

# THE SELF-DRIVING CAR RACE: THE FIVE COMPANIES LEADING THE PACK

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The BI Intelligence Research Team



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# INTRODUCTION

Tech companies, mobility services, and legacy automakers are all racing to be the first to deploy self-driving cars at scale. The stakes are undeniably high — for automakers, the self-driving revolution, coupled with the advent of ride-hailing services like Uber and Lyft, threatens to reduce individual car ownership, a sizeable share of their core businesses. Meanwhile, tech companies are hungrily vying to get a piece of the self-driving car market, which Apple CEO Tim Cook [called](#) "the mother of all AI projects" earlier this year. These companies are all looking to deploy autonomous cars as part of a commercial ride-hailing service, which would operate similarly to how Uber and Lyft do now, allowing customers to request rides to a specified location through a mobile app.

**In this research note, BI Intelligence takes an in-depth look at the most expansive Level 4 self-driving car tests taking place in the US, and offers insights on the leaders in the autonomous car race.** Level 4 and 5 are the two highest classifications of autonomy, according to [SAE International](#), an international automotive standardization organization. Level 4 autonomy refers to cars that can drive themselves under certain scenarios, while Level 5 cars can drive themselves under any conditions, eliminating the need for steering wheels, pedals, or a human operator. Thus far, no company has tested a Level 5 self-driving car on public roads in the US, but most of the companies currently conducting tests of Level 4 autonomous cars are eventually planning on testing, and then deploying, Level 5 vehicles.

## Self-Driving Car Tests In The US

Company	Test Locations	Type of Vehicle	Miles Driven in California in 2016, Disengagement Rate	In-House LiDAR?	Passengers
Waymo	California, Michigan, Phoenix	Specially modified Chrysler minivans	635,867, every 5,127 miles	Yes	Approved members of early rider program, company employees
GM Cruise Automation	California, Michigan, Arizona	Bolt Hatchbacks	9,668, every 34 miles	Yes	Cruise employees in San Francisco
Ford	California, Pennsylvania, Michigan, Arizona	Fusion Sedans	590, every 196 miles	Yes	Company engineers
Lyft	California	N/A	N/A	No	Company engineers
Uber	California, Pittsburgh, Phoenix	Specially modified Volvo XC90 SUVs	+1 million*	Yes	Uber customers in Pittsburgh, Phoenix, company engineers in California

\*Figure represents the total number of test miles Uber's autonomous cars have driven. Uber did not have approval from California in 2016.  
Source: California DMV, Recode, News Reports, 2016

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# WAYMO

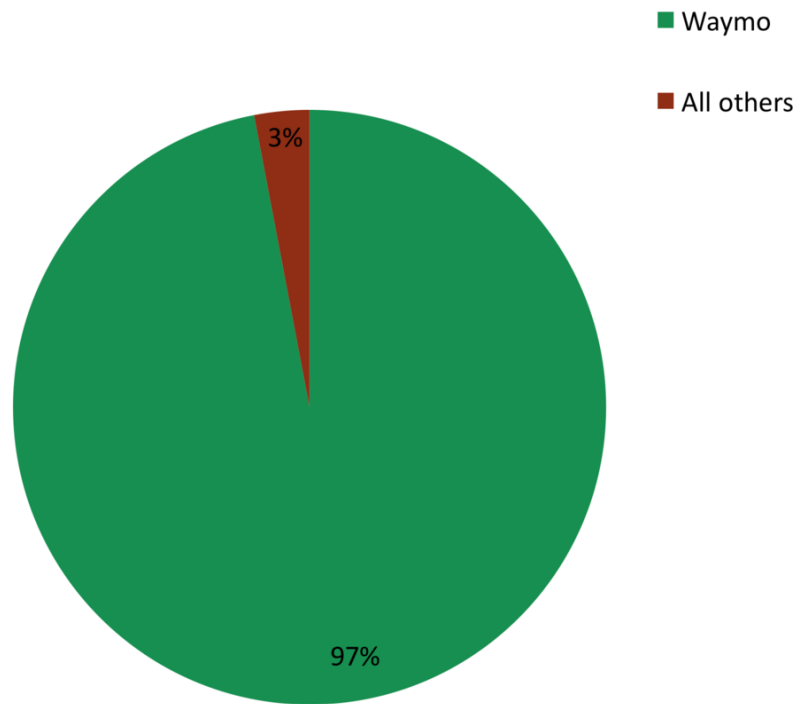
Waymo, the self-driving car spinoff of Google parent company Alphabet, is widely considered to be a frontrunner to bring self-driving cars to market as part of a commercial ride-hailing service.

