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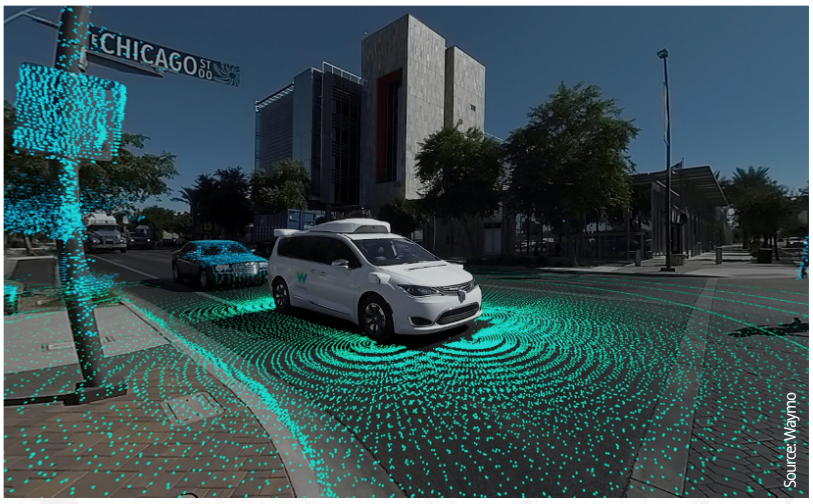
SELF-DRIVING CARS, CLOSER TO REALITY

By Lisa Chai, Senior Research Analyst, ROBO Global



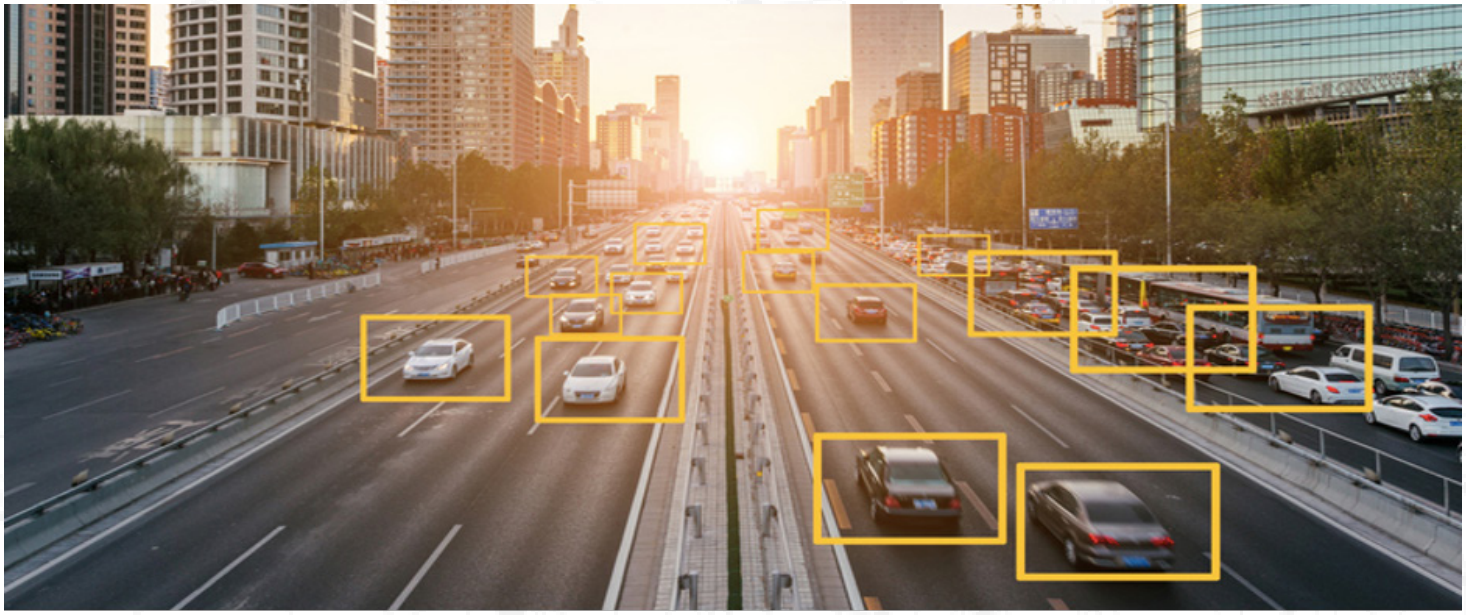
In parts of Arizona, "fully" autonomous ride hailing services from Waymo One are now available to the general public. This has come after months of testing by Waymo, the autonomous driving technology company owned by Alphabet, Google's parent company. Until recently, Waymo One's fully autonomous service was only available to a select group of participants who signed a NDA to take part in a trial study in Phoenix. The newly available ride hailing cars are particularly notable because there are no supervised safety operators in the front seat of the vehicles. They are fully autonomous, marking a huge milestone for Waymo, and for the entire autonomous vehicle industry.

