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Tesla: The Imminent Winner of Autonomous Driving

The winner of autonomous driving and robotaxis needs...

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Introduction

In the past 100 years, transportation has been disrupted by new technologies:

Automobiles (cars, vans, trucks):
We saw the transition from horses and horse-drawn carriages to the automobile for military use, personal use, and business use (e.g., shipping materials and goods via trucks). Highway systems built in the 1950s and the growth of suburbs accelerated the adoption of the automobile.

Trains and Subways:
The 20th century vastly improved 19th century trains and subway systems by making them faster, cheaper, and more widespread.

Air transportation:
Airplanes became cheap enough and safe enough for use by civilians and businesses, especially to travel internationally.

These new technologies affected military transport, personal transport, and business transport.

Transportation soon faces another major disruption by autonomous vehicles & robotaxis

These autonomous vehicles will not only be for personal use, but also will include autonomous trucks (mainly for businesses) and autonomous robotaxis.

The Significance of Autonomous Driving & Robotaxis

1. Autonomous driving will disrupt many, many large industries

Personal car sales:
Ride-sharing apps like Uber & Lyft are already causing people to no longer need or want their own car. The convenience and low price of robotaxis will accelerate this trend. This move away from car ownership is already the case in large cities with unbearable traffic, high gas prices, and expensive parking. But cheap robotaxis may also lead people living in the suburbs to reevaluate car ownership.[1]

Legacy Public Transportation: Subway and Bus Systems
These public transportation systems in major cities around the world are of varying quality, cost, and convenience. Clearly, people will prefer a robotaxi that can pull up in front of your home or apartment and take you directly to your destination. And many of these legacy forms of public transportation are already being disrupted by ride-sharing services.

Taxi Industry
The taxi industry is a $25 billion industry.[2] At least in the United States, this industry has already been dying due to the high cost of union labor and due to ride-sharing disruptors such as Uber and Lyft.[3]

Food delivery services with human drivers (Uber Eats, DoorDash, Grubhub, Postmates)
These have become extremely popular as a result of the COVID-19 pandemic in 2020. DoorDash alone has a market cap of over $60 billion (as of February 2021).

1 *Ben Gilbert, Greekwire, "How I Ditched My Car and Went Full Uber"; Ryan Lawler, Tech Crunch, "When Does Uber Becoming Cheaper than Owning a Car?"; Nick Bilton, The New York Times, "For Some Teenagers, 16 Candles Mean It's Time to Join Uber"*

2 *https://www.ibisworld.com/united-states/market-research-reports/taxi-limousine-services-industry/*

3 *Judd Cramer & Alan B. Krueger, "Disruptive Change in the Taxi Business: The Case of Uber," American Economic Review 106, no 5 (2016): 177-182; Scott Wallsten, "The Competitive Effects of the Sharing Economy: How is Uber Changing Taxis?" Technology Policy Institute (2017); Patrick Wagner, "Ride-Hailing Apps Surpass Regular Taxis in NYC" Statista (2018)*

Ride-sharing services with human drivers (Uber/Lyft)
These have already disrupted public transportation and the taxi industry. But the most expensive aspect of current ride-sharing services is the cost of the human driver (base pay per ride + tips). Furthermore, government intervention is becoming increasingly costly and problematic. California passed a law (AB5)[4] requiring ride-sharing drivers to be classified as employees rather than independent contractors. Great Britain's Supreme Court recently ruled that Uber drivers must receive employee benefits. Such employees must receive benefits such as a minimum wage, health insurance, and paid-leave.

Parking Industry
So much land is "wasted" over parking space. If fewer people buy personal cars, then all the space devoted to parking will be needed less and less. In large cities around the world, parking is extremely expensive, but autonomous cars will eliminate the need for parking. This excess land can be torn down and re-used for more productive purposes than simply parking cars.

Trucking Industry
According to UBS Group AG, the trucking industry is worth $1.5 trillion.[5] Autonomous trucks will disrupt the entire trucking industry once it becomes cheaper to use an autonomous truck vs. a human driver. This will also affect all the associated industries that synergize with trucking (e.g., motels, 24-hour diners, gas stations in remote areas).

