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In today's society, we are submersed in technological advances that have become ordinary. So ordinary, which we take these advances for granted and often forget how these advancements came about. However, we should take the time to think about and reflect on those who make our world the way it is today. For this paper, I will focus on successful businesses started by electrical and computer engineers. Massive corporations that surround us such as Tesla or Apple are common household names. However these companies started somewhere, whether it was started in a basement or government funded. Despite the difference in location, both were started by intimidatingly intelligent engineers whose dreams became a reality.

Tesla Incorporated, originally Tesla Motors, is an American company found in 2003. They are a major electric automaker, energy storage company, and solar panel manufacturer. They specialize in electric cars, lithium ion battery storage and residential solar panels [3]. The name Tesla originates from the electrical engineer and physicist Nikola Tesla. The inspiring engineer is best known for his contributions to the design of the modern alternating current (AC) electric supply system. He also invented the AC two phase induction motor [9]. This design is still used today in modern technology and is used in one of Tesla Inc.'s more popular car, the Tesla Roadster [2]. However, the company was not only inspired by this great man's technological advances, but his love for spreading the new technology for the betterment of society.

Tesla Inc. was initially founded by two men, Martin Eberhard and Marc Tarpenning. These two men are responsible for the startup and initial funding for the company. Martin Eberhard obtained his computer engineering degree at the University of Illinois at Urbana-Champaign and then continued for his masters in electrical engineering. Eberhard has a passion for sports cars but has moral disagreements about imported oil from the Middle East. He also has a strong concern for global warming [3]. With his educational qualifications and personal beliefs, it seems as though Tesla was his destiny.

Marc Tarpenning was a fellow engineer and close friend to Martin Eberhard. The duo met when Tarpenning came to visit Wyse Technologies where Eberhard worked. After doing some consulting work and becoming close friends, they founded a business called NuvoMedia, a company developing eBook readers [10]. A few years later they sold the company and used the profits to fund a company that takes advantage of developments in battery technologies, forming Tesla Motors. Eberhard and Tarpenning were then joined by a fellow engineer, Ian Wright. Wright only lasted a year within the company but his role played an important aspect for the survival of the company. Wrights responsibility at Tesla was to manage the relationship with the two main partners of the company; Lotus Engineering and AC propulsion [10].

The most influential man to come into play for Tesla is Elon Musk. He joined Tesla's board of directors as a chairman after financing the company back in 2004 . Musk took an active role within the company and oversaw the company's first car, the Roadster. He was

responsible for overseeing the product design at a detailed level, however, he was not deeply invested in day-to-day business operations [10]. Musk received his bachelor's degree in physics from the University of Pennsylvania and continued for a second bachelors in economics. At the age of 24, Musk moved to California to begin a PhD in applied physics at Stanford University. However, after two days within the program, he dropped out to pursue his entrepreneurial aspirations in the areas of the Internet, renewable energy and outer space [10].

It wasn't until the 2008 financial crisis when Musk assumed leadership of the company as CEO and product architect. With Musk backing the finances, Tesla set a primary goal to commercialize electric vehicles. They planned to start with a premium sports car targeted at enthusiasts. After the enthusiast exposed the name and the general public caught wind, the company wanted to move as rapidly as possible into mainstream vehicles. These vehicles targeting the general public include cars like sedans and affordable compacts. Musk stated that these cars will "serve as the catalyst to accelerate the day of electric vehicles [3]."

Tesla struggled to take off in the early years and faced the threat of bankruptcy multiple times. Musk, however, invested his own money each time to avoid the foreclosure. For the third round of financing, Musk contributed 70 million to the company, forcing its survival. Without Musk, the company would have crashed and burned long before it held any influence within our society [5]. Government funding and bailouts also provided support for the company. Now Tesla is thriving and producing a variety of cars for the public. The bar graph

below shows just how quickly the company took off once reaching the general public in 2012-2013.

