Note: Waymo vs. Uber May Be the Next *Edison vs. Westinghouse*

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Abstract

During the late 1800's, significant debate resulted from the development of new electric power supply systems. Whereas Thomas Edison supported growth of DC, direct current, supply, competitor George Westinghouse worked to make AC, alternating current, more widespread in both rural and urban settings. This War of Currents is mimicked in the current clash between Google and Uber over LiDAR technology in self-driving vehicles. The study discusses implications concerning *Google vs. Uber* and a comparison of this case to *Edison vs. Westinghouse*, its predecessor. A comparison is made between the similar decisions and actions of Nikola Tesla and Anthony Levandowski, both of whom left one company to work on personal technological ventures before being bought out by another company. An analysis is conducted concerning patents owned by Google, potential patent infringements, and the impact this case will have on our future, the growth of technology and autonomous vehicles, and intellectual property law.

Keywords: Google; Uber; Waymo; Edison v. Westinghouse; LiDAR; Driverless Cars; Technology; Intellectual Property; Patent Litigation.

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I. Introduction

Regardless of time period, technological advancements lead to conflict between competing inventors and companies. The late 19thcentury marked one of the most prominent technological wars between Thomas Edison and George Westinghouse concerning a more efficient electric power supply system. Since then, more arguments resulted from conflicting views pertaining to recent tech advancements. Several years ago, *Apple vs. Samsung* took center stage with arguments concerning Smartphone patents. Now, the most recent war is between Google Waymo and Uber regarding self-driving vehicles.

This study looks into the *Edison vs. Westinghouse* case as well as *Google Waymo vs. Uber*. Both are compared to each other in an attempt to demonstrate their similarity and applicability to public lifestyle, regardless of time period. Key figures, including Nikola Tesla and Anthony Levandowski, are compared based off their similarity in actions and decisions. A discussion of the patents involved and impending IP litigation is also presented alongside an analysis of the autonomous vehicle programs of Google and Uber.

II. Analysis

A. The War of Currents

In the late 1800's, a new era of discovery was on the cusp of changing the future of electric power distribution in the United States. This would have a profound impact on a world that was rapidly industrializing and adapting to continuous change and requests from a demanding global market. The two leaders of this electric power conflict were Thomas Edison and George Westinghouse, both prominent figures in electricity advancements. Their disagreement would become known as the War of Currents.

Disagreement was instigated when a search for new electrical power systems was brought to America's attention. With the recent invention of the light bulb, people wanted bulbs that were affordable and available to every household. At the time, the two supply systems were either alternating current (AC) or direct current (DC). Thomas Edison was a confident supporter of direct current, which he devoutly used in bulbs he provided to urban settings. George Westinghouse, on the other hand, was certain he would advance alternating current usage in the U.S. (Materials World Magazine, 2007).

According to MIT's School of Engineering research, AC and DC are significantly different. They constitute opposing forms of voltage, or current, that conducts and transmits electrical energy. Visually, an alternating current appears as a wave because it changes over time in repetitive oscillations. It is called an alternating current because the peak of the wave represents the positive flow of energy. The trough represents the current moving in the negative direction. On the other hand, a direct current is a straight, horizontal line because energy flows from one direction to the next (Earley, n.d.).

An example of a product that utilizes AC is a lamp, because the current source travels some distance, and the wave-like motion makes it an efficient traveler. On the other hand, DC is utilized in flashlights and other products that require batteries. Since batteries have negative and positive terminals, the electrical charge moves in only one direction, from one pole to the other at a steady rate. Hence, the current appears in a straight line.

In the late 19thcentury, adoption of AC became more widespread, which sparked much of the debate between Edison and Westinghouse. Many preferred AC because it could more efficiently distribute power at significantly lower voltages than DC. However, power is naturally conducted at significantly high voltages. As a result, to get power down to lower transmittable voltages, the current would have to be converted with a transformer from DC to AC (Earley, n.d.). Via this process, it became possible to transmit more power more efficiently throughout the United States.

Despite the growing popularity of AC in the late 1800's, Edison was keen on supporting DC use. He held this position primarily because he had numerous patents concerning direct current electrical supply, including one of the first ever DC power transmission systems (Irfan, 2012). Edison's efforts were not in vain, as he did convince some municipalities to purchase local power plants

supplied by DC. He garnered support for DC supply by demonstrating the dangers of employing AC. Unfortunately, Edison's vision was not powerful enough to encompass rural as well as urban communities. Westinghouse proved that AC was the most optimal and efficient power source to bring power to less populated, rural communities throughout the country (Earley, n.d.). Westinghouse was supported by several European companies, all of whom employed Nikola Tesla's inventions to instigate electricity relying on currents with higher voltages. As a result, it became easier to transmit power over long distances via cheaper and thinner wires (Irfan, 2012). This made it more affordable for people living in rural areas, where already the costs of living and wages were considerably lower. Electricity would no longer be a rich man's commodity if AC supply were adopted nationwide.

Despite the public's plea for ubiquitous electrical power supply, Edison focused primarily on generating DC power in cities. He fully understood DC's limitations in addressing the power needs of people spread thin across vast distances. Regardless, he hired a young Nikola Tesla to discover a practical form of DC power transmission. Tesla soon discovered the most efficient way to transport power would be via an alternating current (AC), in which high voltage energy would be converted and transmitted over long distances using a low current. Edison did not want to accept a shift from the concentration of his numerous patents and business in DC power, so Tesla left in 1885 to develop his own AC supply systems.

Tesla created many inventions that would change the electric supply industry. In 1903, with the assistance of Westinghouse, Tesla utilized energy from Niagara Falls to transmit AC power to distant, rural areas throughout New York. He then developed the synchronous AC electric motor, neo and fluorescent lamps, ultra high voltage transformers, electrical devices for radios and TVs, and a system for wireless power transmission (NY Times, 1979). Shortly after breaking from Edison, Westinghouse bought various patents from Tesla with the full intention of commercializing affordable electric lighting via AC power (King, 2011).

This tactic brought Westinghouse to the front of the electrical supply market as he began installing AC generators throughout America, focusing on the goal of providing electric light to the rural areas that Edison's DC system could not reach. It was indicated, "By 1887, after only a year in the business, Westinghouse had already more than half as many generating stations as Edison" (King, 2011). He was a growing force to be reckoned with, thus threatening Edison's once competitive advantage in the marketplace.