- **The company began testing vehicles with self-driving features back in 2009, and has [logged](#) over 4 million miles on public roads in the US.** No competitor has come close to matching that number. Additionally, Waymo's vehicles drove 97% of all the miles driven by autonomous test cars in California in 2016. And it has been granted 2,118 patents for self-driving technologies, more than any company working in the space in the US. Waymo also recently became the first to test self-driving cars [without](#) a driver behind the wheel.
- **It's also scored several partnerships it can leverage once its vehicles are ready to be part of a commercial ride-hailing service.** The company has an [ongoing relationship](#) with Fiat-Chrysler, which involves the automaker supplying specially designed Pacifica minivans that Waymo outfits with its sensors, cameras, and software to give the vehicles Level 4 self-driving capabilities. In addition, Waymo [announced](#) an agreement with Lyft earlier this year, which will enable it to test and later deploy its specially outfitted Chrysler minivans in the ride-hailing firm's network. The company is also [relying](#) on Intel to provide computing systems for its cars.

**Waymo has multiple paths to monetize its self-driving technology project.** The company's [early rider program](#) in Arizona indicates it wants to operate its own ride-hailing service, though that would not preclude it from providing rides for Lyft as well. Meanwhile, it's already [committed](#) to the nascent autonomous semi-truck market and could possibly use its vehicles for last-mile deliveries. This will allow the company to explore multiple revenue opportunities as the market develops. Additionally, Lyft has some of the leading LiDAR sensor technology, has already opened its tests to the public, and will soon be testing in Michigan, California, and Arizona, the top three geographies in the US for self-driving car tests.



## Self-Driving Test Miles Driven In California 2016



Source: California Department of Motor Vehicles

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# GENERAL MOTORS

General Motors' (GM) self-driving efforts are housed in its Cruise Automation division, a former startup that the auto giant [purchased](#) in March 2016. Cruise is working on both software and hardware that it will outfit onto GM's vehicles to allow them to drive themselves. The Cruise division has been testing these technologies as part of a ride-hailing service for its employees in San Francisco. In October, GM [purchased](#) Strobe, a startup that manufactures LiDAR sensors, which help create a visual map of the world around a self-driving car. At the time, GM [said](#) Strobe held several patents for LiDAR sensor units that can be mass produced for a very low cost.

**In addition, GM plans to expand its other tests to new, more difficult geographies in the US in the coming months.**

- **Notably, GM [plans](#) to test its self-driving cars in lower Manhattan starting in early 2018**, when it will become the first company to test its cars on the busy, complex streets of New York City.
- **The company recently [revealed](#) that it plans to roll out a commercial self-driving mobility service for urban environments by 2019**. If this goal is reached, GM will likely be one of the first two or three companies to do so.

GM sees a large, near-term opportunity for an autonomous ride-hailing service in dense coastal cities, CEO Mary Barra [said](#) at the company's 2017 Investor Day. It's possible that means its move to New York could prelude a later commercial launch in the city, and that it might be targeting a similar launch in San Francisco.

# FORD

Ford is developing technologies that it plans to outfit onto its own cars to give them self-driving capabilities, and is exploring the idea of operating its own ride-hailing and delivery service with the vehicles. As of January 2018, Ford has conducted self-driving testing in Michigan, California, Arizona, and Pennsylvania. In addition, the company revealed in February 2018 that it would roll out new self-driving test vehicles in Miami-Dade County. Future self-driving Ford vehicles could include LiDAR sensors designed by Princeton Lightwave, a company acquired by Argo AI, in which Ford has an investment. Princeton Lightwave has been focused on the commercial mapping and defense industries, but Argo AI has expressed confidence that its offerings could help in the acceleration of the sensing systems required for SAE Level 4 autonomous driving by working with Argo AI's in-house hardware and software developer teams.

**The automaker notably has a growing set of mobility services that it could use to monetize its self-driving technologies.** Chariot, a shuttle-based mobility service that lets consumers book a seat via a mobile app, is growing in New York, San Francisco, Seattle, and Austin, and is set to arrive in Columbus, Ohio and London in the near future. In addition to potentially operating its own ride-hailing and parcel delivery services, Ford might seek to build its self-driving technologies into these shuttle buses. These plans could supplement the company's relationship with Lyft, discussed later in this note.