The release of Waymo One is just the first step in what is poised to be the most important wave of disruption since the assembly line was introduced to mass produce Ford Motor's Model T in the early 1900s. The industry has introduced many innovative technologies recently, including powertrain electrification, advanced driver-assistance systems (ADAS), smart GPS, smart key ignitions, and rearview cameras, among many others. The decade ahead, however, will bring innovations that will do more than enhance the automobiles we know today. Thanks to the powerful combination of artificial intelligence (AI), the Internet of Things (IoT), and 5G, this next wave of change is expected to revolutionize and reshape the industry as we know it.

While **fully autonomous driving** may still be many years away (at least for those of us who don't reside in Arizona), major players in the auto industry are already using the power of autonomous technology to reinvent how we use and interact with cars. Consumer demand for greater mobility, smarter vehicles, seamless connectivity, and a more convenient driving experience has steadily increased, spurring an investment of more than $25B[1] in autonomous technology solutions in the past three years alone. The stage has been set for massive industry transformation—whether we like it or not.

According to Allied Market Research, the global autonomous vehicle (AV) market is projected to rise from $54B in 2019 to $557B by 2026, a CAGR of nearly 40%. To help investors capture this growth, the **ROBO Global Artificial Intelligence Index (THNQ)** includes several leaders in the mobility industry, both new players and incumbents, that are delivering the innovations to enable autonomous vehicles. It is these innovators, using the power of AI, that are enabling a digital transformation that will alter many aspects of our lives—including how we drive. Though we are still in the very early innings, the market opportunity is enormous. Following is a snapshot of the industry today.

[1] Pitchbook and Crunchbase



- **Massive advancements in technology and connected devices** have driven automakers and technology companies to compete in the race to develop autonomous vehicles and mobility platforms.

- **Automakers are aggressively building strategies using autonomous software and hardware** to accelerate investments and stay ahead in the industry. Using AI-enabled deep learning algorithms to train the computing platforms is necessary for fully autonomous solutions.

- **Industrial fleets are already using a variety of AVs**, including driverless forklifts, agricultural drones, and farm tractors, all of which rely on machine learning technologies and next-generation sensors developed by companies like Google, Nvidia, Xilinx, Infineon, and Appen—all members of the **THNQ** Index.

- **The entire auto industry is seeing a massive transformation and reformation** due to major partnerships and collaborations with technology companies that are a direct result of the AI and automation revolution.

- **Billions of dollars have been spent on autonomous vehicle research, M&A, and funding**, but not every venture has been fruitful, and many challenges remain.

- **The US and Europe are currently leading the AV revolution**, but China, Japan, and Singapore are catching up in the development of safety regulations and autonomous vehicle (AV) adoption.

- **Regulations are coming**. Technology companies and key automakers are working closely with government bodies to share data and safety protocols. Some technology developers are self-regulating in anticipation of stricter policies.

- **Self-driving technology is finally emerging from the research and development stage**, and use cases and the speed of innovation—especially for software platforms powered by AI engines—are growing rapidly, pushing us closer and closer to Level 5 Autonomy using safe, reliable machines. *(Read more on Level 5 Autonomy below.)*

When will we see fully autonomous vehicles hit the road for the rest of the world? The following look at how the technologies work, the key players, possible adoption hurdles, and the latest emerging technologies may hold the answer.

2020: OUR SEMI-AUTONOMOUS WORLD

Today, there are no legally operating, fully autonomous cars or delivery trucks available for purchase in the world. (Even Waymo's vehicles are company-owned and not available for sale to the public.) While the hardware technologies required to enable fully autonomous vehicles are already available, the software components required to enable safe, reliable self-driving technology are evolving rapidly but are still in development. What has been delivered are semi-autonomous vehicles that feature varying levels of automation, such as lane drift correction, autonomous parallel parking, adaptive cruise control, and autonomous emergency braking. Progress is being made, but the leap from where we are today to full autonomy will require more than technology alone.

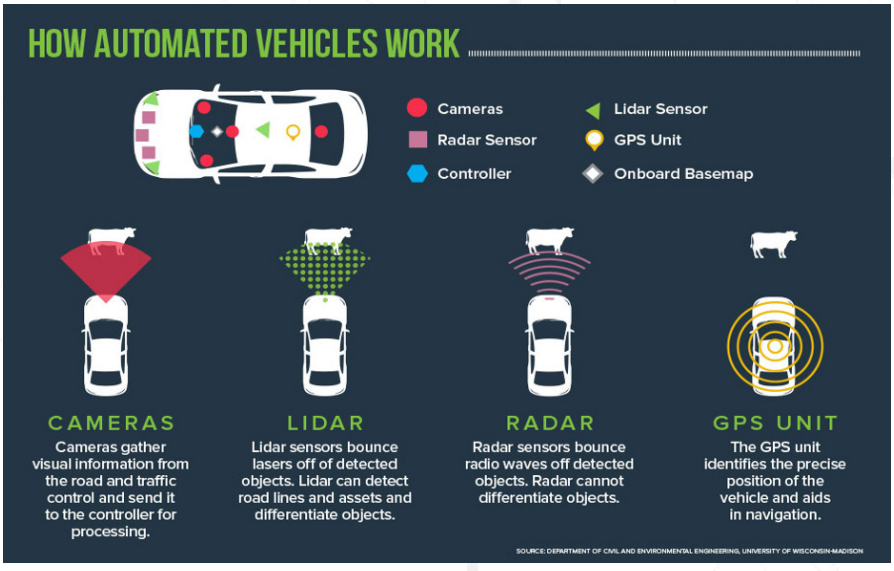
According to **ROBO Global Strategic Advisor, Wyatt Newman, PhD**, a professor in the Electrical, Computer and Systems Engineering Department at Case Western Reserve University, in order for self-driving technology to work fully autonomously and help alleviate consumers' fears for safety, it is essential to gather huge training data sets that include 'bad' and 'good' use examples. Newman stresses that simulations are increasingly important in the training of the data sets, especially the 'bad' scenarios, such as automobile crashes, that can become part of the training set. To understand the role of this training data in creating a truly safe experience for passengers of autonomous vehicles, it is helpful to break down the meaning of 'self-driving' and how it works in the real world.