Edison began the War of Currents with demonstrations of AC's lethal power in killing humans and animals alike. Although somewhat successful, his efforts were not enough to deter a growing acceptance of cheaper, more affordable electricity that could light up *every* home in the country. One of Edison's biggest stunts was to use an AC electric chair to punish criminals. Westinghouse spent $100,000 in legal fees to appeal to the US Supreme Court for death by electric chair of murderer William Kemmler, stating that it would be cruel and unusual punishment. Unfortunately, he was not met with success, and Kemmler was

sentenced to death via the electric chair in 1890.

After 17 seconds of receiving shocks from the AC supply, it was perceived that Kemmler was dead. However, he was suddenly gasping for air, which took witnesses by surprise. He was shocked with more current, and it took several minutes before he finally was dead. Many in attendance were dismayed by this approach to punish criminals and did not want it to be pursued in the future. Edison, however, was convinced that execution by the electric chair would eventually become more popular and effective. Thus, he continued his efforts to convince Americans of AC's lethal power. In fact, at Coney Island, New York, he injected an elephant with 6,000 volts of AC. She was immediately killed before a crowd of aghast spectators (King, 2011). Such atrocities and campaigning did not benefit Edison's case in advocating for DC power.

In 1893, Westinghouse was given the opportunity to illuminate Chicago's World Fair. This was a form of positive publicity and campaigning that propelled AC into the future as the preferred electric power supply. Following this honor, AC power was readily accepted nationwide. Edison had lost the War of Currents.

Such a major dispute between Edison and Westinghouse, with Tesla as the pawn in the center, is analogous to the current debacle between Google Waymo and Uber. Anthony Levandowski, who left Google and sold his Otto project to Uber, is modern day's Nikola Tesla. This paper discusses how the two conflicts are similar and how *Waymo vs. Uber* may just be this generation's War of Currents.

B. A New Era Stimulates DC Acceptance and Use

Although AC became the common electric supply source in America for over a century, DC is beginning to experience a slight comeback as a potential new energy supply leader. The renewable energy industry is growing in popularity, and with it comes more production of DC. Solar panels are one way to produce direct current power. To use this DC power, it must first be inverted into AC since homes, offices, and the grid are built to process AC power. If a company wishes to have a net-zero-energy building, or one that produces the same percentage of energy that it consumes, then investing in solar panels and bypassing a conversion to AC will undoubtedly shrink payback period and result in more garnered and useful energy. A doctoral student in engineering and public policy at Carnegie Mellon suggests that installing and utilizing a DC power system will be cheaper overtime and more feasible for buildings to own alongside AC systems. It is anticipated that "hybrid electrical systems are the future," but that new rules for current routing and design must be pioneered to ensure the systems are safe and as efficient and effective as anticipated (Irfan, 2012).

The tides have turned now in the quest to provide energy to less populated, rural areas. In fact, developing countries will be burdened with more expensive electric supply systems should they utilize AC power. Many of these regions, for example, can construct and install turbines and solar farms that produce directly accessible DC power. As previously mentioned, this would provide

higher returns in the future on present solar investments since it removes the intermediary step of inverting DC into AC compatible power. Whereas in the late 1800's there was limited to no exploration in solar, renewable energy sources, the only best option for providing cheap and reliable energy to less populated, rural areas was via AC transmission lines. Now, it is quite the opposite.

Just as there was much debate concerning AC or DC usage in the past, such debate is expected to continue into the future. However, it is anticipated that as buildings become retrofitted for DC delivery and support, the "technology will spread in a manner analogous to the internet, driven by larger firms before it spreads to homes, where rooftop solar panels charge electric cars" (Irfan, 2012). Anything is possible in the future, which is now demonstrated by a sudden increase in researching and developing autonomous vehicles.

C. An Analysis of *Waymo vs. Uber*

Google's Waymo business segment accused Uber of stealing aspects of its autonomous driving technology seen in its recent self-driving car development. Should the lawsuit take a turn in favor of Google, Uber may be forced to end its self-driving research and development. This would have negative repercussions on Uber's ability to remain a viable competitor in the marketplace as it progresses towards reliance on autonomous vehicles.

It is important to note some facts pertaining to the case. Firstly, Google was involved in self-driving research and development since 2009, which was before it created Waymo. Uber only recently began its self-driving efforts in February 2015. Anthony Levandowski began working at Google in 2007. He was immediately accepted as a software engineer in the company's autonomous vehicle development program. He is considered one of the pioneers in Google's self-driving efforts. In 2016, Levandowski left Google to begin commercializing his personal self-driving vehicle project called Otto. In May 2016, Otto launched, and by late July 2016, it was acquired by Uber for $680 million. While working at Google, Levandowski was seen at Uber headquarters, possibly attempting to garner investors for his startup (Kerr, 2017).

Google immediately filed a lawsuit, claiming that Levandowski took some of its trade secrets and used them to build Otto. Uber became privy to these secrets when it bought Otto. Following the filing, Levandowski pleaded the Fifth Amendment, refusing to testify. Since the Fifth Amendment shields one from self-incrimination, Levandowski had the right to refuse to answer any questions pertaining to the supposed theft (Kerr, 2017). Levandowski's choice to take the Fifth prevented the U.S. District Court from granting Waymo's motion for a preliminary injunction.

U.S. District Court Judge Alsup, who presided over various patent trials, including a 2012 case between Google and Oracle, asked Uber's attorney, Arturo Gonzalez, to provide specific documentation for the Court order. The attorney was vague in his response, merely stating he would present documents for the order by the deadline. Judge Alsup knew immediately it was a bluff and that Gonzalez would not produce everything required. When Gonzalez responded, explaining that Uber did not have possession of all requested documents, "Al-

sup asked if Levandowski had the rest of them, only to hear from his lawyers that he would be taking the Fifth" (Cava, 2017). This effort on Levandowski's part was strategic in preventing the granting of a preliminary injunction that would force Uber to temporarily stop its driverless car program. Google was not too pleased with the turn of events.

The lawsuit filed in February of 2017 alleges "former Google engineer Anthony Levandowski secretly downloaded 14,000 proprietary technical files before leaving to found self-driving truck startup Otto. Uber acquired Otto last summer and put Levandowski in charge of its self-driving efforts" (Marshall, 2017). Waymo, Google's self-driving car project, was able to file the suit under the Defend Trade Secrets Act, which is a federal law enacted in May 2016 to expand intellectual property protection. Waymo also used the California Uniform Trade Secret Act to accuse Uber of patent infringement (Marshall, 2017).

