NO PREP

AI in Self-Driving Cars

Tesla, Waymo, and the Rest

Includes: Student reading, case study, differentiated questions, teacher key

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Name: Period: Date:

AI in Self-Driving Cars: Tesla, Waymo, and the Rest

The Promise and the Timeline Problem

In 2016, Elon Musk predicted that a fully self-driving Tesla would complete a cross-country trip without human input by the end of 2017. That trip has not happened. In 2018, the CEO of Ford promised fully autonomous vehicles in commercial production by 2021. Ford's robotaxi project, Latitude AI, is still in development. The history of self-driving cars is a history of ambitious promises running into a wall of genuine technical difficulty — and understanding why helps explain a great deal about what AI can and cannot currently do. As of 2025, we have achieved Level 2 and Level 3 autonomy on some consumer vehicles, and Level 4 autonomy in limited geographic areas with specific commercial robotaxi services. But full Level 5 autonomy — a car that can drive itself anywhere, under any conditions, without any human backup — remains

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The Five Levels of Autonomous Driving

The Society of Automotive Engineers (SAE) developed a six-level framework for describing driving automation. Level 0 is no automation: a human controls everything. Level 1 includes basic driver assistance features like adaptive cruise control or automatic emergency braking. Level 2 is partial automation: the car can control both steering and speed simultaneously, but a human must stay alert and ready to take over. Tesla's Autopilot and Full Self-Driving systems operate at Level 2. Level 3 is conditional automation: the car handles all driving in specific conditions, and the human can disengage, but must be ready to take control within seconds when the system requests it. Level 4 is high automation: the car drives itself completely within a defined geographic area, with no human needed at all. Waymo's robotaxis in

San Francisco and Phoenix operate at Level 4 within their defined service zones. Level 5 is full automation: the car can drive anywhere, in any condition, with no human involvement ever. No commercial vehicle has achieved Level 5.

How AI Makes Driving Decisions

Self-driving systems process the world through a combination of sensors: cameras, radar, and LiDAR (Light Detection and Ranging, which uses laser pulses to build a precise 3D map of the car's surroundings). The AI system takes in this sensor data, classifies everything it sees (is that a pedestrian? a cyclist? a plastic bag blowing in the wind?), predicts how everything will move in the next few seconds, and then decides on a steering, braking, and acceleration response, all in milliseconds. The decision-making AI is trained on enormous datasets of real driving scenarios. Tesla's approach is camera-based and relies on learning from billions of miles driven by Tesla vehicles worldwide. Waymo's approach uses LiDAR as a primary sensor and relies on extremely detailed 3D maps of the specific areas where its cars operate. These are philosophically different bets: Tesla bets that cameras plus machine learning can generalize to any road; Waymo bets that detailed maps plus richer sensor data produces safer, more reliable performance in a controlled zone.

What AI Still Cannot Do Reliably

The technical challenges that remain are significant. Self-driving AI systems struggle with unusual or rare edge cases — the scenarios that don't appear frequently enough in training data to be learned reliably. A mattress fallen off a truck in the middle of the highway. A road worker gesturing with their hands in a way the AI has never seen before. Heavy snow or rain that obscures road markings and confuses sensors. A child running into the street from behind a parked van. Each of these is a manageable situation for an experienced human driver; each can be catastrophic for an AI system that has never encountered exactly that configuration before. There is also the problem of moral decision-making. When a collision is unavoidable, what should the car prioritize — the safety of its passenger or the safety of a pedestrian? These are not technical questions with algorithmic solutions. They are ethical questions that societies must answer, and the answers must somehow be encoded into the AI's decision architecture. No consensus has emerged on how to do this.

