on Mobility Service

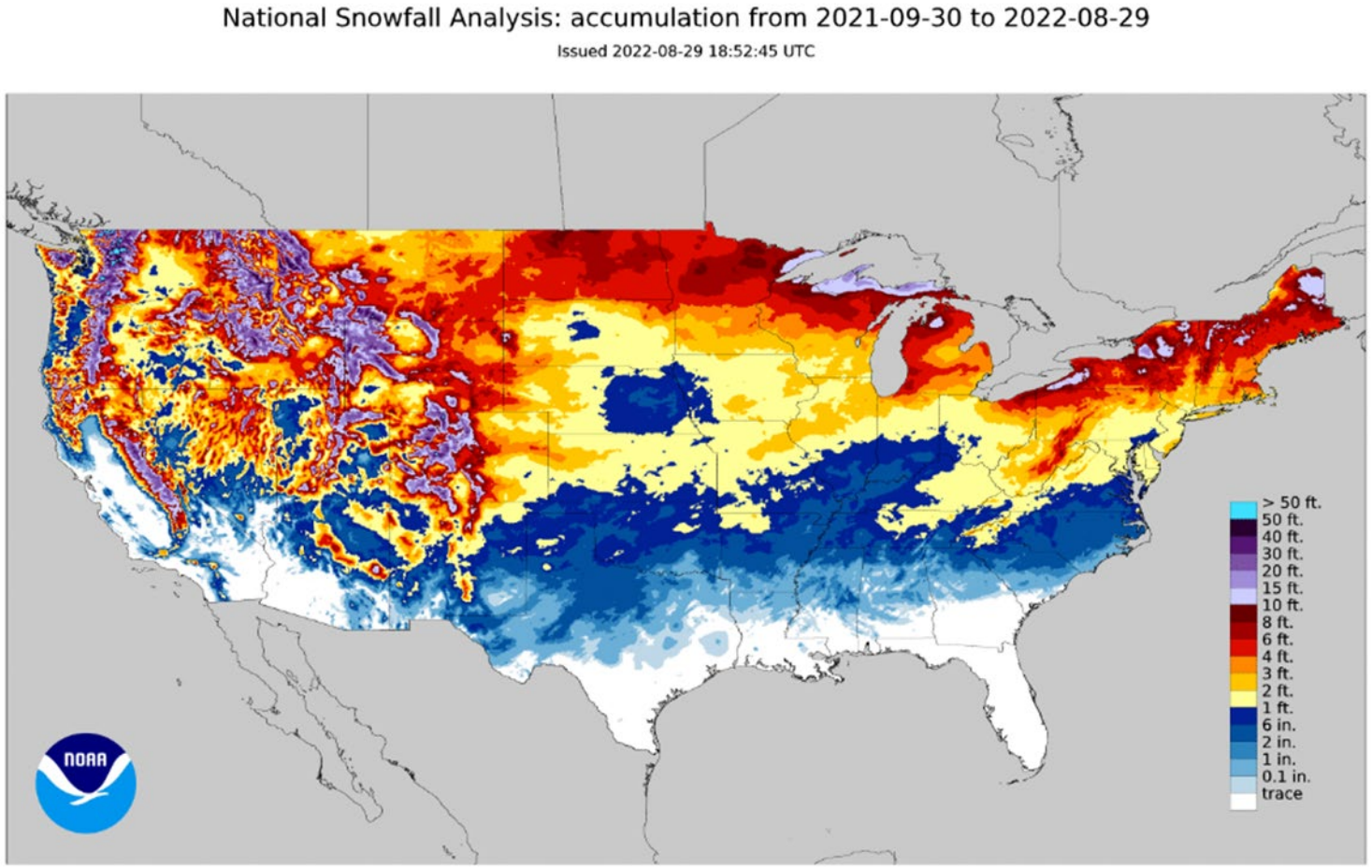
- **Evacuations**
  - Fires, storms, volcanos, tsunami, power plant failures, damn failures, chemical spills, etc.
- **Operation in unique situations:**
  - shoulder running
  - reversed lanes
  - debris
  - covered or flooded roadways

Energy Efficiency of Automation

- The significant amount of electrical power required for data processing alone.
- Based on Tesla calculations: 1.5 kW to 2.75 kW needed just to process incoming and in-vehicle data (from on-board sensors, other vehicles, infrastructure and the cloud)
- Vehicles may turn out not as energy efficient as expected
- Natural fit between AV and EV
- Smart Roads

Weather Impact

- Will weather differences lead to differential deployment with travel and economic impacts?
- Some areas may be at a disadvantage



Impacts of Government Revenues and Costs

- Infrastructure is funded from gas taxes
- More EVs AVs on the road will strain transportation funding
- Potential ways to address funding shortfall:
  - Continue indexing gas taxes (short to medium term)
  - VMT fees
  - Tolling/PPP to fund transportation infrastructure
- FDOT/CUTR study: "AV and AFV Market Penetration Rate And VMT Assessment Study (2019)"

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