In March 2017, Uber requested that it not be an involved party in the lawsuit, but that Waymo seek binding arbitration with Levandowski. One reason Uber made this suggestion is because it is relatively less expensive to pursue arbitration instead of a trial. Furthermore, a trial would be public. After all, Uber is keen on minimizing the impact of a court trial (Cava, 2017). If a court trial is pursued, there is the potential that all trade secrets will be released to the public. Uber believes this is information that only the involved parties should be privy to. Should the public be aware of all Uber's, and Google's, trade secrets, then it may lose a competitive advantage in the marketplace and have greater difficulty remaining afloat in comparison to other innovative companies.

Uber instigated another measure to protect itself against lawsuits. The company threatened to suspend Levandowski until he turned over the allegedly stolen documents. Judge Aslup then issued an injunction against Uber in the beginning of May 2017, "ordering the company to keep Levandwoski away from working on Uber's self-driving car, to prevent him and other employees to see Waymo's documents and return them to Waymo by May 31st" (Smith, 2017). Uber has yet to deny that Levandowski stole Waymo's documentation, however the company insists it does not utilize Waymo technology in its vehicles. Regardless, Judge Aslup alluded to the fact that some of Waymo's trade secrets do in fact appear in Uber technology, but that some of Waymo's claims against Uber are meritless. Recent news indicates that since Levandowski missed the May 31 deadline to produce the mandated evidence, Uber fired him.

D. Implications of the Defend Trade Secrets Act

The Defend Trade Secrets Act was initially created to protect against foreign secret infringers. Regardless, Google Waymo was able to apply it to American-born Uber. The law has a profound impact on the future of the defendant, which may be a reason Google strategically chose to file a suit under it. For example, a plaintiff can ask the court for an immediate and temporary injunction. Waymo did not hesitate in making this request (Marshall, 2017). With an injunction, the court has the authority to stop Uber's self-driving vehicle research and development until the case is settled. It is also possible for Google to extend the time the case sits in court in order to prevent Uber from pursuing

R&D efforts for a longer duration of time. This is one way to greatly benefit Google and give it the upper hand in progressing research and development of self-driving vehicles while Uber remains stagnant, nose-deep in litigation.

There is another implication regarding this law. The plaintiff, Google, can receive permanent injunctive relief. This would permanently prevent Uber from pursuing its research and development efforts for its self-driving trucks and cars program. As one can imagine, this extreme feature would prevent Uber from remaining in a marketplace that potentially moves to autonomous vehicles reliance.

Finally, with this Act, the plaintiff can "seize the profits of its trade secrets, even before the case is decided." (Marshall, 2017). This would negatively impact Uber because Google can rescind the LiDAR technology it believes Levandowski brought to Uber. The three factors discussed in this section can drastically deter Uber from developing in the future market. The Act may even have the power to eradicate Uber from the industry altogether.

E. Court's Discretion in *Waymo vs. Uber*

Google claims to have substantial evidence that Levandowski made an expansive theft of LiDAR secrets and that it cost the company a significant amount of profit and valuable resources. According to Google, Levandowski tapped into Waymo services and stole 9.7GB of data before leaving to create his startup, Otto. Further evidence was unearthed in December 2016 when a supply-chain manufacturer accidentally emailed a Waymo employee something that was intended for Otto. The email demonstrated that "Uber and Otto were copying a vital bit of tech for their self-driving cars" (Swearingen, 2017). If Google can prove this in court, the presiding judge will be presented with several options to penalize Uber.

For one, the judge can impose a royalty on all future driverless taxi rides stemming from Uber. The revenue from this royalty would be rewarded to Waymo. Another option is to have Uber return the allegedly stolen technology to Google. This would be considered an effort that potentially ends Uber's research and development of self-driving vehicles if it cannot sustain its efforts in developing its own unique technology (Marshall, 2017). This may even require Uber to relinquish its rights and ownership of Otto. Regardless of the judge's verdict, the final sum can amount to millions, if not billions, of dollars in settlement paid to Google.

F. Google Waymo

As previously mentioned, Google began efforts in researching and developing self-driving vehicles in 2009. It only recently renamed the program to Waymo after becoming closer than ever to commercializing software that can be licensed to auto manufacturers. In fact, Waymo currently has a contract with Chrysler to make 100 minivans that are driven solely by Waymo technology and software (Cava, 2017). In a 2017 research report, Morgan Stanley estimates that Waymo has a separate business net value of $70 billion, which exceeds that

of all the United States' auto industry giants. Uber falls shortly behind Waymo, with a current value of $68 billion, and Tesla is in third, with $51 billion (La Monica, 2017). Furthermore, Waymo created a partnership with Lyft, Uber's rival, which will only benefit Waymo's quest for market dominance. Although the program is anticipating continuous growth, Waymo most likely will not become its own company. Instead, we will find its software and technology licensed to other car companies and incorporated in their designs.

Waymo's vehicles are equipped with LiDAR sensors and advanced software to detect pedestrians, cyclists, vehicles, and roadwork. LiDAR creates imagery of the surrounding environment for the vehicle employing it. It has the capability to detect obstacles from two football fields away and 360 degrees around the vehicle. For example, if there is a cyclist to the right of the vehicle and he puts out his left arm, a signal to turn left in front of the vehicle, the software will detect the signal and predict the cyclist's next move. As a result, the vehicle slows down to permit the cyclist to pass. The biggest concern with this program is ensuring overall driving safety. After all, numerous studies indicate that 94% of all crashes involve human choice and error. It is anticipated that unnecessary accidents from human mistakes can be avoided by self-driving vehicles that are attuned to safety procedures and mechanisms (Waymo, 2017).

Waymo created the early rider program to test and perfect its driverless vehicles. Phoenix, Arizona has been the main hub for testing since 2016, in which individuals can apply to use the self-driving vehicles to go to their frequented destinations. The team at Waymo then collects user input and experiences to better shape the future of the driverless cars before they are released to the commercial market. Other locations for the early rider program include Kirkland, WA, Mountain View, CA, and Austin, TX. Over the course of one year of testing (2015-2016), Waymo test drivers substantially decreased safety-related disengages. In 2015, there were 0.80 disengages per 1,000 miles. By 2016, this number was reduced to 0.20. This has an additional effect of convincing three out of every four drivers in America that driverless vehicles are safe and viable options for transportation in the near future (Waymo, 2017).