# UBER

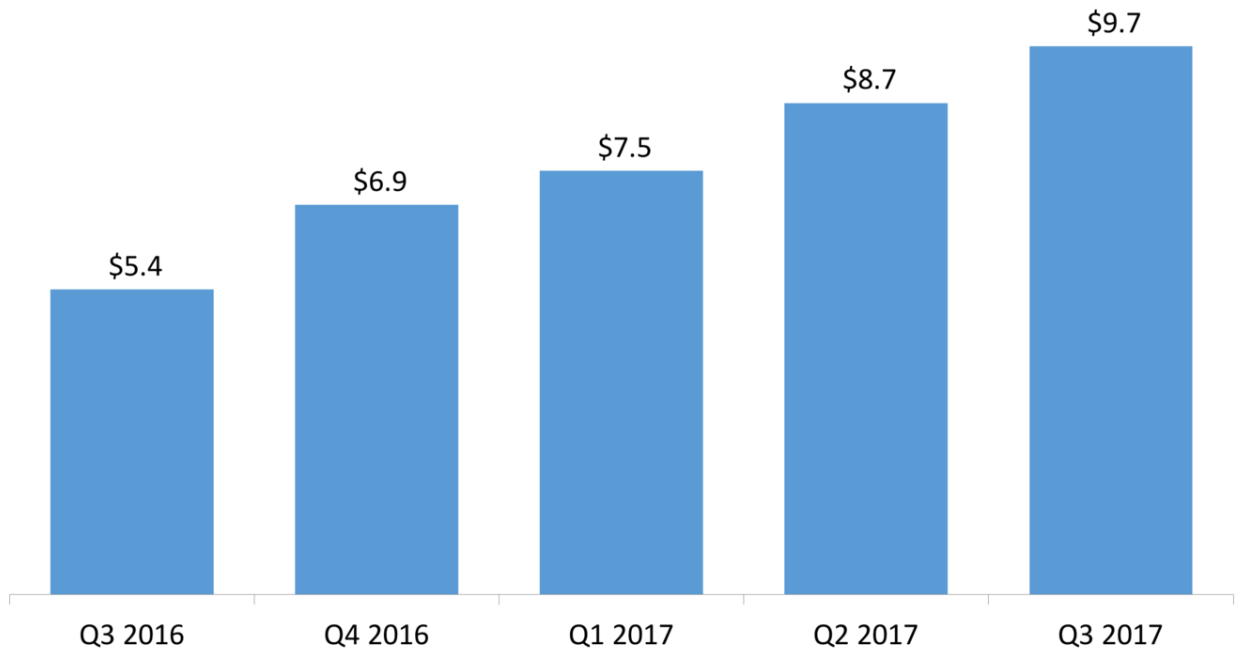
Uber is currently conducting some of the most high-profile tests of self-driving taxis on public roads. The company seems intent on designing self-driving technologies to outfit onto cars it purchases from automakers — an approach it took with the Ford sedans it's tested and the Volvo SUVs it is testing in multiple geographies. The company recently [signed](#) an additional agreement with Volvo to order about 24,000 of the same XC90 SUVs it's currently using, which it will outfit with its self-driving technologies starting around 2019 or 2020.

**Uber's self-driving car project is one of the most prominent in the market, but it's also been mired in controversy, and isn't leading the pack.** Notably, the company is being sued by Waymo, which [alleges](#) Uber conspired with a former Waymo engineer to steal its LiDAR designs and found an autonomous trucking startup, which was subsequently bought by the ride-hailing giant. The lawsuit has persisted for most of 2017 and may threaten the company's self-driving ambitions. Additionally, Uber [moved](#) its tests from California to Arizona in early 2017 after a dispute with the California DMV, which resulted in the DMV revoking Uber's self-driving car permit. The company eventually returned to California later in the year. Uber told BI Intelligence in an email that its test cars have driven over 1 million miles between its three test locations — California, Arizona, and Pittsburgh —making it one of the most experienced players in the self-driving car space outside of Waymo.



## Uber's Quarterly Gross Bookings

Billions (\$)



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Source: Crunchbase, Bloomberg

# LYFT

Lyft [operates](#) an open platform that allows any company working on self-driving technologies to pick up customers who request rides on its mobile app, a more collaborative approach than other players are taking. Announced in July, the platform allows Lyft to leverage the technological development and testing of its partners to potentially deploy autonomous cars in its fleet before Uber. To date, Lyft has attracted some of the biggest names in the self-driving space to the platform, and has significantly more partners than its competitors. In addition to the company's relationship with Waymo, Lyft is working with GM as part of the auto giant's \$500 million [investment](#) in the company in 2016. Meanwhile, nuTonomy, a self-driving startup recently acquired by Aptiv, is now [conducting trials](#) of its cars in Lyft's fleet in Boston, marking Lyft's first public self-driving car tests. The ride-hailing company has similar agreements with [Ford](#) and Jaguar Land Rover.