HOW DO SELF-DRIVING CARS WORK?

Fully automated. Self-driving. Driverless. Regardless of the name used to describe autonomous vehicles, the technology they require combines sophisticated sensors and software to control, navigate, and drive a vehicle without human intervention.

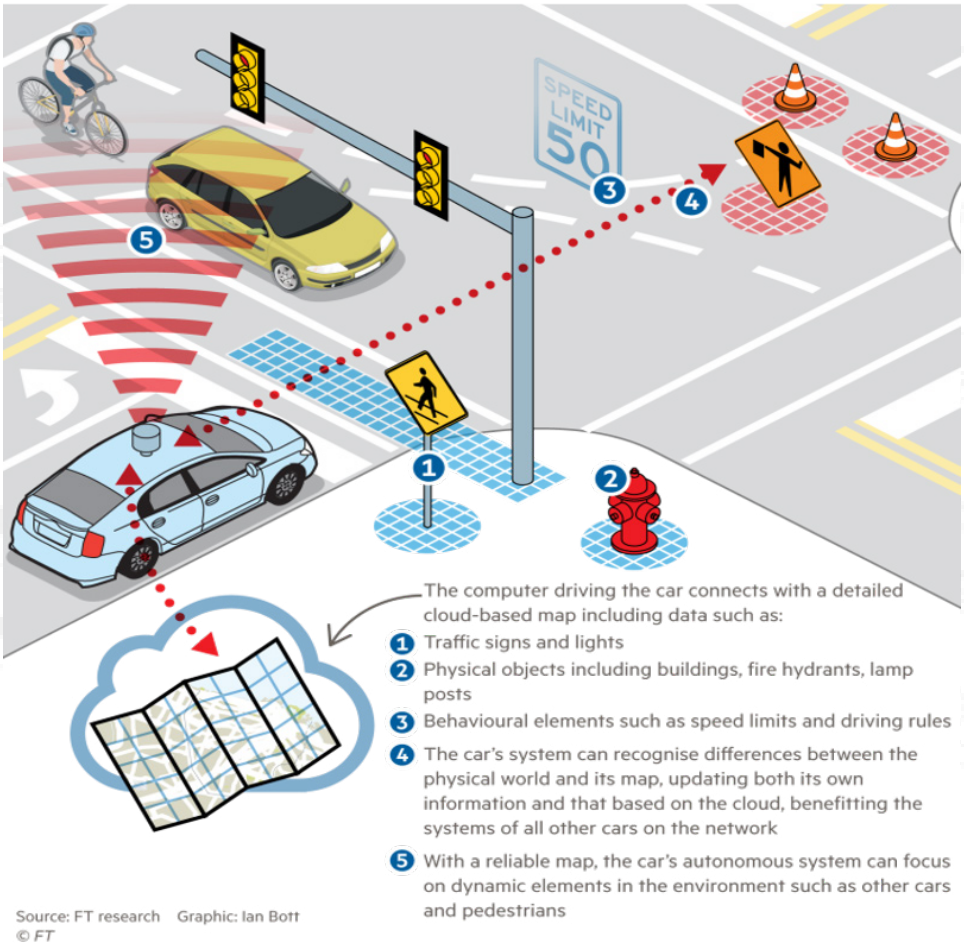
Google, Uber, Baidu, Tesla, Audi, Volvo, and other major automakers, researchers, and technology companies have developed a variety of approaches and technologies to address the challenge, but while design details and hardware components may vary, most self-driving systems operate using the same basic structure. In every case to date, AI-enabled software is used to create and maintain an internal map of the vehicle's surroundings. The data that fuels this map is based on information from a wide array of sensors, each with specific strengths and weaknesses:

- **Cameras** gather visual information from the road and traffic control, but offer imagery alone.
- **LiDAR sensors** bounce lasers off of detected objects and differentiate objects, but are limited in their ability to detect and read road signs—especially at a long distance.
- **Radar sensors** bounce radio waves off detected objects, but cannot differentiate objects.
- **GPS units** identify the exact position of the vehicle and navigate from point to point, but cannot sense objects along the path.



