What Does the Future Hold for Self-Driving Cars?

Description

Self-driving cars are poised to revolutionize the transportation industry. There have been many significant shifts in the auto industry since the beginning of commercial auto production roughly eight decades ago, but the basic formula of a human operator guiding a vehicle using a steering wheel and pedals has held pretty steady across that time span. That's changing quickly. Newer cars already have automated features for things like parking and collision detection, and auto and tech companies are hard at work to deliver vehicles that are capable of advanced navigation without input from a human driver.

Automated driving systems (ADS) for cars, trucks, and vans are on the way and set to bring some huge changes and opportunities. Here's a look at what the future might hold, some of the big roadblocks facing driverless technology progression, and what the major breakthroughs from the improvement of the tech could mean.

What are the levels of autonomous vehicles?

Autonomous car functionality is often referred to and judged on a six-tier scale, with Level 0 representing no autonomous component and a Level 5 ranking signifying an autonomous vehicle that can consistently perform all driving functions without the need for any human input. The table below outlines the basic characteristics of each of the five levels of autonomous cars as outlined by the Society of Automotive Engineers (SAE):

Level	Defining Characteristics
Level 0 — No automation	The driver is responsible for all core driving tasks. However, Level 0 vehicles may still include features like automatic emergency breaking, blind-spot warnings, and lane-departure warnings.
Level 1 — Driver assistance	Vehicle navigation is controlled by the driver, but driving-assist features like lane centering or adaptive cruise control are included.

Level 2 — Partial automation	Core vehicle is still controlled by the driver, but the vehicle is capable of using assisted-driving features like lane centering and adaptive cruise control simultaneously.
Level 3 — Conditional automation	Driver is still required but is not needed to navigate or monitor the environment if certain criteria are met. However, the driver must remain ready to resume control of the vehicle once the conditions permitting ADS are no longer met.
Level 4 — High automation	The vehicle can carry out all driving functions and does not require that the driver remain ready to take control of navigation. However, the quality of the ADS navigation may decline under certain conditions such as off-road driving or other types of abnormal or hazardous situations. The driver may have the option to control the vehicle.
Level 5 — Full Automation	The ADS system is advanced enough that the vehicle can carry out all driving functions no matter the conditions. The driver may have the option to control the vehicle.

Information source: Society of Automotive Engineers.

What can autonomous driving systems do right now?

Newer cars already feature machine-corrective and machine-assisted technologies like lane correction, potential collision detection, and automated parking. Some cars from manufacturers including **Tesla** and **Audi** include semi-autonomous driving features that fall in the Level 3-functionality tier.

Most of the more advanced ADS-enabled vehicles that have been released fall into the Level 2 and Level 3 designations, while commercially available vehicles with true Level 4 functionality are still in the development and testing phases. **Ford** expects to launch Level 4 vehicles in 2021, and **Baidu** (NASDAQ: BIDU) and Volvo are also teaming to launch Level 4 vehicles in 2021. Some sources suggest that Level 4-capable vehicles will be available even earlier, and **Alphabet**'s (NASDAQ: GOOG) (NASDAQ: GOOGL) Waymo already has a fleet of self-driving vehicles that are seeing limited use as taxis on on public roads. Tesla founder and CEO Elon Musk has stated that his company will have Level 5 electric vehicles ready in 2020.

However, other analysts and industry figures have a more cautious outlook on the technology's development, taking the position that many projections are too optimistic.

Steve Wozniak, **Apple** co-founder and a person who was once bullish on the future of self-driving cars, believes that self-driving car technology is very far away from being good enough to implement at scale. And you might be surprised to hear that Waymo CEO John Krafcik has stated that autonomous vehicles will never be able to drive in all conditions.

ADS technology has come a long way, but some significant hurdles and big advancements still mustbe worked out and implemented before true Level 4 and Level 5 cars are made available toconsumers. The diverging range of projections on when these tech advancements will arrive at theconsumer level suggests that companies and prognosticators may be using different definitions andgrading systems for evaluating driverless functionality.

Are self-driving cars safe?