G. Uber Otto

Uber added Otto to its self-driving research efforts in 2016. Prior to this acquisition, Uber began development of driverless vehicles through its Advanced Technologies Group. ATG's primary goal is to create a new approach in modern transportation that incorporates self-driving technology to improve and enhance safety and efficiency in the trucking industry. Once Uber acquired Otto from Levandowski, the company began developing more technology for cars and trucks (Uber, 2017). In fact, Uber discretely relinquished the name Otto after various trademark infringement claims were made against it in April 2017. Otto immediately became integrated in AGT.

The California DMV was also unaware of the change, and immediately after hearing the name Otto was dropped, it investigated whether Otto broke state law by operating automated trucks without permission. Otto contended that the trucks, with advanced safety technology, were still operated by human

control, and therefore broke no laws (Ohnsman, 2017).

Uber suggests that it is most optimal to deploy autonomous cars and trucks for highway driving, where consistent patterns and predictable road conditions are the norm. As a result, developing safer and accurate driverless technology is more feasible. In fact, in 2016, one of Uber's trucks drove 120 miles across Colorado highways with a trailer of Budweiser (Uber, 2017). This was the first commercial shipment made by a self-driving truck.

Uber also extended its self-driving vehicles research to Pittsburgh, PA. Hybrid Ford Fusions employ Uber's driverless technology to collect mapping data and test the car's ability to drive without a human driver. The vehicle is fully equipped with radars, laser scanners, high-resolution cameras, and LiDAR. These features help it extensively map details in its surrounding environment (Uber, 2017). One Uber engineer explained, it is "decked out with a small fortune of computing gear–20 cameras, seven lasers, and 360-degree radar coverage. It has more computing power on board than you'll find in a typical small business" (McFarland, 2016).

Uber shares the same vision as Waymo–to increase safety on the road and diminish the number of accidents resulting from human error. Uber cars are designed so a passenger sitting in the driver's seat can press a red button on the center console if he wants to gain control of the vehicle. In some instances, the car will chime to request the passenger to take over. For example, if coming to a right turn but a bicyclist is in the same lane wishing to continue straight or left, the vehicle may chime, thus indicating the driver is required to temporarily take over for the time being (Mcfarland, 2016). This is a sign that some actions or 'thinking' are not within the intellectual capacity of the car. Fortunately, safety features are not compromised since it is relatively easy for the passenger to pilot the car. Additionally, by giving the passenger the option to press a button and immediately gain control of the vehicle, it ensures the car will not make computational errors in trivial situations.

Although this would be beneficial to make roads safer and transportation less expensive but more accessible, drivers may lose their jobs in the taxi business that Uber revolves around. With self-driving Ubers, passengers can book less expensive rides because the human operator (the driver) no longer is required. Regardless, Uber is convinced that development in self-driving vehicles is creating a worldly shift away from owning cars to one of requesting driverless ones on a whim.

H. The Supposed Patent Infringements

Although Google has a very strong intellectual property team, its strategy against Uber remains uncertain. Stanford law professor Lisa Ouellette speculates Google may create "a broader war on Uber or lucrative licensing deals out of everyone else in the autonomous car space" (Ohnsman, 2017). Google invested countless hours and resources into developing enhanced LiDAR technology to govern its driverless vehicles. It accuses Uber of stealing these LiDAR innovations, and will not seemingly rest until it gains some form of restitution.

On May 17, 2017, Waymo dropped a patent claim against one of Uber's Li-

DAR devices called Fuji. This followed Judge Aslup's granting of a preliminary injunction, even after commenting that Waymo's patent claims were meritless. In the initial claim, Waymo deemed that Uber's LiDAR system infringed on three of the four patents prevalent in the case. Waymo, however, can still pursue a claim against the remaining one patent.

Waymo recently decided to pursue a different approach by focusing on Uber's older LiDAR system called Spider. The first patent claims made by Waymo relate to lens arrangement and design, which were not as directly related to trade secret allegations concerning the LiDAR circuit board that is eerily similar to Waymo's. Uber takes Waymo's withdrawal of the patent claim as a success. It explains, "Yesterday we said that we feel confident that we will show our technology was built independently from the ground up. And just today, Waymo helped us illustrate that by narrowing their patent claims" (Conger, 2017).

Google holds 260 patents relating to autonomous vehicles and 176 concerning designs and usage of LiDAR (Ohnsman, 2017). Uber claims its Fuji LiDAR system, comprised of multiple lenses, does not infringe on Waymo's single lens system called the Grizzly Bear 3. Waymo hired a physicist to review and compare both systems. He indicated at the start of the case that Fuji overlapped with two of Waymo's patents. However, after further in-depth analysis of Fuji, he rescinded this claim and deemed no patent infringement (Conger, 2017). This may be one reason Google withdrew some patent claims against Uber. Furthermore, Uber postulates the infringement is not even possible since Waymo accused Levandowski of stealing a single-lens LiDAR design. Fuji, in comparison, employs *four* lenses (Morris, 2017). This is additional proof that Google Waymo's initial patent claims could not stand. The patents held by Waymo and brought into the patent infringement claims are listed below.

Table 1: Waymo Patents Brought to Court

Patent	Device	Description
U.S. Patent No. 8836922	*Devices and Methods for a Rotating LiDAR Platform with a Shared Transmit/Receive Path*	This patent pertains to a light detection and ranging device that mounts to a rotating structure to receive light on the transit path.
U.S. Patent No. 9285464	*Devices and Methods for a Rotating LiDAR Platform with a Shared Transmit/Receive Path*	This relates to a similar LiDAR where light is focused on detectors to measure distance. This creates a 3D map of the scanning zone.
U.S. Patent No. 9368936	*Laser Diode Firing System*	This device has a voltage source, inductor, diode, transistor, light emitting element, and capacitor. It increases voltage, which causes the light emitting element to emit light pulses.
U.S. Patent No. 9086273	*Microrod Compression of Laser Beam in Combination with Transmit Lens*	This is a LiDAR with a laser diode emitting uncollimated laser beams. As a result, it reduces complexity and the cost of using these devices in commercial, self-driving vehicles.

Source: (Brachmann, 2017)

Because Google has a significant foundation in driverless vehicle patents, it has a comparable advantage in IP litigation against Uber. At the same time, patents are accepted left and right, encompassing common, essential, or even unnecessary additions to autonomous vehicle design and improvement. For a patent to be granted, it must, for example, incorporate an idea that is not common to the average person or that is necessary for vehicle functionality. Regardless, various companies in the autonomous vehicle industry seek patenting every minor advancement in autonomous vehicle design. This creates inherent patent overlap and potential lawsuits down the road. This is a mirror example of the Smartphone warfare between Apple and Samsung, except now, it concerns patents and intellectual property regarding self-driving vehicles (Margulis, 2017).