Depending on the specific approach, these technologies are used in a variety of different ways. For example, Uber's self-driving prototypes consist of sixty-four laser beams, along with other sensors, to construct an internal map. In contrast, Waymo uses lasers, radar, high-powered cameras, and sonar. In every case, once the sensors gather the data, machine learning algorithms are used to process the resulting inputs, plot a path, and then send instructions to the vehicle's 'actuators' that control acceleration, braking, and steering. Hard-coded rules, obstacle avoidance algorithms, predictive modeling, and 'smart' object categorization and discrimination (i.e., knowing the difference between a bicycle and a motorcycle) help the autonomous driving software follow traffic rules and navigate obstacles.

How autonomous cars understand the world around them



Source: FT research Graphic: Ian Bott
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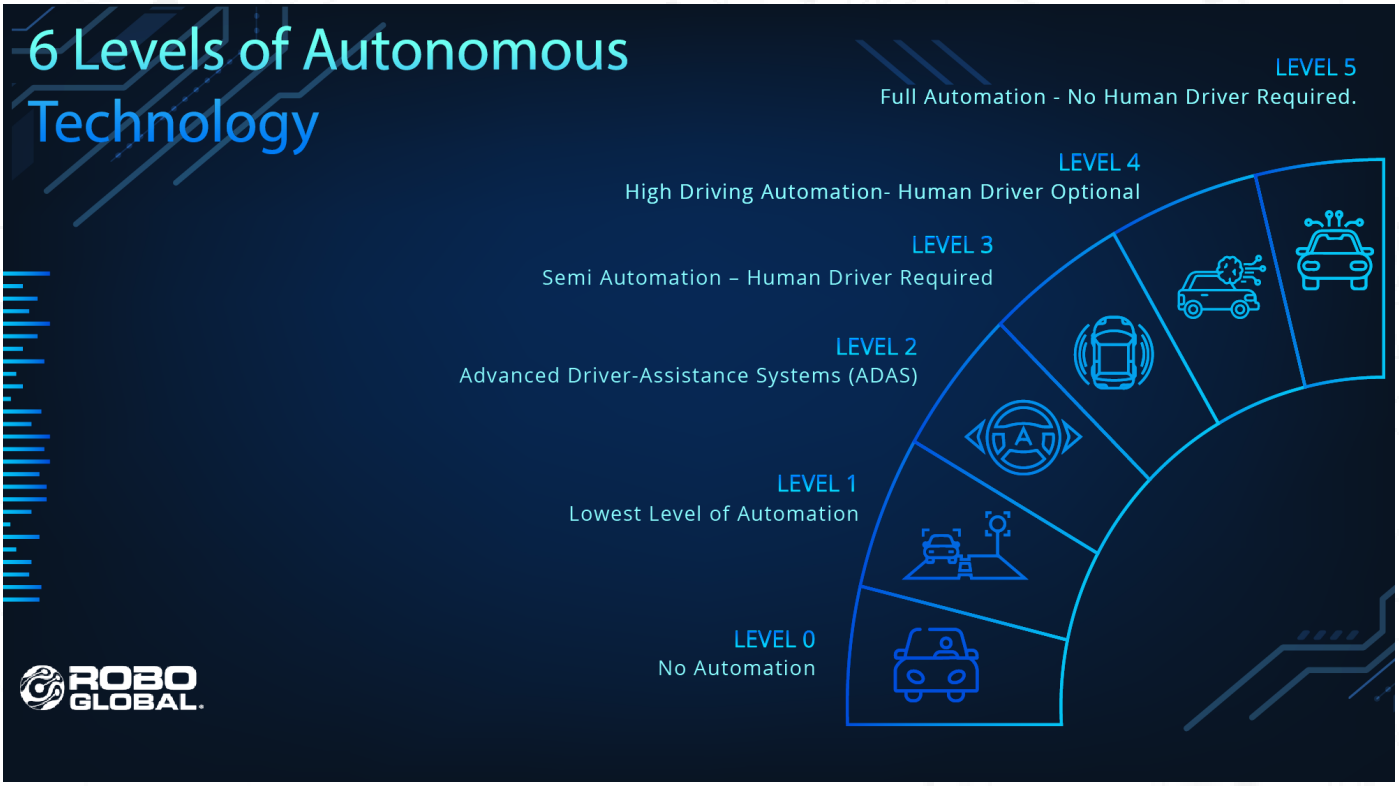
Because these technologies are not yet 100% effective, most autonomous vehicles today require a human driver to intervene. The fully autonomous vehicles of the future, which may not even offer a steering wheel, will require new capabilities that increase effectiveness and safety. New networking technologies such as 5G are expected to accelerate this evolution by connecting self-driving cars to next-generation traffic lights and communicating with other vehicles. Prototypes at large automakers already feature some of these capabilities. Also key is the neural network of the car that acts as the vehicle's 'brain' and is responsible for critical decision-making. The neural network is used to combine data from all available sources—cameras, LiDAR, radar, GPS, and more—to work together.[2] Various sources indicate that tens of millions of miles logged in various driving conditions and in simulations are needed to train the deep neural network algorithm to achieve +99% accuracy, which is comparable to that of a human driver.