Some reports and experts suggest that ADS vehicles are already safer than human-operated vehicles when it comes to performing some driving functions. Self-driving cars don't suffer from sleep deprivation, and they can't drive under the influence of drugs or alcohol. They also have wider fields of vision and are designed to obey traffic laws, while human drivers will sometimes disregard laws or fail to follow them due to being distracted.

Self-driving technology has the potential to reduce crashes, but some high-profile accidents have raised questions about risks posed by poorly functioning autonomous-driving systems. In January 2016, a man was killed in China after his Tesla crashed into the back of a cleaning vehicle. The Tesla reportedly had its self-driving features activated at the time of the crash. This marked the first reported death in which a vehicle's ADS features were viewed as a potential contributing factor, although the police did find that the Tesla driver had not been paying attention to the road in accordance with the autopilot rules.

In May 2016, a man died in the U.S. after his Tesla hit a truck and its tractor while in autopilot mode. The Tesla's sensors misidentified the truck's white tractor as being part of the sky. There have been instances in which self-driving cars appear to be at fault for crashes, but human operators not paying attention to the road (as is required in Level 2 and Level 3 systems) has also been a factor.

Debate about the safety of driverless cars intensified in 2018 after a woman in Arizona was struck and killed by an Uber vehicle that was reportedly operating in self-driving mode. The accident prompted the ridesharing company to temporarily suspend its testing of autonomous vehicles on public roads. The vehicle involved in the crash was categorized as operating with Level 3 functionality, and reports suggest that the pilot of the car was looking down at the time of the accident — which means the accident could have partially been the result of human error. Uber resumed testing roughly nine months after the fatal crash.

The public data available for evaluating how safe self-driving cars are remains somewhat limited. Most of the cities and states in which autonomous driving testing is taking place tend to have relatively dry weather conditions and simple road systems that make it easier for driverless vehicles to function. California is also the only state in America that requires companies testing driverless cars to submit reports detailing each accident involving autonomous vehicles on public roads. But even California's reporting requirements do not provide a very detailed view into the performance of driverless vehicle systems.

It's difficult to make a clear across-the-board assessment about the level of safety that autonomous vehicles provide. Competing automated driving systems also rely on different technology platforms, and some systems are likely safer than others, but it does appear that autonomous driving systems

can outperform human drivers in ideal operating conditions. A study from Axios found that humans were responsible for most of the accidents in California involving self-driving cars from 2014 to 2018. However, as noted by Waymo's John Krafcik, the technology still needs improvements to make it more functional in a wider range of scenarios.

Will people accept self-driving cars?

Self-driving cars have some perception issues to overcome. The 2019 installment of AAA's annual autonomous-vehicle survey found that 71% of people surveyed would be afraid to ride in fully autonomous vehicles — down slightly from the 73% of respondents in 2018 and up substantially from the 63% of respondents who said that they would be scared to be a passenger in a driverless vehicle in 2017. Just 19% of respondents in the 2019 survey said that they would be comfortable with putting their children and other family members in autonomous vehicles.

A report from CivicScience produced similar results, with 72% of respondents indicating that they were "not comfortable at all" with driverless cars. Just 6% of respondents in the CivicScience study reported that they were completely comfortable with the technology.

Data shows that people are cautious about ADS technology and that many will need to see evidence that it is safer than having people drive before embracing it. A Reuters Ipsos poll published in April 2019 found that half of people thought that autonomous vehicles were more dangerous than vehicles operated by human drivers. Two-thirds of survey respondents indicated that they thought self-driving cars should have to demonstrate a higher standard of safety than human drivers.

Some experts believe that weak support for driverless vehicles stems from high-profile accidents involving ADS technology and people having little experience with autonomous vehicle technology. Greg Brannon, AAA's director of Automotive Engineering and Industry Relations, laid out this explanation for the current perception surrounding driverless technology and what he expects will improve sentiment:

> Automated vehicle technology is evolving on a very public stage, and as a result, it is affecting how consumers feel about it. Having the opportunity to interact with partially or fully automated vehicle technology will help remove some of the mystery for consumers and open the door for greater acceptance.