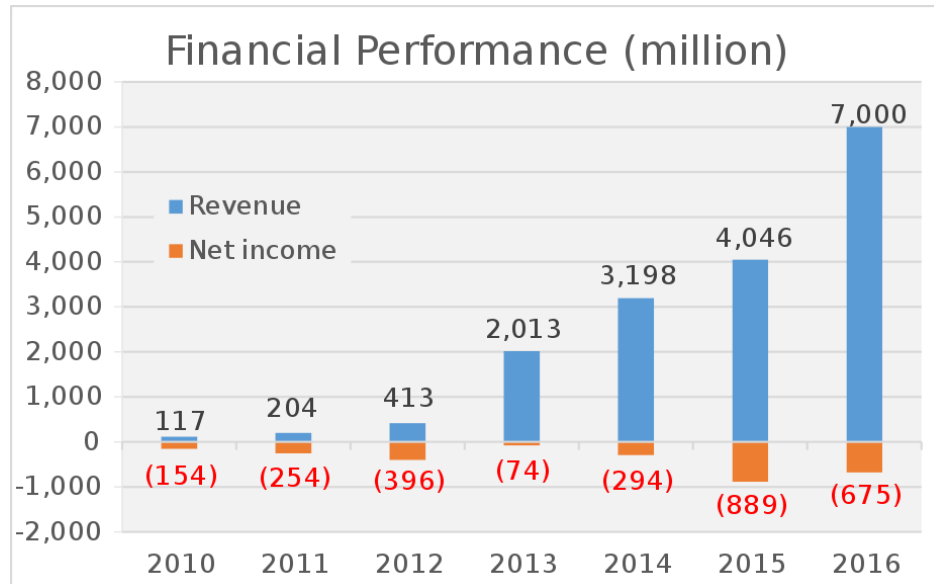


Figure 1: Financial Performance [3]

Tesla first released the first electric sports car, the Tesla Roadster in 2008. This car uses the AC motor descended directly from Nikola Tesla's design from 1882. This car was the first to automobile in production to use lithium-Ion battery cells. It was also the first in production to exceed the milestone of 200 miles per charge. This car has the capability of reaching sixty miles per hour in under four seconds. With this car, Tesla was able to expose themselves to the public by creating an exclusive market. Only selling 2,400 of these cars allowed their name to spread and demand to grow [7]. This car also served as a trial run before selling to the masses. It allowed Tesla to work out any bugs or kinks with their designs without having to recall thousands of products creating bad publicity.

The next cars into production were the Model S and Model X. These two cars were full size luxury sedans with the capability to travel 265 miles per charge. These cars were the product of Tesla's initial goal of reaching the everyday consumer. They were priced at an affordable price of roughly \$35,000. With over 158,000 units sold worldwide, Tesla earned the award for world's best-selling plug-in car for two years in a row [6, 7].

Tesla's products come with purposes that benefits society in multiple ways. These cars reduce carbon monoxide and carbon dioxide emissions and greatly reduce household's costs on gasoline and oil. These cars are considered "zero emission vehicles," however, many forget their need for precious metals and the electricity needed to charge [11]. This creates an argument on whether or not these cars can actually be considered "green." Tesla has created ways to debunk and fix these claims to prove that they truly are more economically friendly than their fossil fuel counter parts. To start, the lithium-ion batteries require the precious metal lithium, which in turn creates heavy land pollution while mining this specific metal. Lithium is flammable and extremely reactive [11]. It occurs naturally compounded in forms such as lithium carbonate which requires a chemical process to be made useable. This chemical cleaning uses a heavy supply of water that leaches into the earth. This is where the main counter argument for electric vehicles comes into play. Is it really worth mining for the materials considering the harmful effects? The answer, is yes. Tesla recycles seventy percent of carbon from their old batteries, and as technology increases, so does this percentage [11]. As

the percentage decreases, less and less pollution is released into the environment. The system that Tesla has created is designed to reduce emissions as more people invest in the idea of electric vehicles.

This is the answer for multiple arguments. As we invest our time in new and greener technologies, fossil fuels will decrease which in turn decreases the greenhouse gases released into the environment. The carbon footprint created by electric cars is also entirely dependent on a general areas source of power. If a towns power supply comes from natural gas, nuclear, hydroelectric or other similar techniques, the carbon footprint of the cars is extremely small compared to gasoline based engines. If more areas in the country reduced their supply from the coal companies, the carbon footprint will only continue to decrease. As time and technology progresses, we can become entirely energy efficient while simultaneously saving the overall health of the planet [11].