[2] Hannah Fry, *Hello World: Being Human in the Age of Algorithms*

LEVELS OF AUTONOMOUS TECHNOLOGY

According to the Society of Automotive Engineers (SAE), a car's level of autonomy is measured on a scale of 0-5:



Level 5 Autonomy is the goal of most automakers, but the highest levels achieved to date, at least commercially, are Level 3. Conventional autopilot technology falls under Level 2, with the ability to detect some objects and do basic classification to help the driver with hazardous conditions. Newer level 3 platforms, including Tesla's Autopilot, Audi's A8L, Polestar's Pilot Assist, and Nissan's Pro Pilot, take driver assistance to the next level by offering partial 'hands off' and 'eyes off' capabilities. Only Waymo One currently offers Level 4 and 5 autonomy today.

"These technologies have taken us to a point in time where we can realistically discuss the future of full autonomy on the roads. The next milestone, driving autonomously for long stretches of highway, is almost within reach. While Level 4 autonomy has many commercial applications, there is plenty of work to be done. True Level 5 autonomy is still many years away."

— Prof. Daniela Rus, PhD

Director of MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL)

ROBO Global Strategic Advisor

WHEN WILL LEVEL 5 CARS BE AVAILABLE?

We at **ROBO Global** expect that true Level 5 autonomy may be as much as +10 years away, but we expect to see strong use cases and industry impact over the next 3-5 years. Waymo One's historical launch should demonstrate not only that the technology works, but also that it can be used safely in some environments—and that there is consumer demand for fully autonomous vehicles.

While there has been tremendous progress on the hardware and software side of autonomous technology systems, the cost of the critical technological components such as cameras and LiDARS must drop significantly for fully autonomous cars to be broadly available. This shift is already starting to happen. According to Waymo, the price of LiDAR has declined 90% over the past 5 years. Today, Waymo is developing its own LiDARs, while other self-driving players such as Cruise, Aurora, and Argo have acquired LiDAR developers for in-house production. Currently, the cheapest producer in the market, privately-held Luminar, is selling LiDAR for $500 per device, while the top of the line LiDAR by Velodyne can cost as much as $75,000 per unit.

Another big challenge is to get enough real-world driving experience to obtain the necessary data to train AI systems. According to Professor Wyatt Newman, barriers like this are making it likely that achieving full autonomy will come in increments of driver assistance. Newman believes autonomy technology will become more reliable over time, creating "an evolution vs. flipping a switch to full autonomy." For example, according to a study by BCG, by 2035, one quarter of the new car market may include cars with Level 5 features. But that doesn't mean autonomous vehicles won't be on the road well before then. Based on our own research with auto manufacturers and technology companies, the commercial launch of Level 4 self-driving freight trucks is anticipated as early as the next 12 months. The reason: the combination of a compelling use case based on a massive reduction in transportation costs, and the fact that the highway driving required by freight trucks is far less complex than driving in urban settings.

"Machine vision is key to achieving the vision of truly autonomous vehicles. Success hinges on our ability to train machine learning algorithms to effectively mimic the deep neural networks of the human brain."

— Prof. Wyatt Newman, PhD

Electrical, Computer and Systems Engineering Department

Case Western Reserve University

ROBO Global Strategic Advisor

WHICH COMPANIES ARE LEADING THE WAY?

As with any emerging technology, the evolution of autonomous vehicles has created a dynamic field of players. While the following companies are the current leaders, we expect the dominant names to shift over time. Our **ROBO Global Index Methodology** is designed to capture these changes as they occur.

Waymo (GOOGL-THNQ member): The undisputed leader and the most established pure-play player in the space, Waymo has been working on driverless technology since 2009 and has conducted 25M+ miles to date according to our research. The company has already spent billions on research and is the only company generating revenue from autonomous ride hailing and cargo transportation services. Waymo's strategy is to focus on building out its self-driving software, not to be a manufacturer of cars. Toward that goal, it has partnered with automakers, including Chrysler, Nissan, and Volvo, to develop autonomous cars and trucks for commercial use. Waymo's cars use massive amounts of sensors, on-board AI computing power, and Google's extensive mapping data to 'see' the world around them and choose an optimal route from point-to-point.

Cruise (GM): A start up by GM, Cruise has a line of electric shuttle buses called Origin that was built for the ridesharing market. Its new design, which has no steering wheel or pedals, was co-developed with Honda Motors in an effort to catch up with market rivals. Via a partnership with Lyft, GM now has the most aggressive test plans among legacy automakers. In 2019, Cruise was valued as high as $19 billion. In March 2020, GM announced plans to invest more than $20B through 2025 on its next-gen electric and automated cars. In October 2020, Cruise announced that the company will begin testing autonomous vehicles without safety drivers in San Francisco by the end of the year.

Tesla (TSLA-THNQ member): One of the most aggressive players in the market, Tesla's current models feature a semi-autonomous and incredibly powerful computing platform. The company's CEO, Elon Musk, has spoken about introducing a Level 5 car, but it remains to be seen what that will actually entail. While Tesla's current models are wildly popular, their lack of LiDAR technology for 'driver assistance' may not be sufficient to qualify as 'semi-autonomous' for some. Because the cars are incapable of seeing immobile obstacles (due in part to the limitations of current sensor technology), a human driver is still needed to monitor the road at all times.