AAA's study found that drivers who had experience with automated driving features including lane-keeping assistance, automatic emergency braking, and self-parking were more likely to trust autonomous driving features. If the technology continues to improve and machine-operated driving systems are shown to be reliably safe, favorability ratings for self-driving cars will likely increase over time.

What benefits could self-driving cars offer?

If self-driving technology continues to progress as many analysts anticipate, autonomous vehicles could actually dramatically reduce the occurrence of automotive accidents. Tens of thousands of

people in the U.S. are killed in car accidents each year, and many more people are injured.

Auto collisions are also hugely costly, causing hundreds of billions of dollars in damage each year in the U.S., according to some studies, and the National Highway Traffic Safety Administration (NHTSA) estimates that 94% of auto accidents are caused by human error. Reducing human input has the potential to result in fewer deaths and injuries and reduced economic damage if automated driving systems are up to the task of taking over.

Having self-driving cars could also give people a lot more free time. Commutes might be spent working on projects, talking to other passengers, or watching a favorite television show on an in-vehicle entertainment system. While many people enjoy driving, the opportunity to get things done or enjoy leisure time while in transit could translate to significant productivity and quality-of-life improvements. The average American spends more than 12 days driving each year, and the country's drivers register more than 80 billion combined hours on the road annually, according to the Federal Highway Administration and the Department of Transportation.

Image source: Getty Images.

Could driverless vehicles completely replace regular cars?

With a staggering number of deaths and massive expenses stemming from automobile accidents due

to human error, some people have asked whether human driving might be phased out if autonomous vehicles are shown to be significantly safer. The argument could be made that failing to fully transition to autonomous transport will result in lives being lost, unnecessary damage being incurred, and energy resources being wasted.

Major technological improvements would likely be needed before a full movement away from human-operated vehicles could gain public and legislative support, but some people in the field see the shift happening. Elon Musk stated in 2015 that he believed that cars operated by humans would one day be outlawed because autonomous vehicles would be much safer.

Robotics and artificial intelligence expert Rodney Brooks wrote in a 2017 report that he sees a long road to getting driverless cars to the point at which they are as smart as humans and can reliably handle the unexpected anomalies that pop up on the road. However, Brooks also stated that he believed many people reading his report would see autonomous vehicles make human driving disappear within their lifetimes.

Many experts believe that fully autonomous vehicles functioning at scale could be decades away or that the technology might never be capable of fully replacing human drivers. Even if driverless cars were reliably shown to be as safe as or safer than human drivers, many people would not want to give up having the ability to drive. A poll conducted by Gallup in 2018 found that 34% of people enjoyed driving "a great deal," while another 44% enjoyed it "a moderate amount." Those results suggest considerable affinity for having control over vehicles, and it's not unreasonable to think that a hypothetical legislative push to have human drivers completely relinquish the steering wheel would be met with resistance.

As Musk and others have pointed out, it is possible that significant safety improvements brought about by driverless cars could result in government efforts to further regulate or outright ban human-operated vehicles. It might seem far-fetched at present, but no one can say with certainty what the future holds, and evidence showing that accidents would be reduced and lives would be saved could be very persuasive.

Is the rise of self-driving cars an investing opportunity?

With automated driving systems on track to continue improving, it's reasonable to think that the technology could be a huge tailwind for companies that are positioned to capitalize. Business Insider Intelligence reports that roughly 10 million cars with automated navigation technology will be on the road in 2020. McKinsey has predicted that roughly 15% of automobiles sold in 2030 could be fully autonomous. **Intel** has estimated that the global market for autonomous vehicles, or "the passenger economy" as it dubs it, will surpass $7 trillion annually by 2050. Morgan Stanley has estimated that providing service to autonomous vehicles will be a $200 billion industry annually for telecom providers in 2050 and expects that roughly 300 million autonomous vehicles will be on the road at that time.

The rise of [autonomous vehicles](#) will have big impacts across a wide range of industries, and this means many companies could benefit from the emerging tech. Leading technology companies like **Amazon** and Apple can be counted on to have product and service offerings in the autonomous vehicle space. Morgan Stanley has referred to smart cars as "iPhones on wheels" — a description that reflects the automobile's potential to emerge as one of the next big consumer-level computing hubs

and suggests the potential for services beyond one-time vehicle sales.