To compensate for the growing demand of electric vehicles, Tesla plans to triple the amount of Tesla Supercharging Stations within the country. These charging stations are free and also save people time do to the ability of charging at night or during the work day [1, 2]. Charging a Tesla is roughly three times cheaper than fueling a gasoline based car. For example, a study was completed in California comparing a Tesla Model S and a BMW 7 series. At nineteen miles per gallon, it cost \$4,951 to fuel the BMW for 23,000 miles. Meanwhile, over the

same distance, it cost the Model S \$1,226 to recharge. This study is an incredible display of cost savings for the average homeowner while simultaneously reducing greenhouse gases [5, 8].

On top of their environmental benefits, newer Tesla models come equipped with autonomous behavior. This allows for safer travel by reducing human error behind the wheel. Tesla first implement semi-autonomous behavior in 2014. This included adaptive cruise control and AutoPark. The cars come equipped with radar systems, cameras, and ultrasonic sensors placed strategically around the car [1, 8]. The cars are able to detect road signs, lane markings, obstacles and other vehicles. Adaptive cruise control allows the car to run autonomously at a certain speed on the highway or freeway. AutoPark allows an individual to let the car park itself instead of struggling to parallel park themselves. These features are improving every day as the cars constantly send data back to the headquarters. Tesla then analyzes this data to improve the cars abilities. Tesla plans to implement full autonomous behavior by the end of 2017 [1, 7]. Other car manufacturers are implementing this technology already, however, Tesla will become the first fully electric and autonomous vehicle to be released. Similar to the reduced greenhouse emissions, as technology advances, so will the implantation of autonomous behavior. This will prevent human error behind the wheel such as falling asleep or driving while intoxicated.

Over the next few years, Tesla also plans to increase the variety of vehicles they have to offer. Expanding into vehicles such as pick-up trucks and mini-vans. Elon Musk also wants to



implement a strategy called “complex coordination.” Complex coordination is the standardization of electric cars parts, making it easier for the consumer to replace broken or worn parts on their vehicle independent of the car model [6, 7, 8]. This will lessen the cost of parts and create an environment that will allow the average non-mechanical individual to replace broken parts. This standardization will also include add-ons to a person’s car. An individual will be able to upgrade or enhance certain aspects of their vehicle without the need for major services. The parts will be considered “snap on” or “plug and go.”

The reason Tesla has made it this far was due to the business strategy implemented by the engineers running the company. Tesla started with a high quality, high priced item targeted at enthusiasts and affluent buyers. As the popularity grew, so did the demand. The high demand allowed Tesla to increase the variety of products and reach a competitive market at lower costs. Before they expanded to the public, they used the product they had to perfect any imperfections to optimize the product. This is a typical strategy for new technology, however, it is not always executed as smoothly. It is also important to keep in mind that Tesla is competing with 150 years of a monopoly from the oil and gas companies [5, 8].

This leads into the question of what makes an engineer a successful business owner. Engineers are trained to problem solve and think in a logical and methodical manner. This allows them to truly understand the situation at hand and gives them an advantage to finding the solution. Engineers also know and understand their product thoroughly. They have built

their design to their idea of perfection and can fix just about any problem that occurs. This also builds a trust with the customer base. Consumers want to trust and believe in the product they are investing in giving an engineer the advantage over a general salesman. Engineers are also known to take meticulous and calculated risks. They fully investigate and understand the risk before making any critical decisions. This avoids any actions that might be detrimental to the company [4].

Tesla is just one example of a successful company started by electrical or computer engineers. Eberhard, Tarpenning, and Musk created a leading car manufacturer based off intuition and dedication. Their characteristics as engineers and intelligent business strategy allowed the company to survive through tough times. Tesla only plans to continue to build their company and advance their technology in order to obtain truly green vehicles. As more people become invested in green culture, the more the technology can advance.

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