2. As a result of such massive disruption, we estimate that autonomous driving and robotaxis will be a multi-trillion dollar market

It should be obvious that if autonomous driving can disrupt so many industries, it will clearly be a multi-trillion dollar market.

There might be room for numerous competitors, but most likely robotaxis will be dominated by only a few companies that are competitive with regards to cost, ease of use, quality of the ride, and speed.

4 *The law can be found here: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB5. Discussion of its implications can be found here: https://www.investopedia.com/california-assembly-bill-5-ab5-4773201 and https://www.epi.org/publication/how-californias-ab5-protects-workers-from-misclassification/.*

5 *Jack Denton, "Watch Tesla, Nikola and these other stocks as change comes for a trucking market worth $1.5 trillion," MarketWatch, March 19, 2021*

What is necessary to win autonomous driving & robotaxis?

Volt Equity believes that Tesla is best positioned to win the race to autonomous driving for the following reasons:

1. Big data is the most important need to achieve autonomous driving

A car can be equipped with the best and most expensive sensors in the world (LiDAR, cameras, radar, ultrasonics). However, if the car cannot process what it is seeing (perception) and decide what to do (driving experience) – then all the expensive sensors are for nothing. The car needs to understand what it is like to drive in the real world.

All the giant tech businesses of the present utilize big data to crush their competitors and solidify their dominance (Amazon, Google, Facebook). The company with the most data and which can best utilize and monetize that data always wins.[5]

The autonomous driving market will be similar. The winning company will both have the most data about driving and be able to utilize all that data well.

What kind of data is necessary?

An autonomous vehicle needs a *large* and *varied* amount of *real world* data

A) The data set must be **a large amount** because artificial intelligence (AI) gets smarter the more data it is fed. This principle has been proven through AI learning to beat the greatest human players in chess, Shogi, and Go,[6] through speech recognition,[7] and through image recognition.[8]

5 *Andrew McAfee and Erik Brynjolfsson, "Big Data: The Management Revolution," Harvard Business Review, October 2012.*

6 *David Silver et al., "Mastering Chess and Shogi by Self-Play with a General Reinforcement Learning Algorithm," ArXiv, 2017, 1–19.*

7 *Dario Amodei et al., "Deep Speech 2: End-to-End Speech Recognition in English and Mandarin," Proceedings of The 33rd International Conference on Machine Learning 48 (2016): 173–82.*

8 *Dhruv Mahajan et al., "Exploring the Limits of Weakly Supervised Pretraining," Proceedings of the European Conference on Computer Vision, 2018, 181–96; Chen Sun et al., "Revisiting Unreasonable Effectiveness of Data in Deep Learning Era," Proceedings of the IEEE International Conference on Computer Vision, 2017, 843–52.*

B) The data must be **varied**. Trillions of images of highway driving is useless. Data must be drawn from all types of street configurations (traffic lights, stop signs, one-way streets, v-shaped turns, roundabouts), in all types of weather (rain, snow, fog, facing direct sunlight), in all types of areas (cities, suburbs, rural areas, villages), and during any time of day.

An autonomous car must be able to recognize and safely navigate construction sites, animals on the road, debris on the road or flying in the air, boats connected to trucks, bikes racked up behind a car, etc. It is these 0.1% of "edge" cases that the car must know and know how to react.

C) The data must be **real world data**. Many companies run simulations on what they imagine a car might encounter. But the real world is filled with the unexpected. As Elon Musk has said, "In a simulation, you are fundamentally grading your own homework. If you know you're going to simulate it, you can definitely solve for it. But...you don't know what you don't know. The world is very weird and it has millions of corner cases."[9]

Tesla's existing fleet of one million+ cars already on the road feed Tesla data and Tesla receives this data (worth billions) at no cost

Each Tesla car has eight cameras providing 360° coverage of the vehicle's surroundings. Tesla is able to easily receive this data through over-the-air (OTA) updates. Even a large car company like Volkswagen has yet to figure out how to pull data from its car via over-the-air (OTA) updates.[10] And this data drawn from its fleet fits exactly what is needed to win autonomous driving: a large amount of varied and real world data.

