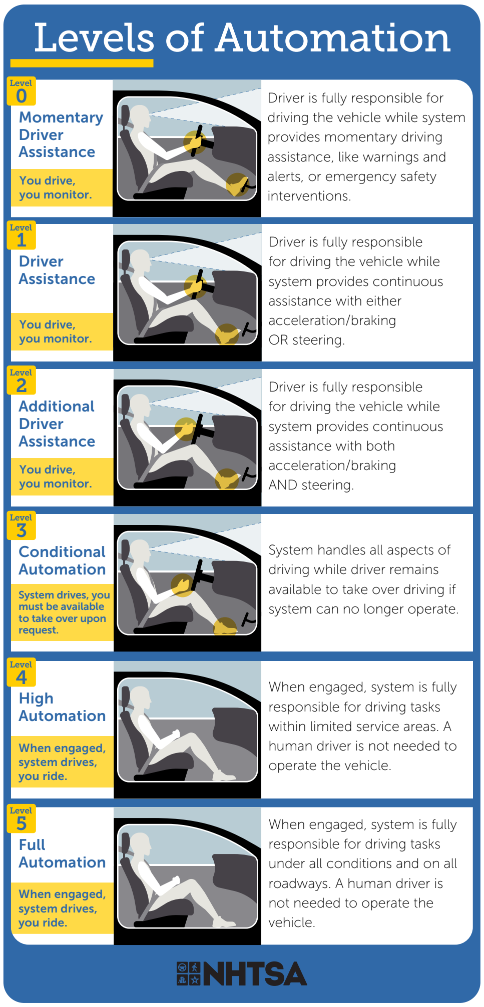
Autonomous Vehicles

Autonomous vehicles (AVs) use technology to partially or entirely replace a human driver in navigating vehicles, responding to traffic conditions, and avoiding road hazards.[1] The U.S. National Highway Traffic Safety Administration (NHTSA) uses a classification system developed by the Society of Automotive Engineers (SAE), based on the degree of human intervention.[2]

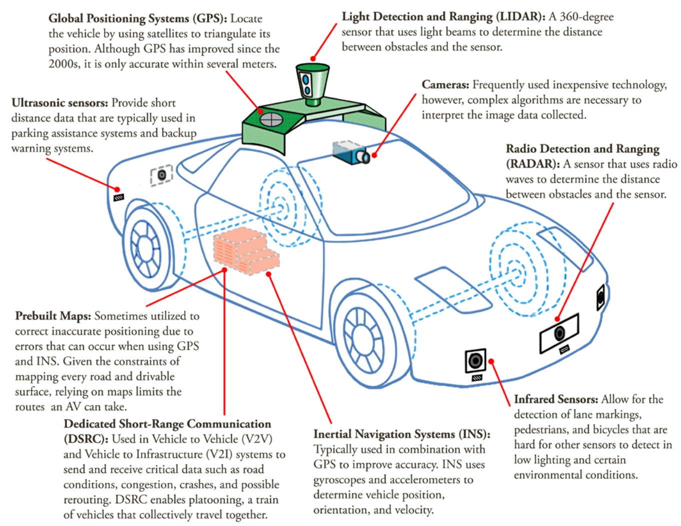
SAE Levels of Automation[3]



Development of AVs

- In 1980, university researchers began work on two AV concepts, the first required automated roadways, while the other did not.[1]
- From 2003–2007, The U.S. Defense Advanced Research Projects Agency (DARPA) held three grand performance challenges with up to $2M incentives to accelerate advancements in AVs.[1] No vehicle successfully finished the 2004 challenge—the best covered just 8 mi. In 2005, five completed all 150 mi. In 2007, six teams finished the third challenge; a 60-mi course navigating a dense urban area while obeying traffic laws.[1]
- Tesla launched its 'autopilot' software in 2014.[4] Waymo launched its fully autonomous ridesharing system in 2018.[5]

Autonomous Vehicle Technologies[1,9,10,11]



- Amazon obtained permission from the U.S. Federal Aviation Administration to fly drones for Prime Air without direct operator line of sight in 2024.[6]
- Autonomous drones were first used in 2024 by both sides of the war in Ukraine to avoid jamming technologies.[7]

AV Technologies

AVs use a combination of sensors to detect their surroundings, including obstacles and signage. Based on this data, artificial intelligence software identifies appropriate navigation paths.[8]

Current Market and Projections

Key Market Leaders

- Waymo's ride-hailing service has driven over 170.7M mi on public roads without a human driver.[12] In 2025, they launched a partnership with Toyota to develop a next-generation personal use vehicle.[13]
- Teslas have driven 10.97B mi at Level 2 since 2014.[14]
- BMW and Mercedes-Benz are the first to offer Level 3 AVs.[8,15]

Regulations, Liability, and Projected Timeline

- In 2018, Congress introduced the AV START Act to establish a framework for testing, regulating, and deploying autonomous vehicles. The legislation ultimately failed to pass both houses.[16]
- By February 2020, 29 states and D.C. had enacted legislation regarding the definition, use, and liability of AVs.[17]
- In 2025, the U.S. Department of Transportation unveiled a new framework to modernize federal standards for commercial AVs, including new safety reporting guidelines and deregulation to accelerate development.[18]
- Laws are being updated to allow AV manufacturers to be cited for traffic infractions.[19,20]