What do self-driving vehicles mean for car companies?

It's still not clear what the rise of autonomous vehicles will mean for the automotive industry's major players. Cars that are capable of navigating the streets without a human driver could be rented out by their owners for use in ridesharing services — a trend that might result in a drastic reduction of individual car ownership and work against auto manufacturers.

The introduction of self-driving cars is widely viewed as the key to getting ridesharing businesses like **Uber** and **Lyft** into states of consistent profitability. In some markets, labor accounts for roughly 60% of the total cost structure in a traditional taxi business, so there's room for huge efficiency improvements with the shift to autonomous vehicles. If ridesharing services become significantly cheaper, individual car ownership could decline substantially. The convenience offered by individual car ownership won't vanish in the near future, but the value proposition is already changing thanks to ridesharing services, and shifts could be even more dramatic with advancements in ADS technology.

Alternatively, some models for how automated driving systems will impact auto manufacturers hold that carmakers and fleet operators like **General Motors** (NYSE: GM), Fiat Chrysler, and Waymo will own most of the market's self-driving vehicles, and consumers will simply use them through a ride-hailing service. Others suggest that driverless vehicles could actually increase personal ownership because people would be able to easily rent their vehicle out for ridesharing.

Stocks for investing in self-driving cars

It's still too early to state definitively who the big winners of the driverless revolution will be, but there's lots of opportunity in the broader category. The table below profiles companies in autonomous-vehicle technology that deserve a close look from investors who are interested in the space.

Company	Key Strengths
Alphabet	• Leadership in the search and operating system markets gives the company access to a treasure trove of valuable data that can be used to improve AI and driverless technology performance for Waymo and other ventures. • Top software development teams • Strong core businesses and financial position allow the company to fund its autonomous vehicle projects and prioritize long-term results over near-term profitability.

General Motors	• Expertise in large-scale automobile manufacturing • The company's Cruise subsidiary is attracting plenty of funding, is broadly considered a top player in autonomous vehicle technology, and could be one of the first players to roll out a large-scale driverless ridesharing fleet.
NVIDIA (NASDAQ: NVDA)	• Expertise in graphics hardware and systems that are crucial for machine vision • The company's data center business is also positioned to see significant tailwinds from the growth of the autonomous vehicle market.
NXP Semiconductors (NASDAQ: NXPI)	• Biggest global supplier of automotive computer chips • Leading position in automotive infotainment chips and growth opportunities in automotive radar and other sensing products
Baidu	• Leading position in China's search market means access to data that can be used to improve its artificial intelligence systems • Partnered with the Chinese government for the development of the country's autonomous vehicle and smart-city initiatives

Alphabet

Alphabet launched Waymo, its self-driving car unit, under the Google division of the company before spinning it off as its own subsidiary in 2016. Waymo is an early leader in driverless technologies and was the first player in the space to roll out an autonomous taxi service at the consumer level. Alphabet has also been using self-driving cars to ship goods between its Waymo and Google divisions, and its autonomous vehicle arm is also working to develop self-driving trucks suitable for commercial shipping needs.

Waymo is partnered with vehicle manufacturers **Fiat Chrysler** and Jaguar Land Rover and has been purchasing and updating vehicles in large quantities to rapidly expand its self-driving fleet. Alphabet's strong position in data and search gives it big advantages in the artificial intelligence space that will carry over to the race for leadership in autonomous vehicles and associated services. Efforts to establish Android as a top operating system for connected cars are also likely to benefit its driverless vehicle push and could give the company a way to benefit from other companies' autonomous vehicle initiatives.

General Motors

General Motors has been an aggressive mover in the driverless car arena. Big investments from the company combined with its solid footing in the electric vehicle space and streamlined large-scale auto manufacturing expertise could help it build an early edge that solidifies into a long-term leadership position in autonomous vehicles.

GM's self-driving, ridesharing subsidiary Cruise could also position the company to see strong tailwinds from the rise of driverless technology and help insulate it against the potential of resulting slowdown for personal vehicle sales. The company believes that it could generate hundreds of thousands of dollars in revenue across the lifetime of one autonomous vehicle. Cruise has attracted billions of dollars in investments from companies including **Honda** and **Softbank** for the development of ADS technologies. Along with Waymo, GM's Cruise appears to be at the forefront of the driverless taxi space.