**The company also [carved out](#) a separate unit that's working on self-driving hardware and software.** The group of about 30 employees is based in a new research facility in Palo Alto, California. It's already been granted approval by the California DMV to test cars on the state's roads, paving the way for it to [test](#) the technology stack it's developing in vehicles with semi-autonomous features, in partnership with technology startup Drive.ai, next year. It's unclear how this group's efforts fit in with Lyft's open platform, but it could be a way to attract new partners or supplement the efforts of its existing partners.

# WHAT COMES NEXT

While most companies are still working on the underlying technologies for self-driving cars, a handful of firms are already looking ahead and laying the groundwork for commercial launches. Waymo, Uber, and Lyft have all opened up their self-driving tests to the public, for example, likely in an effort to reverse consumers' negative sentiments toward the cars — [54%](#) percent of US drivers would feel unsafe sharing the road with a self-driving car, while only 29% of US consumers would allow their child to ride alone in one, according to a BI Intelligence [survey](#).

**GM and Waymo have also moved LiDAR production in-house, in an effort to inexpensively produce the image-sensing technology at scale.** Notably, Waymo [showed off](#) its own LiDAR sensor kit that it produced in-house for only \$10,000, which is 90% less expensive than competing kits on the market. Additionally, Ford seems prepared to move further into LiDAR with its ties to Princeton Lightwave, but is also one of many self-driving car players partnered with [Velodyne](#), a prominent LiDAR startup targeting self-driving applications. Chinese search giant Baidu also relies on Velodyne's sensors, while Toyota has [partnered](#) with Luminar, another LiDAR startup. Uber manufactures and designs its LiDAR units in-house as well, but these efforts have been plagued by the company's ongoing lawsuit with Waymo. In a court filing earlier this year, the company [admitted](#) that the units were inferior to Waymo's, and that it was also purchasing sensors from Velodyne.

**Going forward, California, Michigan, and Arizona will be the first states to get self-driving taxi services, and serve as the launch point for the forthcoming war to operate an autonomous taxi service at scale.** That's largely because all three states have established themselves as hubs for pre-commercial tests of self-driving cars due to the favorable conditions they provide — Michigan is the home of Detroit, the historical center of the auto industry, while California's home to Silicon Valley, and Arizona's flat, straight roads and temperate weather make for an ideal proving ground. Once frontrunners like Waymo, GM, and possibly Lyft launch initial services in these confined locations, they'll begin to scale up the offerings around the country to create new business models and revenue streams. As this occurs, these firms will move into fierce competition with each other in major markets, such as the largest metropolitan areas in the US. Meanwhile, in addition to winning over consumers, these companies will have to navigate through a patchwork of state-level laws that are still murky and unclear, and manage their relationships with potentially up to a half dozen suppliers. The winners of this difficult war likely won't be decided for at least the next decade, leaving plenty of time for different players to battle their way to the top.

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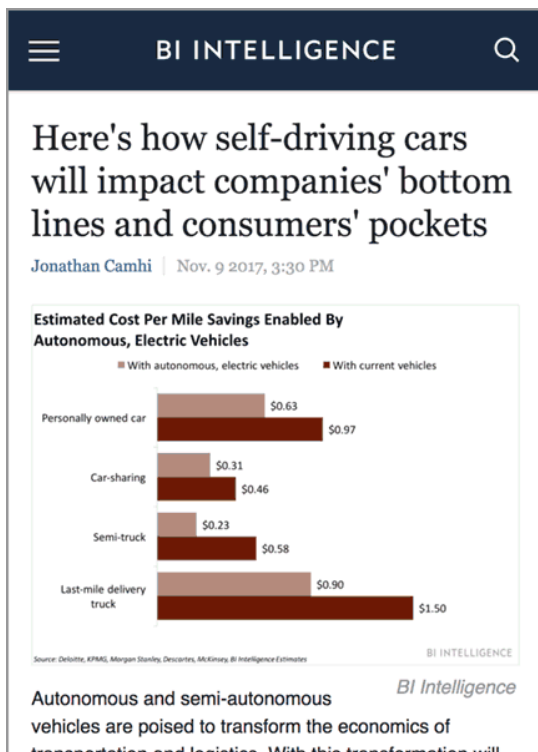
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