- Widespread adoption of Level 5 vehicles is unlikely by 2035,[21] while some speculate that Level 5 autonomy might be adopted in trucking before personal vehicles.[22]

Limitations and Barriers

- Advancing vehicle autonomy becomes increasingly complex and costly at each step. Level 2 systems are becoming standard, but require the driver's constant attention. Current driver attention sensors are easily defeated, requiring more secure solutions like eye-tracking.[21]
- Level 3 autonomy poses a major liability shift from driver to automaker, slowing industry adoption. Level 4 AVs (e.g. robo-taxis) are limited to specific geofenced areas and conditions, and consumer demand for personal vehicles is too low to justify costs. Without strong willingness to pay for Level 4 capabilities, mass-market deployment is unlikely in the next decade.[21]
- Additionally, data security concerns, vulnerability to cyberattacks, and public distrust impede the widespread adoption of AVs.[8]

Impacts and Solutions

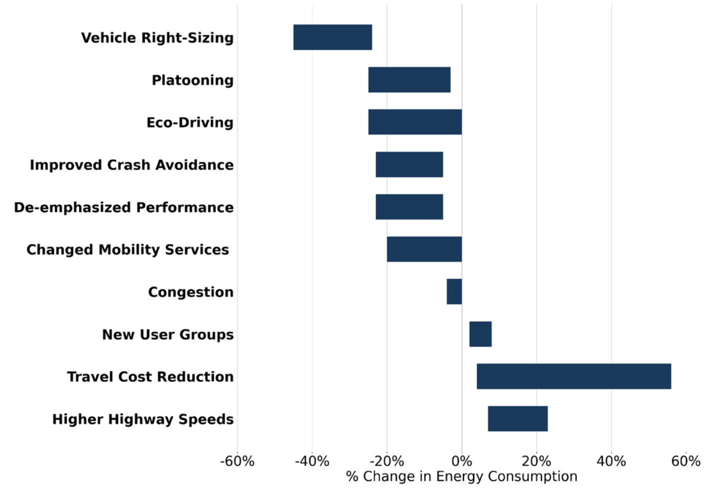
- AVs impose a direct energy cost: roughly 1 kW per vehicle constant power draw when operating.[25] Widespread AV adoption could result in more emissions from AV software than from all the data centers in 2018. AVs allow for new driving practices and automotive designs that could save energy.[23] Combined with other technologies and new transportation models, they could have significant economic, environmental, and social benefits.[24]
- While AVs can increase energy consumption and transport time in urban environments, connected and cooperative AVs can reduce both.[26]

Metrics and Associated Impacts

- *Congestion* is predicted to increase, as AVs can slow traffic at intersections. Connected and cooperative AVs can ease congestion.[27]
- *Eco-Driving*, a set of practices that reduce fuel consumption, is predicted to reduce energy consumption by up to 20%.[23] If AV algorithms do not prioritize efficiency, fuel efficiency may actually decrease.[28]
- *Performance*, such as acceleration, is likely to be de-emphasized as comfort and productivity become travel priorities, leading to a 5-23% reduction in fuel consumption.[23]
- *Improved Crash Avoidance,* due to the increased safety features of AVs, may allow for the reduction of vehicle weight and size, decreasing fuel consumption 5-23%.[23]
- *Vehicle Right-Sizing*, the ability to match the utility of a vehicle to a given need, could decrease energy consumption 21-45%, though the full benefits are only likely when paired with a ride-sharing on-demand model.[23]
- *Higher Highway Speeds* are likely due to improved safety, increasing fuel consumption 7-30%.[23,29]
- *Travel Cost Reduction*, due to decreased insurance cost and improvements in productivity and driving comfort, could result in increased travel, increasing energy consumption 4-60%.[23]
- *New Users* could increase vehicle use by up to 14%.[30]

An accurate assessment of these interconnected impacts cannot currently be made. Projections for road transport energy range from 40% decrease to 105% increase.[23]

Projected Change in Fuel Consumption[23,29]



Potential Benefits and Costs

- The U.S. AV market is expected to grow to over $75B in 2030, an increase of 350% from 2023.[33]
- Trucking costs for longer routes could decrease by 42% by 2035.[22]
- Energy savings by pairing public transportation with last mile AVs are as much as 37% compared to private vehicles.[34]
- Potential benefits include improved safety, quality of life, public health, mobility, and accessibility, especially for the elderly and disabled.[1,25,35]
- AVs may also reduce energy use, environmental impacts, congestion, transportation costs, and promote greater adoption of car sharing.[25,36]
- Potential costs of AVs include increased congestion, vehicle-miles traveled (VMT), urban sprawl, and total travel time.[29,30] High upfront costs raise social equity concerns.[1]
- Additional challenges stem from heightened concerns about security, safety,[29,36] and effects on other transport modes.[25]
- 39,254 people died in vehicle crashes in 2024, roughly 1 person per 100M miles of driving.[31] In the long term, experts expect AVs to reduce the number of fatalities and injuries in crashes.[23] There is not enough data to specify if AVs are currently safer than human drivers.[32]

Cite as: Center for Sustainable Systems, University of Michigan. 2026. "Autonomous Vehicles Factsheet." Pub. No. CSS16-18. August 2026
Sources for this factsheet are online, help with units and abbreviations is here. See css.umich.edu/publications/factsheets for other factsheets.