Although Google may have an advantage in IP litigation because it filed many of its autonomous vehicle-related patents before its competitors, the future still appears muddled with patent overlaps, lawsuits, and cross-licensing agreements. For example, Toyota, Nissan, Volkswagen, GM, Tesla, and Ford are advancing autopilot techniques in their vehicles. Argo AI is a company started by a former Google autonomous vehicle engineer. The company is en-

gaged in creating software to make self-driving Ford rideshare vehicles by 2021 (Ohnsman, 2017). Even small startups, many founded by Google engineers, are beginning to populate the market and congest the intellectual property industry with overlapping patents. There are only so many changes and improvements that so many competitors can make in a saturated industry. Only time will tell whether Google can dominate the market and ascertain its IP influence over its competitors, or whether it will share the industry but risk continuous patent overlaps.

I. How Business Models Impact Success for Google and Uber

It appears that Google knows how to strategically run its business in comparison to Uber. Because of its extensive business modeling and planning, Google has a stronger chance of succeeding in the autonomous vehicle market. Uber has been experiencing several fallbacks in its leadership and business composition, which presents a threat to its ability at remaining the most valuable private company in Silicon Valley. Within the past several months, most of its senior leaders left, including CEO Travis Kalanick on June 19, 2017. The company currently lacks a backbone of authority, having lost its chief financial officer, chief operating officer, general counsel, head of engineering, and chief executive. Uber's board did not explain how it plans to move the company forward without its senior officers, but Kalanick did put 14 executives in charge in his absence.

The recent events in leadership changes at Uber make it "a poster child for what can happen when start-up culture goes wrong" (Hook, 2017). Management was poorly organized since Uber's creation. This is evidenced by the notion that the CFO left 2 years ago and has not been replaced since. Uber's head of finance was put in charge of the CFO's duties; however, he also plans on leaving Uber in the next month. Once the head of finance leaves, Uber is left without anyone to govern finances. Financial operations are a crucial aspect of Uber's success, especially since recently it has had to refund drivers millions of dollars.

It is worrying to see that this company's apparent leadership vacuum is unprecedented and that its business model is not altered to accommodate to the changing market as well as its competitors. Uber faced several other hurdles throughout the past year. Among those includes sexual harassment and sexism reports filed by employees, employing a software program that misled regulators, and mishandling the medical records of a woman who was raped by an Uber driver in India. Former CEO Kalanick even composed emails to his employees regarding his concern that he was not a good enough leader for Uber.

The biggest issue Uber seems to face concerns its business model. Controversies regarding the company's internal culture and its attempts at being revolutionary in self-driving research and development raise questions about how the organization is run and ought to be run. Uber's current business model relies predominantly on developing new technology. Unfortunately, this is not a preventative nor resourceful measure to deter competitors from infiltrating

the ride-sharing market, Uber's main source of profit. Before Kalanick left the company, he explained it would require a complete overhaul of the current corporate culture. How that will transform is unbeknownst to the public, and perhaps even Uber. What is known, however, is that change must be derived from the business model.

Uber's original approach is not necessarily a long-lasting one. Kalanick employed a hyperactive management style to preemptively eliminate ride-hailing market competition by gaining more money and market share from the get-go. Unfortunately, this speedy procedure did not guarantee corporate integrity, and left Uber with the impression that it had a solid business structure. Uber's major competitor, Lyft, utilizes a different business model, and even though competitively slower in its strategic moves, Lyft is closing in on Uber's market share and value. With less initial investment than Uber, Lyft now works in the same number of markets as Uber as well as major cities that competitively compete based on prices.

Other companies, such as Google and Apple, became leaders in their respected industries by slowly climbing to the top with superior technology and infrastructure. The only way this was made possible was by strong, determined leadership and strategic business models. On the other hand, Uber had one image in sight when it started: to be dominant in "the marketplace where everyone from drivers to self-driving car manufacturers would be forced to sell their services. [Unfortunately, i]t's now just as likely that Uber will be one of that industry's many players, competing in a race to the bottom on both price and service" (Mims, 2017).

Uber can learn from some of the leading companies in varying industries about how to change its business model for the better. For one, it can pursue vertical integration. In this respect, it would not solidify employee contracts with drivers. Rather, it could invest in owning fleets of self-driving cars, depending on how *Waymo v. Uber* pans out. Regardless of case turnout, it is evident that Uber requires reorganization of its business structure, model, strategies, and leadership. Kalanick's leave from Uber presents the ideal opportunity for Uber to start over and make the necessary changes to come back stronger in the market.

Sometimes, it is not merely the best technology that propels a company to lead in a market. What makes a company better than its competitors is how it constructs a unique yet strategic business model. As previously mentioned, Google may have an upper hand on Uber because of its extensive strategies and structure. Google employs generic and intensive strategies. It's one generic strategy is derived from Harvard Business School Professor Michael Porter's Five Forces Model. The purpose of this model is to maintain a broad market scope, in which products are available to everyone, regardless of location or other characteristics. The level of differentiation in this model helps the company cultivate unique capabilities, making it more competitive. This includes a variety of products and search algorithms (Thompson, 2017). To maintain this competitive advantage, Google must constantly be innovating, which is why it started looking into autonomous vehicle research and development.