Appen (APPN-THNQ member): A pioneer in the space with over 25 years of AI training data experience, Appen will help accelerate self-driving capabilities for the industry. Its cutting edge tools and software platform use machine learning algorithms to assist LiDAR, video, speech, and NLP. Headquartered in Australia, Appen currently works with seven of the top 10 auto companies.

Microsoft (MSFT-THNQ member): The company provides various cloud solutions for Ford, Nissan, and BMW. It aims to play a bigger role in collaborating with automakers by providing cloud-based AV technologies using Azure and Windows O/S to assist in powering machine learning algorithms.

BMW (BMWYY): With plans to launch Level 5 AVs by the end of 2021, BMW has deep financial resources and has invested heavily in autonomous motorcycles. The company operates several R&D centers throughout the world and has been very aggressive in its pursuit of JVs with Chinese partners.

Source: Nvidia

Baidu (BIDU-THNQ member): The first to complete a commercial launch in China, Baidu announced in October that its AI-powered Apollo cars will offer ride hailing services in Beijing. These Level 4 vehicles are capable of handling massive amounts of data and use 5 cameras and 12 ultrasonic radars to map the road. Baidu is currently rolling out mini shuttle buses, as well as driverless valet parking solutions. The company is also working on a smart traffic signal solution that can reduce average wait times by 20-30% during rush hours.

Source: Baidu

Ford (F): Ford has pledged $4B to AV development this year. In addition to its aggressive investment in ArgoAI, it has partnered with Walmart to develop driverless delivery trucks. The company's recent acquisition of Quantum Signal adds unmanned remote systems for simulation purposes to the toolbox.

Fully autonomous vehicles require extremely reliable, high performance, power-efficient, adaptive computing solutions. Leading chip providers include **Xilinx (XLNX-THNQ member)**, **Nvidia (NVDA-THNQ member)**, and **Infineon (IFX-THNQ member)**. All of the leading automakers have mapped out their architecture with accelerators, controllers, and GPU/CPU processors for data processing with leading-edge solutions from these top chip makers. These index members play a very significant role in enabling autonomous/ADAS platforms, sensors, and electrification.

Other promising providers include:

- **ArgoAI (Private):** Currently valued at $7.5B, Ford invested billions on ArgoAI's AV technology in 2017 in exchange for large ownership of the company. In recent months, Ford has sold its partial stake to VW for $3.5B, the only profitable division for the company in second quarter.

- **Aurora (Private):** This startup focuses on AV hardware and software. Its first commercial service will be in trucking—a market that is more viable today due to better unit economics and fewer technology hurdles on highways. Including investments from Amazon, the company has raised $700M in funding since inception.

- **TuSimple (Private):** This company recently raised $300M in funding, putting its latest valuation at +$1B. Backed by key investors and partners like UPS, it has R&D centers in China and the US.

- **Luminar (Private):** Based in California, Luminar has developed a LiDAR that is small enough to fit on a car's bumper. The company has already

raised over $500M to boost manufacturing capacity and is currently working on several pilots with large automakers. Results look promising, and the company has announced plans to go public in a SPAC deal.

- **Navya and May Mobility (Private)**: These two newcomers are developing and testing Level 4 autonomous driving software systems for ridesharing shuttle services.

- **Pony.ai (Private):** After raising $726M, the company is working to build a full-stack autonomous driving solution.

WHAT ARE THE CHALLENGES IN AV TECHNOLOGY?

While we are seeing evidence of tremendous progress over the past few years, the industry still faces many complexities and challenges before mainstream adoption of AVs is possible. The supporting technologies must go through the development, pilot, and commercialization stages before they can be applied commercially, and many of them are still in the development to piloting stages. According to our ROBO Global Strategic Advisors, the complexity of the required software and hardware increases exponentially the closer the system is to becoming fully autonomous.

In order to move beyond today's semi-autonomous solutions to achieve Level 4 or Level 5 autonomy, the industry faces a number of significant hurdles, including the need for more advanced technology, higher-quality AI datasets to feed the neural networks to train the vehicles, a lack of regulatory framework, and the ability to offer AVs at a commercially viable price point.

- **The technology challenge**
  For AVs to run safely and reliably, they require software that operates seamlessly using hardware that offers the computational power needed to run the sensors to enable reliable perception and object analysis. At a high level, AVs must be able recognize pedestrians and other objects in various scenarios in order to operate safely. Human drivers make intuitive, experienced decisions based on a wide variety of information, such as interpreting signals from other human drivers while making a turn, or deciding to let a driver pass. To accomplish these same tasks, an AV's neural network requires 'experience' via AI data gathered from thousands and thousands of trials (and errors) and simulations.

  Also, according to joint research by MIT's Computer Science and Artificial Intelligence Lab (CSAIL) and Delft University of Technology's Cognitive Robotics Department, in order to achieve Level 5 driving, autonomous systems must behave as human-like as possible.[3] This requires AI to fully understand human behavior, as well as be able to predict the next level of action in each scenario without human intervention. The study reinforces the fact that autonomous systems are designed to learn these functions through deep learning algorithms (reinforcement learning), and that these algorithms require extensive training in order to be effective. The study concludes that by incorporating key social aspects of human-like behavior, the industry can potentially improve autonomous performance and reduce errors in human trajectory predictions by 25%. But according to Professor Daniela Rus, a key contributor to the study, there is significant work to be done before autonomous systems can be trained to understand the intent of human drivers and adapt to driving styles.