Simply put, no other company pursuing autonomous vehicles has that many cars collecting real world data for them at zero cost.

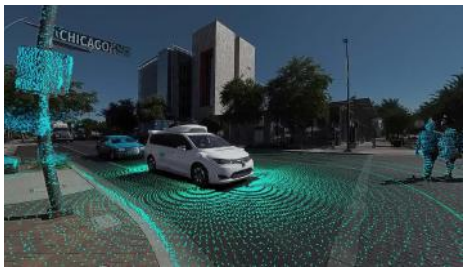
9 *Elon Musk, Tesla Autonomy Day, 02:04:40–02:05:15*

10 *William Boston, "How Volkswagen's $50 Billion Plan to Beat Tesla Short-Circuited," Wall Street Journal, January 19, 2021.*

2. An autonomous car needs a small, energy-efficient supercomputer that is able to handle such a large amount of data

It would be useless to have so much data if the car's driving computer cannot process and use such data. Essentially, an autonomous car needs a supercomputer.

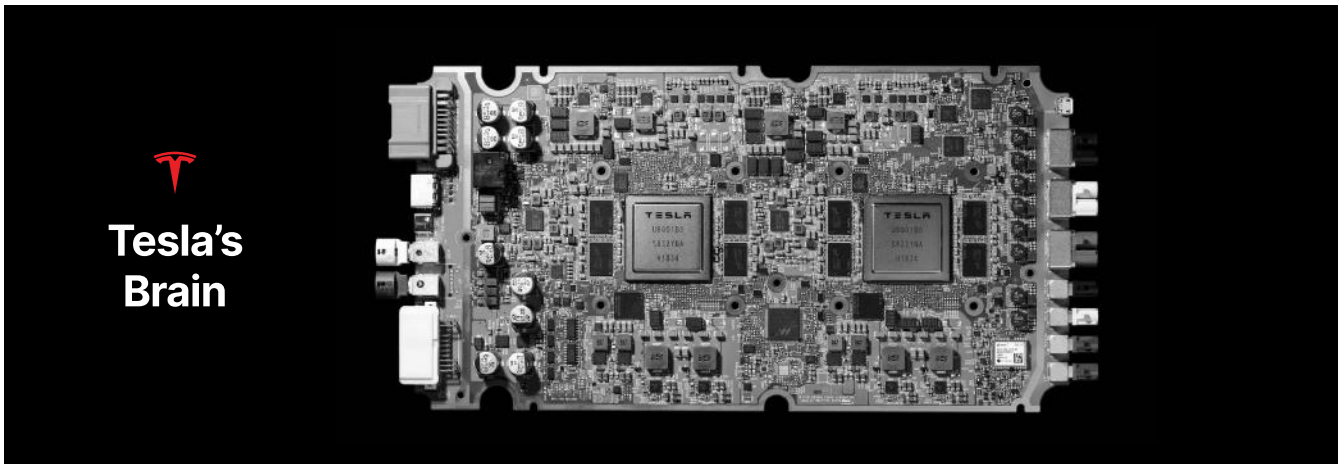
Waymo (a spin-off of Google) is a major competitor to Tesla. Waymo's driving computer is both enormous (taking up most of the car's trunk space) and energy hungry (limiting rides to about 30 minute demos).



Source: Waymo

Computer chip companies have to balance the needs of many customers. They must build chips for phones, TVs, laptop computers, desktop computers, servers, and/or tablets. No existing computer chip company designs computer chips only for cars. Thus, existing computer chip companies would never prioritize designing a chip specifically for autonomous driving, namely, a chip that is small, energy efficient, yet powerful.

Thus, Tesla decided to create their own custom neural network chip rather than wait for a computer chip company to build one for them.



Source: Tesla

Tesla's full self-driving (FSD) computer fits exactly what is needed:

A) It is ***small*** (260 mm2) and fits behind the glove compartment box

B) It is ***fast*** (144 trillion operations per second)

C) It is ***energy efficient*** (100 watts)

D) It is ***redundant*** for safety (two independent chips)

Nvidia is working on the new Orin computer chip that will likely outperform Tesla's existing FSD computer – but Tesla itself is working on a next generation chip[11] and Nvidia may be too late by the time it completes the new chip.