The Real-World Safety Record So Far

The safety data on autonomous vehicles is genuinely mixed. Waymo published data in 2024 showing its vehicles had significantly fewer injury-causing crashes per million miles than human-driven vehicles in comparable conditions. Tesla's Autopilot data shows a similar improvement in some metrics. However, critics note that both companies operate in favorable conditions — Waymo in geofenced, well-mapped areas; Tesla Autopilot mostly on highways — and that the comparison to human drivers is complicated by selection bias. There have also been high-profile crashes. Multiple Tesla Autopilot incidents have been investigated by the National Highway Traffic Safety Administration (NHTSA), including fatalities involving Autopilot failing to detect obstacles. A Cruise (GM) robotaxi in San Francisco struck a pedestrian in 2023, then dragged her, leading to a complete suspension of Cruise's commercial operations. These incidents matter not because they prove autonomous vehicles are categorically unsafe, but because they reveal the specific gaps in current AI decision-making under real-world conditions.

The Sensor Suite: What Autonomous Vehicles Actually See

Human drivers rely almost entirely on vision to navigate. Autonomous vehicles use a much broader sensor array because no single technology provides enough information on its own. Lidar — Light Detection and Ranging — fires rapid pulses of laser light and measures how long each pulse takes to return, building a precise three-dimensional point cloud of the environment up to 200 meters away. Radar uses radio waves and excels in poor visibility conditions like heavy rain or fog where lidar performance degrades. Cameras provide color and texture information that neither lidar nor radar captures well. Ultrasonic sensors handle close-range detection for parking and low-speed maneuvering. The AI systems in self-driving vehicles must fuse all of these data streams simultaneously, reconcile conflicts between them, and act on the combined picture in real time. The computational load involved is substantial — a single autonomous vehicle generates roughly 40 terabytes of sensor data per hour of driving.

Regulatory Frameworks and the Path to Full Autonomy

The Society of Automotive Engineers defines six levels of driving automation, from Level 0 with no automation to Level 5 with full autonomy in all conditions. As of now,

no vehicle sold to consumers achieves Level 5. Most production systems operate at Level 2, which requires the driver to remain attentive and ready to take control at any moment. Waymo's commercial robotaxi service in select U.S. cities operates at Level 4, meaning it can handle all driving in specific geographic areas without a human driver, but only in those defined zones. Regulatory approval for Level 4 and Level 5 vehicles varies significantly by state and country, and the legal question of liability in the event of an accident involving an autonomous vehicle remains actively debated in legislatures worldwide.

The Human Factor in Autonomous Driving

Despite significant technological progress, autonomous vehicles still struggle with scenarios that human drivers handle intuitively. Unusual road markings, informal signals from construction workers, flooded streets, and the unspoken social negotiations that happen at four-way stops all present challenges for current AI systems. Human drivers rely on theory of mind — the ability to infer what other drivers and pedestrians intend to do — in ways that autonomous systems approximate but do not fully replicate. Researchers refer to edge cases as the long tail problem: the vast majority of driving scenarios can be handled reliably, but the uncommon situations — a mattress falling off a truck, a child chasing a ball into traffic, a traffic light obscured by a tree branch — are both rare and critical. Progress on the long tail is the central challenge standing between current Level 2 systems and true full autonomy.

Key Information: Autonomous Vehicle Levels and Companies

Detail	Information
SAE Level 2	Partial automation — car controls steering + speed; human must stay alert (Tesla Autopilot)
SAE Level 4	High automation — fully self-driving within a defined geographic area (Waymo robotaxi)
SAE Level 5	Full automation — drives anywhere, any condition; not yet commercially achieved

Detail	Information
Tesla Approach	Camera-based; trains on billions of miles from global Tesla fleet
Waymo Approach	LiDAR-based; uses detailed 3D maps of specific service zones
Key Sensor Types	Cameras, radar, and LiDAR (laser-based 3D mapping)
Major Challenge	Edge cases — rare scenarios not well-represented in training data
2023 Incident	Cruise robotaxi struck and dragged pedestrian; operations suspended