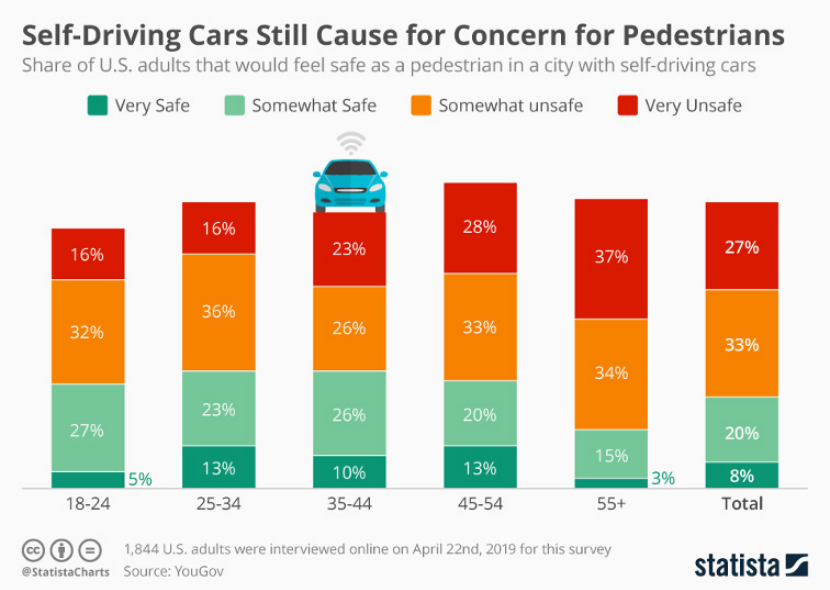
[3] "Social behavior for autonomous vehicles," Proceedings of the National Academy of Sciences (PNAS), October 2019

- **The regulatory challenge**

Statistically, autonomous vehicles are safer than other vehicles—but they are not perfect. Unfortunately, there have been numerous accidents involving AVs, some of which have resulted in injuries and fatalities, and all of which have attracted the attention of the media. This has complicated the regulatory landscape. And yet, for wide adoption to occur, regulations are mandatory.

The first step in tackling the regulatory challenge is to ensure AVs are safer and more reliable. This will require AVs to log millions of driving miles. AI software will also need to be effectively trained using the many different types of scenarios and simulations that drivers face every day—from driving in difficult weather conditions to making unexpected stops to avoid crashing into foreign objects. To support the communication requirements of AVs, 5G components on our roads will also need to be tested extensively, and infrastructure upgrades may require rapid changes to regulations.

The second step is to work with government agencies and other parties to establish safety standards and regulations that not only ensure the safety of the general public, but also give the public confidence in this safety. According to Statista, about 50% of people younger than 45 feel self-driving cars are unsafe, and older people are even less confident in this technology:



Automakers and ridesharing providers have been working to address this challenge. And yet despite the current trials and commercialization of autonomous cars throughout Europe and US, there are currently very few established guidelines or regulatory frameworks to operate AVs on public roads. It's clear that gaining regulatory clearance will require AVs to be as safe as—or even safer than—cars driven by humans.

In 2016, the National Highway Traffic Safety Administration (NHTSA) worked closely with AV developers like Waymo to release its first version of regulations on the manufacturing and sale of AVs. The process has continued, and Waymo is now sharing all of its data on road accidents, cyberhacking of AV software, and more to the National Highway Traffic Safety Administration. Cruise has also made progress, recently receiving a permit from the California Department of Motor Vehicles to begin piloting its fully autonomous vehicles on the streets of San

Francisco. Germany and the UK have also developed some initial guidelines for the development of AVs and are working to improve their laws. The process has been slow, but we are seeing a turn by US regulators, and there has been significant improvement around permits and guidelines on the public roads.

Asia seems to making faster headway. Our research indicates that Asia is one of the fastest growing areas for driverless cars, and governments in Singapore and other developed nations are supporting initiatives by providing logistical, financial, and operations support for AVs. These governments are creating new rules based on AV trials, car design, and data sharing. The Chinese government is in the process of setting regulations on AVs, but has not yet authorized any automakers to pilot AVs on the highways. China hopes to be the leading user of AVs by 2025, so we anticipate it will move quickly. Meanwhile, the Japanese government is working on setting regulatory standards for AVs, as well as working with its National Police Agency to consider who will be liable for accidents that occur with driverless cars.

- **Affordability**

  Price may ultimately be the easiest hurdle to overcome. The cost of all the advanced hardware and software components required by AVs is shrinking with every cycle of development. The massive amount of venture funding flowing into the AV industry has helped startups to innovate and achieve important technological breakthroughs. Amazon's acquisition of AV technology provider Zoox in June 2020 for $1.3B is notable, and the fact that VCs spent over $12B[4] in venture funding on mobility start-ups driven by investments in self-driving technology speaks for itself. Despite the global pandemic, the development of AVs has continued to advance and progress has continued. With that progress will come better, safer technology—and a lower price point for consumers.

