Appendix I: Autonomous Ride-Hailing Companies

Waymo[1]

Waymo, formerly known as the Google Self-Driving Car Project, is a subsidiary of Alphabet. Waymo has GPS maps which give their AVs a navigational advantage. Waymo AVs (commonly Jaguar models affixed with ADS kit) use lidar, radar, and cameras that all deliver information to a central computer. Waymo One, its ride-hailing service, operates in Phoenix and San Francisco. In Phoenix, Waymo vehicles are now available through the Uber app, marking the beginning of the two companies' strategic partnership.[2] Waymo Via is its autonomous trucking development project. A UBS report estimates Waymo could own up to 60% of the market share in AVs by 2030.[3]

Cruise[4]

Cruise is a subsidiary of GM. Cruise's modified Chevy Bolts utilize cameras, lidar, audio sensors (which can detect the high pitch of emergency vehicle sirens, for example), and radar. The company deploys ARH vehicles in San Francisco, where it will soon pass 2 million miles of driverless operation. Cruise is also developing the Origin shuttle vehicle. Importantly, Origin is designed specifically for autonomous driving, not for operation by a human driver.[5] The vehicle is reminiscent of a minibus. Honda, a partner, wants to deploy Origin in Japan. Also of note, Cruise has also developed custom chips for their vehicles rather than contracting with a chip designer like Nvidia.[6]

Zoox[7]

Zoox, an Amazon subsidiary, builds mini-shuttle vehicles. Unlike Waymo and Cruise, Zoox is not affixing an ADS to conventional vehicles, but is solely developing autonomous-only cars. Zoox describes this as designing for riders, not drivers. The company engineers all hardware and software in-house. The Zoox design has a sensor suite on all four corners of the shuttle rather than one central unit that is often found on AVs.[8] Zoox is operating tests in San Francisco, Las Vegas, and Seattle. It was the first company to be granted a permit by the California Public Utilities Commission to transport passengers, as part of the state's service pilot program in late 2018.[9]

Nuro[10]

Nuro focuses specifically on the AV delivery market and has done so using smaller vehicle designs that can only carry deliveries like food and packages, rather than passengers. They started the project by outfitting the Toyota Prius with self-driving technology but are now focused on their small custom vehicles. Their focus on smaller vehicles also allows for greater safety. Since the vehicles only carry deliveries, they are fully focused on the safety of people outside the vehicle rather than inside. Nuro also builds their own maps. Nuro already partners with Domino's,[11] Uber Eats,[12] Walmart,[13] Chipotle,[14] FedEx,[15] Kroger,[16] and others. Nuro operates in California, Texas, and Arizona.

AutoX[17]

AutoX, a Chinese company backed by Alibaba, operates AVs in China and San Jose, California. Its fleet in Shenzhen covers the China's largest driverless area.[18] AutoX operates across a range of vehicle platforms, fitting its system to the different vehicles. Honda is a partner.[19]

Pony.ai[20]

Pony.ai, a Chinese company founded by former Baidu engineers and backed by Japan's Toyota, operates fleets in both China and a number of small California cities including Irvine and Fremont. They use multiple platforms of cars, including Toyota, Hyundai, and Lincoln. Their sensor technology is designed to be applied across vehicle platforms including long-distance trucking. They use detailed local mapping to help determine exact vehicle location, as well as a custom sensor suite. In 2023, Pony.ai began offering driverless rides in Guangzhou.[21]

Uber

While Uber was at one time active in developing its own autonomous technology, it has now offloaded its intellectual property and instead is partnering with AV companies like Waymo and Aurora to incorporate autonomous options into its suite of offerings. It also partners with both Cartken[22]—a company that makes a sidewalk-scaled robot—for food delivery services, as well as with Nuro. Uber's exit from the development of its own autonomous driving systems followed a fatal 2018 collision in which an Uber testing vehicle in autonomous mode struck and killed a person walking across a road in suburban Phoenix.[23] From this tragic incident we can draw several lessons. One lesson is the importance of roadway design. As Uber's video shows, the person its vehicle struck was traversing a stretch of road without any crosswalk in sight. Providing frequent marked opportunities for people on foot to cross roads is essential to maintaining mobility for people who are not in automobiles. In the fatal 2018 incident, the Uber vehicle, even though it was traveling under the speed limit, was unable to adjust its course adequately once the person was detected. Had that person had better, more ready options for crossing the road, the tragedy may have been averted. A second, related lesson is that though we can mitigate risk neither autonomous vehicles nor improved roadway design will eliminate all collisions.

Tesla

According to the auto industry site Elektrek, Tesla began pushing its full self-driving (FSD) beta v11 software update in March 2023.[24] "FSD Beta," Elektrek explains, "enables Tesla vehicles to drive autonomously to a destination entered in the car's navigation system, but the driver needs to remain vigilant and ready to take control at all times. Since the responsibility rests with the driver and not Tesla's system, it is still considered a level-two driver-assist system, despite its name." This software update could reach as many as 400,000 Tesla drivers in North America. Shortly after release, the software was subjected to a voluntary recall by NHTSA.[25]

Ambiguity over the true abilities of Tesla's Autopilot and FSD modes creates significant risks on the roadways as human drivers are lulled into inattention by a mostly autonomous experience. A *Washington Post* analysis of NHTSA data in June 2023 found that Tesla's Autopilot has been a factor in more than 700 collisions since 2019, killing 17 people.[26]

Appendix II: Autonomous Ride-Hailing in U.S. Cities

San Francisco

With its favorable weather and integration with the Silicon Valley tech industry, San Francisco has seen extensive research and development in the autonomous vehicle sector. California law uses a three-tiered permit system that allows AV companies to test and operate their vehicles in

the state.[27] The permit options include testing with a driver, driverless testing, and deployment. Cruise, an autonomous vehicle company owned by General Motors, is based in San Francisco and now operates autonomous ride-hailing 24/7 in the city. Alphabet's Waymo and Amazon's Zoox are also in the San Francisco mix.