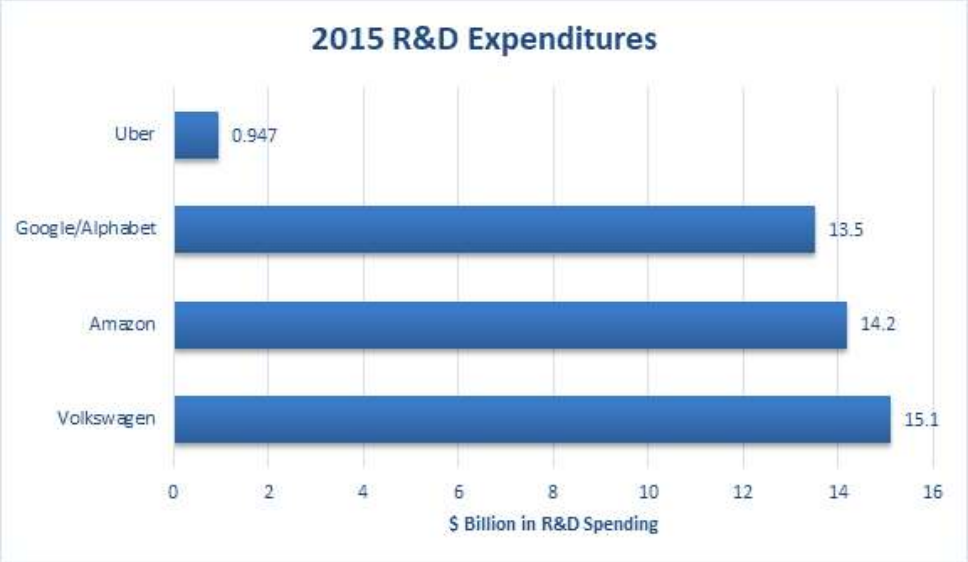
Google also employs various intensive growth strategies to expand its global presence. These strategies are listed in the following table.

Table 2: Google's Intensive Strategies

Strategy	Description
Market Penetration	This strategy works in foreign countries since Google already maintains a distinguished leadership position in America. In other countries, it directly competes with companies regarding search engines and online advertising. This strategy helps Google create a bigger share in the global online advertising market through strategies such as bundling, advertising, lowering prices, and discounting volumes to increase market share.
Market Development	This strategy is important for growth in America, specifically regarding Google's Fiber internet and TV service. It employs this strategy to offer the Fiber product to more states. Google targets non-purchasing customers in the currently targeted and new segments.
Product Development	This strategy applies to all innovative efforts, including autonomous vehicle R&D. Google is continuously developing new products and models for existing products. It spurs innovation by trying to meet the needs of the future generations.

Google maintains one of the highest research and development expenditures in the world, which makes it significantly more successful in the market than Uber. Only two companies invest in more R&D spending than Google, those being Volkswagen and Amazon. In 2015-2016, Volkswagen was leading with $15.1 billion and Amazon took second with $14.2 billion. Google followed closely behind with $13.5 billion (Fox, 2016). This year, Google increased its R&D spending on a monthly and quarterly basis. The average quarterly expenses amount to $3.942 billion, which was recorded this March, 2017. The closest benchmarks are Facebook, coming in at $1.834 billion and Microsoft at $3.355 billion per quarter (YCharts, 2017). Uber, on the other hand, pales in comparison with its research and development spending. In 2015, its R&D expenses amounted to only $94.7 million, which is only 7% of Google's spending during that same year (Statistia, 2017). Uber has the largest expense category in sales and marketing. In 2015, these expenses were $295 million, $50 million more than the prior year. While sales and marketing expenditures increase, the R&D expenses only marginally increase at Uber. In 2014, it amounted to $65.9 million, and as previously mentioned, by 2015, R&D expenses amounted to $94.7 million (Solomon, 2016). Regardless, these expenditures are incomparable to the Google R&D powerhouse. Google has a massive upper hand on Uber concerning investments in research and development efforts. This is one reason it is able to remain competitive in almost and market and does not feel threatened by Uber's recent attempts at autonomous vehicle development.

Uber has not released more information concerning its finances. Therefore, R&D spending since 2015 is unknown to the public. A comparison of the R&D expenditures of the above-mentioned companies are depicted in the figure below.



As mentioned, Uber employs a different and simpler business model than Google. Its value propositions come in the form of ease of use, usefulness, and unprecedented services (Koch, 2017). This is one of the rare occasions in which a business model of proposition simplifying was successful in its initial stages. The features in Uber's value proposition helped the service rapidly gain headway in the market. However, as previously mentioned, other ride-hailing competitors are saturating the market and offering the same features. That is potentially one of the reasons Uber resorted to research and development of autonomous vehicles, even though it did not invest nearly as much as its competitors in these efforts. This was an attempt in the company's uncertain and loose business model to expand its influence in different industries to remain afloat while competitors saturate the ride-hailing market. Unfortunately, such endeavors were in vain, because the business strategy was not strong enough to predict how to handle autonomous vehicle growth in the face of competition from other leading companies.

Whereas Google relied on advertising to gain popularity and acceptance, Uber focused on word of mouth to achieve the same goal. It began as a company with small capital, but grew to have a market value of $70 billion by November 2015 (Koch, 2017). Its premature business model invoked the idea of completely disrupting the traditional experience of taxiing by radically simplifying its proposition. Its revenue model was direct, which helped it gain significant profits from each transaction. Furthermore, because customers were happy about the service, they told others about it, which meant Uber did not have to invest extensively in marketing and advertising efforts.

Because Uber has such a simple business model, it was not hard to replicate throughout the world. As soon as Uber began gaining leverage in the market,

that same market became saturated with other startups that copied Uber's basic services. These competitors now dominate numerous other major international markets. Uber would have to make astronomical profits to remove these new competitors from the marketplace. Its business model and leadership, however, did not know how to properly tackle the challenge. This is evidenced by the way it competes with Lyft, which came into the market with a different, more subtle business model, and now is Uber's main contender. Unfortunately, Uber's original business model is no longer applicable since it is spending extensive amounts of money in advertising and recruiting new drivers in an effort to keep up with those new competitors flooding the market. The future is even more uncertain for Uber now that its senior executives are gone and the company is left with no visible propositions regarding a change to the current business model.

J. LiDAR and Autonomous Vehicles

LiDAR stands for Light Detection and Ranging, which employs laser lights to create 3D maps of an environment. It determines the distance between the laser light and a surface it bounces off of. A sensor on the device determines the time it takes for the laser to travel back to its origin. In a LiDAR sensor, thousands of laser lights are dispatched at a time. When the results are stitched together, the sensor returns an accurate 3D image. The technology is now more advanced to render real-time images, which is most beneficial in autonomous vehicles. Technology such as this has the ability to steer autonomous vehicle development into a competitive market stance. In fact, the Business Insider found that between 2015 and 2020, the self-driving market "will experience a compound annual growth rate of 134%...when there will be nearly 10 million cars containing self-driving features on the road" (Goulding, Saenz, & Margulis, 2017).

Although the automobile industry is most keen on using LiDAR sensors, other industries are joining the market. LiDAR sensors are evident in manufacturing, wind farm optimization, spaceflight, and atmosphere physics. It is even employed in drones to prevent collisions from occurring since it can detect programmed obstacles. This drone application is very popular in agriculture and forestry, where farmers and scientists employ LiDAR sensors to inspect vegetation and crops. Other features are available which were never before imaginable in this sector (Goulding, Saenz, & Margulis, 2017).