The company that is first-to-market will likely capture large market share and name recognition, so speed is critical.

Tesla already has a small, energy-efficient supercomputer in its existing cars.

11 https://electrek.co/2021/01/25/tesla-partners-samsung-new-5nm-chip-full-self-driving-report/

3. To win at robotaxis, a company needs a low-cost electric fleet

Once a company has big data and a driving computer able to handle that data, it still needs to be price-competitive, otherwise robotaxis will become a luxury service.

Low-cost

A) **Cost per mile**

Based on AAA data from December 2020,[12] the average cost is anywhere from 55¢ to 85¢ per mile (averaging out to 70¢ per mile). This depends largely on how many annual miles driven, but also from paying for gas, car insurance, driver's license, car registration, and maintenance. If all those yearly costs were eliminated in the case of an electric robotaxi, the cost could fall to 18¢ per mile.[13]

B) **Per mile efficiency.**

Tesla leads EVs in the lowest cost per mile. As of January 2021, there is no production EV that beats the 2012 Model S and its 265 mile range. And Tesla has improved the current Model S to boast a 400 mile range.

12 https://newsroom.aaa.com/wp-content/uploads/2020/12/Your-Driving-Costs-2020-Fact-Sheet-FINAL-12-9-20-2.pdf

13 Elon Musk, Tesla Autonomy Day, 03:12:36.

Tesla has achieved this growing per mile efficiency not by increasing the size of its batteries, but through better manufacturing and the lowest drag coefficient in the industry. The Model 3 has a drag coefficient of 0.23, which is even lower than a Toyota Prius.[14]

The low drag coefficient results in more miles per kilowatt-hour (kwh), thus increasing the car's range and reducing how often it needs to be re-charged.

C) **Car longevity.**
Tesla's cars are designed to last one million miles, including the battery.[footnote] Most people retire their gas-powered cars around 200,000 miles, but Tesla is designing its cost to last 5x as long.[15]

Why electric?

While strictly not necessary for robotaxis, there are numerous reasons to think that robotaxis will and should be electric:

A) **Safety.** There is no current technology that allows a car to re-fuel itself and no company seems to want to develop such technology. This means that a gas-powered fleet would have to be re-fueled by a human, further driving up costs. Electric cars can re-charge through induction (wireless, like smartphones), which is safe and easy to teach the car.

B) **Cost.** The trajectory of future cars is already moving towards electric and away from fossil fuels, especially as more and more governments push this development. This means that the cost of re-charging will likely become cheaper than re-fueling. And electric cars naturally have lower maintenance costs because they have fewer moving parts and do not require oil changes.

14 *https://arstechnica.com/cars/2019/03/the-tesla-model-3-reviewed-finally/*

15 *Jessie E. Harlow, et al, "A Wide Range of Testing Results on an Excellent Lithium-Ion Cell Chemistry to be used as Benchmarks for New Battery Technologies," Journal of the Electrochemical Society 166, no. 13 (2019): A3031-A3044.*

Conclusion

The winner of autonomous driving and robotaxis needs . . .

1. Big data – namely, a large amount of varied and real world data

Tesla's existing fleet of one million+ vehicles is gathering such data for Tesla at no cost. No other rival has such data gathering at no cost.

2. A small, energy-efficient supercomputer

Tesla's full self-driving (FSD) chip fulfills these requirements and has been in production since 2019. While competitors may eventually catch up, it may be too late by then.

3. A low-cost electric fleet

Tesla leads the way in per mile efficiency and car longevity, which will be crucial to winning the market for robotaxis. A low-price point will encourage more people to use robotaxis as one of their transportation options and for many to even forgo car ownership altogether in favor of robotaxis.

Thus, Tesla is poised to capture the multi-trillion dollar autonomous driving industry and disrupt all the major industries previously discussed: car sales, subway and bus systems, taxis, trucking, ride-sharing services, food delivery services, and the parking industry.

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