Phoenix

Phoenix is America's AV Second City. With similarly favorable, if warmer and drier, weather, Phoenix has been a leader in AV research and development in the United States. The Arizona government has released extensive legislation on autonomous vehicles to facilitate testing in the state by over a dozen companies.[28] In 2015, Arizona Governor Doug Ducey signed an executive order directing state agencies to support the testing and operation of autonomous vehicles.[29] Three years later, the state dropped the safety driver requirement and allowed for fully driverless testing.[30] Waymo is the most prominent company that has sited operations in Phoenix. Waymo operates a 24/7 autonomous ride service in the city in addition to a shuttle service from Sky Harbor Airport to downtown Phoenix.[31] Autonomous trucking research is also very active in the Phoenix region. TuSimple, a San Diego-based self-driving truck company, operates in Arizona and has completed autonomous drives out of distribution centers between Phoenix and Tucson.[32] Waymo's autonomous trucking program has also operated across Arizona throughout its testing efforts.[33]

New York

In 2021, New York City granted a special AV testing permit to Mobileye, an Israel-based company owned by Intel.[34] Shortly afterwards, the city adopted a new set of rules that created a defined permit process for AV testing.[35] After showcasing their vehicles to the city's DMV and paying a $5,000 annual fee, companies now have the opportunity to run tests on Manhattan streets. Mobileye tested vehicles in the city until October 2022.[36] Spokesperson Alexis Blais told Emerging Tech Brew that its initial round of tests in New York had been completed as planned, explaining, "We test our autonomous vehicles in cities worldwide, to ensure that our technology can be flexible enough to adapt to local conditions and reach an impactful scale. We frequently rotate our test vehicles into new cities, such as adding Miami and Detroit this year, and plan to keep doing so."[37] Waymo brought its technology to the Big Apple in late 2021 to start developing maps of the city, but it did not use any autonomous vehicle modes.[38] Due to the city's traffic patterns, combined with the risk of rainy or snowy conditions, New York sets a high bar for autonomous technology to function safely.[39] Even so, the city has been actively preparing for a transition to an autonomous driving future. The New York DOT ran a 5-year Connected Vehicle Pilot project that ended in 2021.[40] The program looked to advance vehicle communication with infrastructure, pedestrians, and other surrounding vehicles.

Los Angeles

Though Los Angeles has not seen as much autonomous vehicle testing activity as San Francisco, companies including Waymo[41] and Motional[42] have tested their vehicles in the LA-area. The city's sunbelt location offers favorable weather patterns for testing autonomous technology, but critics fear self-driving vehicles will worsen the city's notorious traffic problems.[43] Testing in Los Angeles follows the California DMV's three-tier permit system. For autonomous trucking, California's laws are far less salutary. The state's DMV is working on new regulations to start allowing self-driving trucks with a safety driver on board.[44] Though tech companies are fighting for a chance to test their trucking technology without a driver, the Teamsters are pushing back in an effort to safeguard truck driving jobs in the state.[45]

Chicago

The Windy City has made relatively little progress in the autonomous vehicle sector. Illinois created the "Autonomous Illinois" initiative in 2018 to be headed by the state's DOT.[46] The program's goal is to create a seamless environment to integrate automated driving technologies in the Land of Lincoln.[47] Innova EV, a Chicagoland-based company that makes small all-electric vehicles, has run pilot programs transporting senior citizens in Chicago suburbs with hopes to expand to autonomous rides in the future.[48] In 2018, Illinois banned local governments from making laws against autonomous vehicles, but the legislature hasn't addressed the issue statewide. Lawmakers have attempted to make driverless vehicles fully legal in the state, but none of the proposed legislation has been passed.[49] Chicago's winter storms will also present a challenge for future autonomous vehicle development in the city.

Houston

Houston (and Texas more broadly) has been a hotbed for development and testing in the autonomous vehicle sector. This is in large part due to the sunbelt weather conditions that help the technology remain aware of its surroundings. In autonomous trucking, Waymo Via is working with trucking giant JB Hunt on a pilot route between Houston and Dallas-Fort Worth.[50] Pittsburgh-based Aurora also recently announced they aim to begin their own self-driving truck route between the same two cities in 2024.[51] Nuro, which operates last-mile autonomous delivery vehicles that are smaller than standard cars, also operates out of the city and has partnered with companies like Kroger, Wal-Mart, and FedEx.[52] Houston operates under Texas's state legislation that allows for autonomous vehicle testing both with and without a driver behind the wheel.[53] Texas Governor Greg Abbott also directed the state to create a Connected and Automated Vehicles task force in 2019 to anticipate the development of autonomous driving.[54] The Houston city government has been involved in advancing AV testing and started an autonomous shuttle system in partnership with Texas Southern University in 2019.[55]

Endnotes

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