Another use of LiDAR is only beginning to hit the market. In 2014, self-made Palmer F. Luckey sold his startup Oculus VR to Facebook for $2 billion. This company specializes in virtual reality hardware and software products. Now, Luckey is working on a new startup to create surveillance technology that can be installed on country borders and military bases. This technology will employ LiDAR in conjunction with infrared sensors and cameras (Wingfield, 2017). Inclusion of LiDAR sensors ensures the technology has more effective and accurate methods to monitor borders in the event of illegal crossings. Luckey's technology is not only applicable to border control, but also in perimeter security around military bases, sports stadiums, and even concert halls. Its software can be programmed to disregard certain objects, including animals,

that do not present a threat. Incorporating this type of technology into popular, large venues can enhance security and potentially prevent bombings or massacres. Several investment plans are in the works to begin this form of project development.

Before Google began developing its own LiDAR sensors, it employed the nearly $80,000 sensor made by Silicon Valley based Velodyne LiDAR, Inc. This sensor measured distances of up to 100 meters away, had a 64-beam laser, rotated 360 degrees, and took 1.3 million readings per second (Goulding, Saenz, & Margulis, 2017). Shortly after this investment, Google developed a medium-range LiDAR that sits atop a car. Waymo then created two new categories of LiDAR–short and long range. Its autonomous vehicles employ all three sensors, which is a redundancy unprecedented in the industry (Korosec, 2017). That is one reason Google was skeptical when it saw similarities with Uber's LiDAR circuit boards.

Various advancements are continuously made in LiDAR sensors for autonomous vehicles. For example, Innoviz Technologies in Israel is collaborating with a U.S. global manufacturing services company called Jabil to create less expensive LiDAR products for self-driving cars. They plan to produce solid-state devices with longer detection, ranging at 200m. At the same time, Luminar Technologies in Silicon Valley is also working to advance the range of LiDARS from 100m to 200m. Canadian company LeddarTech created one of the best LiDAR sensors for the UAV (unmanned aerial vehicles) industry called the Vu8 LiDAR sensor. This device is solid-state and compact with no moving parts. It has an unprecedented detection range of 215 meters. Furthermore, because of its fixed laser light source, both robustness and cost-efficiency are enhanced (Goulding, Saenz, & Margulis, 2017). These advancements in LiDAR technology for UAVs can be just as applicable to autonomous vehicle development.

If competitors in the industry seek to make autonomous vehicles ubiquitous and inexpensive for all, it is necessary the companies pursue development of cost-efficient LiDAR sensors. Current LiDAR sensors amount to almost $80,000 per unit. In reality, engineers want them to cost $100 to $500 per vehicle. Therefore, advancements in LiDAR sensors are required before the vision of autonomous vehicles overtaking our streets and highways becomes a reality.

K. What Constitutes a Driverless Vehicle?

Driverless vehicles will undoubtedly change the future and have a profound impact on our lives. Many of its features will provide more benefits to users than traditional cars. The first and most important benefit is safety. Secondly, driverless cars can improve traffic flow and reduce fuel consumption. Making driverless taxis more affordable also decreases the need for individuals to own vehicles, which further diminishes the issue of congested roadways. In fact, KPMG speculates, "Autonomous vehicles could increase highway capacity by up to 500 percent" (Goulding & Bonafe, 2017). These advances will also reduce the need for parking garages and lots, which is a profound issue in urban settings limited in available space. As mentioned, fuel efficiency will improve for two reasons. The first is that autonomous cars will be developed with fuel-

saving technology. Secondly, since traffic is diminished, fuel efficiency naturally increases, which then reduces carbon dioxide emissions.

It is more likely that autonomous vehicles will enhance the ability of the elderly, unlicensed, and disabled to be more mobile. Furthermore, it will alleviate some stress in long commutes. Finally, there would be significant economic gains from employing driverless vehicles. Morgan Stanley predicted in 2015 that autonomous vehicles can contribute $1.3 trillion in annual savings to the U.S. economy and amount to global savings upwards of $5.6 trillion (Goulding & Bonafe, 2017). These gains are inherent in increased productivity resulting from shorter commutes, increased fuel efficiency, and savings from accident avoidance.

Autonomous vehicles will use a combination of technology to be the most effective and efficient. LiDAR is the most prominent addition, as discussed in this paper. The other technologies include radar, cameras, positioning systems, and advanced software. Radars are beneficial in monitoring real-time speed of surrounding objects. This deters accidents. The cameras work solely for mapping and localization. Coupled with the other technologies, they help estimate distances, read signs, and distinguish pedestrians from other objects. Positioning systems pertain to precision and real-time mapping to improve safety and functionality. Finally, software derived from complex algorithms are required to analyze and make sense of incoming data (Goulding & Bonafe, 2017). If the software lags in any regard, it can compromise the safety and functionality of the autonomous vehicle, as well as endanger the lives of its passengers.

Precision and accuracy required in technological development will lead to significant competition between companies creating autonomous vehicles. It is anticipated that the war of self-driving vehicles will continue into the future, regardless of how *Waymo vs. Uber* is resolved.

L. What is Uber's Future?

It is uncertain what route Uber will take proceeding this lawsuit. It is highly possible that Uber will have to terminate its self-driving vehicle program, which would greatly impact its ability to remain afloat in the rapidly advancing and competitive global market. Uber was interested in pursuing development of self-driving car services to eliminate the expensive intermediary–human drivers. However, if another company other than Google achieves this goal first, Uber could be severely impacted.

What would be most concerning for Uber's future is if the FBI files a criminal case. This can amount to most of Uber's assets trickling into the pockets of Waymo. This is because it would be considered trade secret theft and economic espionage. Uber's future would be rather grim, with a substantial fine, reinstitution, and even imprisonment. Stealing a trade secret, which Levandowski is accused of, can translate to upwards of 10 years in prison (Marshall, 2017). Any other former Google employees involved in this alleged crime would be charged for conspiracy as well. Again, Uber would suffer.

Uber is head deep in an uphill battle against Google, who claims to have substantial forensic evidence to incriminate Uber and end its efforts in driver-

less vehicle research and development. Uber may lose business, to the point that it is forced to leave the market, or remain intact. One thing is certain that if Uber does advance its autonomous vehicle endeavors, it may replace the need for drivers, thus resulting in an economic downturn in job loss. Only time will tell what route this war of self-driving cars will pursue.