Image source: GM.

NVIDIA

NVIDIA's strength in visual processing chips makes it a leader in artificial intelligence and machine vision. The company's business has historically grown around creating graphics processing units (GPUs) that are used in gaming consoles and video game-focused PCs — which might seem to make it an odd player in the autonomous vehicle space. However, the company's expertise in GPUs meant that it already enjoyed a head start in developing the types of hardware and software needed to process visual data.

Footer Tagline

Being able to read and respond to the environment is the core of ADS technology, and the graphics specialist's efforts to tailor processors and software to meet the specific demands of driverless vehicles helped it grow its customer base in the category to hundreds of companies worldwide. NVIDIA's GPUs and computing platforms are also key components in many data centers, and the explosion of newdata that's likely to stem from increased adoption of driverless vehicles stands to be a significantdemand catalyst for its products.

NXP Semiconductors

As the world's biggest automotive chip supplier, NXP Semiconductors could see a range of tailwinds as vehicles become more advanced and efficient. With autonomous navigation allowing drivers to concentrate on things other than the road, many driverless cars will likely be outfitted with in-vehicle entertainment systems. NXP is the top player in the automotive infotainment chip space and could see significant momentum from the driverless trend. The company is also seeing encouraging growth from its radar-based advanced driver-assist system (ADAS) and is making a push into producing machine-vision computing systems and sensor processors — partnering with French chip company Kalray to accelerate its position in the space.

With advances in technology paving the way toward making the car a major new information and computing hub, there's a huge opportunity for companies that can help turn the automobile into a connected, high-end smart device. Cloud computing will likely play an increasing role over time, but capable on-board hardware will always be essential.

Baidu

Baidu operates China's top search engine, and the company's leading position in the world's largest internet market gives it access to huge amounts of data to feed into and refine its AI applications. Having access to more connected users and more data looks to be the defining advantage in the AI space, and that strength is likely to carry over to the autonomous vehicle space. China's government certainly seems to think so.

China named Baidu's Apollo operating system for ADS software and cloud services the country's national platform for driverless vehicles and is investing in infrastructure like road sensors that should speed the development of the tech. With autonomous vehicles expected to generate massive troves of data, the company's strong position in the Chinese driverless operating-system market suggests it will dominate another highly influential data source and expand its edge in artificial intelligence.

Other ways to invest in driverless cars

Even forÂ more conservative investors, it's not hard to find companies that have the potential to benefit from the driverless revolution. There's plenty of potential to make pick-and-shovel-type investments in companies that will provide the supporting hardware, software, and networks that driverless cars will need to function efficiently. These vehicles will need up-to-date mapping technology, advanced imaging sensors, global positioning system (GPS) hardware and software, and internet connectivity,

among other things.

Providers like **AT&T** and **Verizon** view the rise of connected and self-driving cars as a potential growth source and are ramping up their respective vehicle-connectivity businesses. Companies specializing in networking and security like **Cisco** stand to benefit as well. Driverless vehicles will also be a huge source of data, producing massive amounts of data every day they're in operation.

Why self-driving cars' limits won't hinder their success

While it's still too early in the market's development to predict exactly what the future holds for self-driving cars, the rapid advancement and promise of the technology suggest that it will continue to gain ground and move toward mainstream adoption. The sector must still overcome plenty of limitations before the tech can function as ideally envisioned, and concerns about the safety of autonomous vehicles and the broader societal impact stemming from potential changes like a rapid evaporation of driving-based jobs should be taken seriously.

Still, if the tech continues to improve on its current trajectory, there's a good chance that self-driving vehicles will eventually see large-scale adoption and pave the way for a reduction in accident-related deaths, injuries, and expenses. Advances in computational power, network connectivity and speeds, and an explosion of new data combined with plenty of incentives to further automation and the driverless technology revolution suggest it's only a matter of time before robotic drivers are on the streets in large numbers.

CATEGORY

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