WILL AVS REALLY BECOME SAFER THAN HUMAN DRIVERS?

According to studies from the Virginia Tech Transportation Institute (which was commissioned by Google) and McKinsey & Company, self-driving cars are generally safer than cars driven by humans. This is partly due to the fact that self-driving cars adhere to rules of the road better than humans do. The head of Google's driverless car program predicts that, over time, AI will make it possible for AVs to see other drivers, pedestrians, and cyclists, to predict where they are, and anticipate where they are going better than humans can. AI will both watch for turn signals, and simultaneously use AI to communicate with other cars to determine which car will turn when. AI will also be better at determining the right amount of space between each car to predictably avoid collisions (something we humans can't seem to get right!). Self-driving cars also are programmed to prioritize safety over speed, eliminating the human emotion and impulsiveness, and reducing distractions such as texting that can lead to accidents.

According to a report by McKinsey[5], the penetration of AVs and advanced driver assistance systems could cause vehicle crashes in the US to decline in terms of their lethality ranking among accident types. McKinsey believes that vehicle crashes could drop by 90%, saving billions of dollars once AVs become the primary means of transport by the midcentury. The report also highlights that around 50 minutes could be saved each day for drivers and commuters through the efficiency of AV transportation.

[4] Pitchbook's Mobility Tech 1Q 2020 report and The Robot Report

[5] "Ten ways autonomous driving could redefine the automotive world," McKinsey & Company, June 1, 2015

WHO WILL WIN THE RACE IN THE AUTONOMOUS RIDESHARING MARKET?

Much like Netflix has disrupted the media industry and Airbnb has disrupted the travel industry, ridesharing has turned the auto industry upside down. According to McKinsey[6], if you live in an urban environment, ridesharing can be up to 50% cheaper than owning your own car. Longer term, there is a growing trend among younger generations, across cultures and regions, for more connected cars that run on electric power and improve mobility. They also express a growing lack of desire to own a car. Autonomous ridesharing—which is basically a mobile car hailing service that uses driverless technology—is expected to add to this disruption.

The market opportunity is very large. The ride hailing market is already a $60B market and poised to grow to a $218B market by 2025, at a CAGR of 20%[7]. The addition of AVs to this equation could accelerate that growth dramatically, and these automakers and technology providers are already working to make autonomous ridesharing a reality:

Waymo One (GOOGL-THNQ member). It is hard to imagine a company that can catch up to Waymo at this point. With over 25 million miles driven on public roads and 600 vehicles dedicated to autonomous ride hailing, its vehicles have the most real-world experience of any ridesharing service today, and the service in Phoenix now has over 2,000 monthly active users.

Uber (UBER): With $1B in investments from Toyota, Denso, and Softbank, Uber is finally in a position to move beyond the development stages for its self-driving taxis.

Lyft (LYFT): in 2017, Lyft announced the launch of its Level 5 self-driving cars (despite experts labeling the functionality as Level 4). Together, Lyft and Aptiv have had 100,000 paid self-driving car rides. The two companies are now analyzing the data gathered during those trips to take AV technologies to the next level.

Zoox/Amazon (AMZN-THNQ member): Amazon acquired AV company Zoox in June 2020 for $1.3B, a move that surprised many industry insiders. Zoox has been testing its AI software, but its vision is to be a leader in providing autonomous ride hailing. This acquisition, combined with the company's 100M+ Prime members, makes Amazon's entrance into the space the biggest threat to Uber and Lyft to date. Amazon has also invested in Aurora and Rivian, an electric truck startup, ordering 100k electric self-driving delivery vans by 2030.

[6] "Autonomous-driving disruption: Technology, use cases, and opportunities," McKinsey & Company, November 13, 2017
[7] Markets and Markets

WHAT'S THE OUTLOOK FOR SELF-DRIVING CARS?

There are many complexities that must be addressed before truly autonomous self-driving cars will be a reality for the public. New technologies must be developed, tested, and made commercially available. Regulations must be put into place to ensure human safety. And we humans must reach a point where we are at ease entrusting a computer to be behind the wheel of a vehicle holding our most precious cargo: ourselves.

In short, it is likely to take another decade—at least—before we will see Level 5 cars taking over our highways and byways. But with so many key players running an intense race to launch a viable self-driving car, autonomy will most certainly become a reality. There is no doubt that automakers will succeed in their quest to deliver a safe, reliable, and regulated self-driving car.

Over the next several years, we expect to see more strategic collaborations among automakers and AV technology providers; partnerships will be formed and a slew of M&A opportunities will arise. We also anticipate a rapid evolution of the auto industry, built largely on the active investments in AI software platforms by many of today's legacy automakers and technology companies. Their commitment to delivering on the promise of self-driving cars—and their desire to win the race to market leadership—will make the AV market a reality. **ROBO Global's Artificial Intelligence Index (THNQ)** is designed to fully capture this potential for growth, and to offer investors direct exposure to what will be the auto industry revolution of the century.