M. The Impacts of *Waymo vs. Uber* on our Future

This case has the potential to shape the future of intellectual property litigation. Since driverless vehicle technology can reduce the number of traffic-related deaths and accidents, create low-cost urban transportation for everyone, and relieve drivers from congested highways, it may come at a price. Just as *Apple vs. Samsung* changed the rules of intellectual property and patent warfare, so will *Waymo vs. Uber.* A University of South Carolina law professor and Stanford Law researcher explained, "We could eventually see automated driving patent wars that rival the Smartphone patent wars from several years agoeverybody is going to be infringing everybody's patents eventually" (Ohnsman, 2017). Furthermore, the fact the lawsuit is occurring over technology that is not yet producing profit demonstrates the magnitude of its impact on our future and IP law. Although people are not yet convinced about the use of and reliance on autonomous vehicles, clashing companies see substantial opportunities for growth and domination in the automobile market regarding self-driving cars. Moreover, as previously mentioned, this will undoubtedly provoke an onslaught of continuous IP warfare, in which lawyers pioneer its legality and determine the legal ramifications of patenting and employing fundamental self-driving software.

Speculation has been made about Google's pursuit of restitution via trade secret law instead of patent infringement. This may have the potential of changing the future of the legal industry. It is known that trade secret law is not necessarily considered the best method to protect technology because it presents challenges in safeguarding secrets when they are incorporated into technology sold in the global market. However, if Google wins with its trade secret allegations, it may provoke other companies to employ similar tactics in future intellectual property legal situations, instead of patent infringement (Wharton, 2017). On the other hand, if Google is unsuccessful, companies will most likely return to the previous viewpoint that if you do not have a patent encompassing the technology in question, you do not have substantial protection for your so-called invention.

Regardless of which legal action is pursued in the future, a wave of patent litigation is anticipated. This is because tech companies involved in driverless car technology are not yet sure if trade secret law is the best strategy. They also want to ensure their development is protected against other industry advancements. As a result, companies rush to file as many patents as possible to protect their inventions, even if they overlap with existing ones. This was the case in *Apple v. Samsung,* and will continue to be an issue as long as technology remains innovative.

Determining public policy pertaining to driverless vehicles will be more of

a challenge if Google succeeds with its reliance on trade secret law. This is a primary concern because in the case between Waymo and Uber, major claims were redacted *because of* trade secret law. Good public policy cannot be enacted when "all of these particulars of what makes [driverless cars] work keep getting redacted from the only public papers we have about this, which are the court pleadings" (Wharton, 2017). The major issue with resorting to trade secret law is that companies undergoing litigation will not be able to hold onto their trade secrets since public hearings make all the technology, and its 'secrets,' known to the public. This defeats the purpose of maintaining trade secrets and competitive advantages for companies in an ever increasingly competitive marketplace.

The future of the automobile industry is a little more certain now that we see sudden, rapid growth in autonomous vehicle technology. There may be "competition among a few companies or coalitions of companies that have different models of how they put the hardware and software together for driverless cars. What makes them win may not be being first; it may be some other attribute of performance" (Wharton, 2017). This suggests that patent litigation may be surpassed in the future, in which the protection of a certain company's technology will be derived from its ability to ensure more safety and better performance than its competitors.

However, it might be the case that technological growth pertaining to self-driving cars will be slowed or even halted by the litigation between Waymo and Uber. It is uncertain how long the case will take to be settled. It may be only a couple more months or it can span over several years. The point is, this case is just as uncertain as *Apple vs. Samsung*. The lawyers involved in *Waymo vs. Uber* will undoubtedly pioneer the legal field for autonomous vehicle technology and IP litigation techniques.

N. A Comparison of *Edison vs. Westinghouse* and *Waymo vs. Uber*

In the late 19th century, scientists were discovering new ways to revolutionize the electrical lighting industry. Now, during the 21st century, engineers are pioneering new ways to enhance the automobile industry. During both times, industry practitioners butted heads about the most optimal ways to provide products to the public. Thomas Edison and George Westinghouse argued over DC (direct current) versus AC (alternating current) as a means to supply electricity to all Americans at an affordable cost. Google Waymo and Uber now argue over LiDAR sensors and other technology to provide autonomous vehicles to more people at a lower cost than traditional cars.

In the *Edison vs. Westinghouse* case, Nikola Tesla was the technical senior who moved from working for Edison to having his AC patents purchased by Westinghouse. Similarly, Anthony Levandowski was the technical senior who left Google to create his own self-driving project called Otto. Similar to Tesla, this project was immediately bought by Uber. As one can see, the similarities are uncanny. The impact these individuals had on their respected industries would shape the future of electricity and self-driving vehicles.

The case of *Edison vs. Westinghouse* was pivotal in changing the way homes

were illuminated around the country, regardless of population density, rural setting, or urbanism. It shed the first rays of light on the implications of competing scientists and engineers seeking to advance their unique ideas for the greater good. Now, almost two hundred years later, this type of conflict resurfaces, but in the form of self-driving vehicles. In the past, Edison and Westinghouse employed public campaigning strategies to ascertain their influence over the selection of more affordable electric supply. Currently, Waymo and Uber employ legal tactics in the form of patent infringement claims and trade secret law to win the war. We are still uncertain what the outcome of *Waymo vs. Uber* will be, however it is more than probable that the future will be changed forever, just as our lighting world was as a result of *Edison vs. Westinghouse*.

III. Conclusion

It is anticipated that conflict between inventors will be unavoidable as the world advances and demands more technology. We saw the first signs of this in the late 19th century, when Thomas Edison and George Westinghouse feuded over DC versus AC electric supply nationwide. Such conflict continued well into the 21st century, with *Apple vs. Samsung* and now *Waymo vs. Uber.*

The war between Waymo and Uber will have a profound impact on intellectual property law, patent protection, and especially our personal lives. The idea of self-driving vehicles taking over our streets will have the potential to reduce traffic, save us the headache of unbearable commutes, protect the environment, decrease the need for personal vehicles, and save lives. Nevertheless, before the autonomous vehicle can become a widespread reality, Waymo and Uber must first settle their suit and come to terms with the notion that one company cannot maintain a monopoly over the entire automobile industry. The case further raises the implication that patents for obvious but necessary autonomous technology might not be sufficient enough to protect against a ceaseless intellectual property war relating to self-driving vehicles.

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