Case Study: The Mattress on I-95

Sofia is 22 and works as a safety monitor for a company testing Level 3 autonomous vehicles on Florida highways. Her job is to sit in the driver's seat, hands near the wheel, and take over if the system alerts her. Most days are uneventful. Then one afternoon, an alert fires. The car's AI has flagged something in the road ahead and is requesting human control. Sofia grabs the wheel and sees it: a queen-size mattress lying flat across the right lane, partially obstructing her lane too. She steers around it cleanly. Later, reviewing the logs with her supervisor, she sees that the AI classified the mattress as 'unknown object — possible road surface anomaly' and had slowed slightly but was not prepared to make a confident lane-change decision. 'If you hadn't been there,' her supervisor says, 'the system would probably have continued forward at reduced speed.' Sofia feels a chill. 'So it really does need me,' she says. 'For now,' her supervisor says.

1. This scenario illustrates the 'edge case' problem described in the reading. In your own words, explain what an edge case is and why this particular situation would be difficult for a self-driving AI system.

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2. Sofia's supervisor says 'for now.' What does this suggest about how the company views human safety monitors in autonomous vehicle development? Do you think that is a responsible way to think about safety?

Multiple Choice

1. What is the key difference between SAE Level 4 and SAE Level 5 autonomous driving?

a) Level 4 is self-driving within a defined geographic area; Level 5 can drive anywhere under any conditions

b) Level 4 vehicles use cameras primarily; Level 5 vehicles use only LiDAR and ultrasonic sensors

c) Level 4 vehicles require an on-board safety driver; Level 5 vehicles do not

d) Level 4 is currently commercially available; Level 5 is only available in controlled research programs now

2. What is LiDAR, and which company relies on it primarily?

a) A government safety standard for autonomous vehicles

b) A type of radar that detects moving objects; used by both Tesla and Waymo equally

c) A camera system used by Tesla to process road markings

d) A laser-based sensor that builds 3D maps of surroundings, used primarily by Waymo

3. What lesson does the history of self-driving car promises teach us about AI development timelines?

a) AI developers consistently underestimate how quickly their technology will mature

b) Government regulators have strategically slowed the pace of autonomous vehicle development intentionally

c) Ambitious predictions about AI capabilities often run ahead of the actual technical difficulty involved

d) Self-driving cars are fundamentally impossible to build to work safely under all real-world conditions

Matching

Write the letter of the correct definition on the line next to each term.

Term	Definition
1. ___ SAE Levels	A) A sensor technology using laser pulses to create detailed 3D maps of the environment around a vehicle
2. ___ LiDAR	B) Restricting an autonomous system's operation to a predefined geographic area with detailed maps
3. ___ Edge Case	C) Partial automation where the car handles steering and speed but a human must remain alert and ready to take over
4. ___ Geofencing	D) A rare or unusual driving scenario that doesn't appear frequently enough in training data to be handled reliably
5. ___ Level 2 Autonomy	E) A six-level framework from the Society of Automotive Engineers describing degrees of vehicle automation

Fill-in-the-Blank

1. Tesla's Autopilot and Full Self-Driving features operate at SAE Level _____, which requires a human to remain alert and ready to take over.

2. Waymo robotaxis operate at Level 4 autonomy, meaning they drive themselves completely within a _____ geographic area and only inside those specific service zones.

3. The NHTSA — the National Highway _____ Safety Administration — has investigated multiple Tesla Autopilot incidents.

Short Answer

Answer each question in 2-4 complete sentences.

1. Compare Tesla's and Waymo's approaches to building self-driving AI. What is each company betting on, and what are the tradeoffs of each approach?

_____

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2. The reading raises the question of how a self-driving car should decide what to do when a collision is unavoidable. Why is this question so difficult to answer, and who should be responsible for making that decision?

_____

_____

_____

3. Based on what you read, do you think the safety data on autonomous vehicles so far is encouraging, discouraging, or mixed? Explain your reasoning using specific details from the reading.