https://www.synopsys.com/automotive/autonomous-driving-levels.html

The Society of Automotive Engineers (SAE) defines 6 levels of driving automation now adopted by the U.S. Department of Transportation.

**Human Monitors Driving Environment**

**Level 0. No Driving Automation**
- L1. Driver Assistance: Cruise Control, Adaptive Cruise Control. Driver steering, braking
  - Automated steering / acceleration / braking; Driver can take control at any time.
  - Tesla Autopilot and Cadillac Super Cruise systems.

**Automated Systems Monitor Driving Environment**

- L3. Conditional Driving Automation:
  - Environment detection and decision-making with Driver override.
- L4. High Automation: Automation can intervene if adverse conditions arise without human interaction but humans can still override. Geofencing operations within specific area and speed limits. Currently used for ridesharing in some markets.

**Some Driving Automation Issues:**

1) Human error is system design error. Software must be designed for bottom half of user skill distribution. **Objective stress testing in non-optimal situations** is needed.

2) **Sensor limitations in** non-optimal, ambiguous or misleading environments like rain, snow, fog, night rain/glare, poor signage/graffiti, poor or no lane markings.

3) **Distracted driving / boredom.** Human monitoring of low-probability events is high risk for any partial automation that requires driver attention and automation override. Cognitive inertia to reacquire situation awareness.

4) **Skill decay.** If drivers, particularly new drivers, come to depend on partial automation, will they have the skill to be able to take over when they should?

5) How do non-automated drivers interact with automated systems? Will there be standardized and predictable behavior among independently developed autonomous systems? Is this a new training issue for driver’s ed?

6) **Inferring Intent / Prediction of traffic behavior.** How to emulate human interpretation of local traffic decisions. For example, the car in front of us has a left-turn blinker on. Is it actually going to turn left (opportunity); Is the driver looking to change lanes because traffic
is backed up ahead; Has the driver forgotten the blinker is on? How to react to other aberrant driving behavior like a car tailgating or weaving across lanes? Cyclists / Pedestrian intent?

7) When should the automation break the rules? For example, speeding up to avoid a collision? Proactive behavior to disambiguate situation/ update predictive model.

8) **Ethical decision-making, risk assessment and financial optimization.** How do people decide whether to save the car and driver (industry interest) versus limiting overall impact damage? For example, a human might decide to swerve away from a baby stroller in its path onto a sidewalk with a high risk solution that might send the car into a crowd of people.

9) **Who is at fault** in case of adverse outcomes/ accidents? The driver? The software company? The car manufacturer? The regulatory agencies?

**Future Developments:**

**Connected Vehicle systems,** System level monitoring and direction of traffic including speed, spacing satisfying both individual/shared goals and intent. “Mixed equipage” is an issue here with legacy, non-automated vehicles likely to be on the road for the next 50 years. This issue is a big deal at the FAA for general aviation of mostly small private planes.