Case 12 Tesla: Disrupting the Auto Industry

Tesla's strategy was no secret: in 2006, chairman and CEO, Elon Musk, had announced:

"So, in short, the master plan is:

- Build a sports car
- Use that money to build an affordable car
- Use that money to build an even more affordable car
- While doing above, also provide zero emission electric power generation options
- Don't tell anyone."[1]

By July 2017, Tesla had implemented its master plan. Phase 1 ("Build a sports car") was realized with the launch of its Roadster in 2007. Phase 2 ("Use that money to build an affordable car") began in 2013 with the launch of Model S. Phase 3 ("Use that money to build an even more affordable car") was realized with the launch of Model 3 in July 2017. Providing "zero emission electric power generation options" involved, first, establishing SolarCity, which installed solar power systems; then, merging SolarCity with Tesla in 2016. The only deviation from Musk's original plan had been the introduction of Model X—an SUV derivative of Model S—in 2015.

Tesla's "Master Plan, Part Deux," which would take Tesla into integrating solar energy generation with storage, expanding to "cover the major forms of terrestrial transport" (including heavy-duty trucks), fully autonomous driving, and vehicle sharing, was outlined by Elon Musk on July 20, 2016:

"So, in short, Master Plan, Part Deux is:

- Create stunning solar roofs with seamlessly integrated battery storage
- Expand the electric vehicle product line to address all major segments
- Develop a self-driving capability that is 10X safer than manual via massive fleet learning
- Enable your car to make money for you when you aren't using it."[2]

The success of Tesla's strategy was reflected in the company's stock market performance. Despite incurring huge losses, Tesla's stock market capitalization was $55 billion on August 2, 2018. By comparison, Ford Motor Company—which in 2017 had produced 6.6 million vehicles compared to Tesla's 103,184—was valued at $39 billion. General Motors, which sold 9.6 vehicles in 2017, had a market valuation of $53 billion. The optimism that supported Tesla's valuation reflected the company's remarkable achievements during its short history—including the acclaim that has greeted its first four models of car—and investors' faith in the ability of Elon Musk to realize his mission "to accelerate the advent of sustainable transport by bringing compelling mass market electric cars to market as soon as possible."[3]

Indeed, Musk's vision for Tesla extended beyond revolutionizing the automobile industry: Tesla's battery technology would also provide an energy storage system that would change "the fundamental energy infrastructure of the world." The installation of the world's biggest lithium-ion battery at a South Australian wind farm on December 1, 2017 was a landmark in this ambition.[4]

For a technology-based, start-up company, Tesla's strategy was unorthodox. This was most clearly manifest in the scale of its ambition: not only did Musk wish to establish Tesla as one of the world's leading car companies, he also wanted to "accelerate the world's transition to sustainable energy" and, if this wasn't enough to save Planet Earth, to develop pace travel in order to make homo sapiens an interplanetary species.[5] Rather than minimizing risk and investment requirements by outsourcing to other companies, Tesla was the world's most vertically integrated automobile supplier. Instead of keeping tight control over its proprietary technology, Tesla had opened its patent portfolio to its competitors.

During the first half of 2018, Tesla's strategy was facing some major challenges. Operational difficulties in ramping up the production at its both Fremont CA auto plant and Nevada battery plant, the "Gigafactory," had prevented Tesla from reaching its target production of 5000 Model 3s per week until the final week of June—six months behind schedule. With capital expenditures in 2018 expected to reach $2.5 billion spent in 2018, cash burn remained a problem, despite Tesla's forecast that it would achieve a positive free cash flow in the second half of 2018. Meanwhile, competition in electric vehicles (EVs) was intensifying: the main feature of the March 2018 Geneva Motor Show was the number of new EVs being launched by the world's leading automakers.[6] Was Tesla's strategy consistent with its capability and the emerging situation in the world vehicle market and with the resources and capabilities available to Tesla?

Electric Cars

The 21st century saw the "second coming" of electric cars. Electric motors were widely used in cars and buses during the 1890s and 1900s, but by the 1920s they had lost out to the internal combustion engine.

However, most of the world's leading automobile companies had been undertaking research into electric cars since the 1960s, including developing electric "concept cars," and, in the early 1990s, several had introduced EVs to California in response to pressure from the state. The first commercially successful electric cars were hybrid electric vehicles (HEVs), the most successful of which was the Toyota Prius, 10 million of which had been sold by January 2017. The first all-electric, battery-powered cars (BEVs) were the Tesla Roadster (2008), the Mitsubishi i-MiEV (2009), the Nissan Leaf (2010), and the BYD e6 (launched in China in 2010), In addition, there were plug-in hybrid electric vehicles (PHEVs), which were fitted with an internal combustion engine to extend their range. General Motors' Chevrolet Volt, introduced in 2009, was a PHEV.

Other types of BEVs included highway-capable, low-speed, all-electric cars such as the Renault Twizy and the city cars produced by the Reva Electric Car of Bangalore, India. Others were for off-highway use. These "neighborhood electric vehicles" (NEVs) included golf carts and vehicles for university campuses, military bases, industrial plants, and other facilities. Global Electric Motorcars, a subsidiary of Polaris, was the US market leader in NEVs. Most NEVs used heavier, but cheaper, lead–acid batteries.

Electric motors had very different properties from internal combustion engines—in particular, they delivered strong torque over a wide range of engine speeds, thereby dispensing with the need for a gearbox. This range of torque also gave them rapid acceleration. Although electric motors were much lighter than internal combustion engines, the weight advantages were offset by the need for heavy batteries, which were also the most expensive part of an electric car, costing from $10,000 to $25,000.

Electric cars were either redesigns of existing gasoline-powered models (e.g., the Ford Focus Electric and Volkswagen's e-Golf) or newly designed electric cars (e.g., the Tesla Roadster and Nissan's Leaf). Complete redesign had major technical advantages: the battery pack formed part of the floor of the passenger cabin, which saved on space and improved stability and handling due to a lower center of gravity.

Predictions that electric cars would rapidly displace conventionally powered cars proved false. In 2017, global registrations of plug-in EVs totaled 1,223,600. Although this was a 58% increase on 2016, this still represented just 1.3% of total sales of cars and light trucks, with China the world's largest market. Forecasts of the growth in demand varied substantially—most predicted that the market share of EVs would be between 7% and 20% by 2025. Much depended on government policy: by March 2018, eight countries had announced their intention to ban the sale of new gasoline and diesel-powered vehicles at some date between 2020 and 2040. The countries where EVs had gained the highest market shares were those with the most generous government incentives. Thus, in Norway, where plug-in EVs had a 39% market share in 2017, incentives included exemption from purchase taxes on cars (including VAT), road tax, and fees in public car parks, and the right to use bus lanes. In the US, federal government incentives included development grants to the manufacturers of EVs and batteries, and tax credits for purchases of EVs. Several countries had announced a phasing out or scaling back of subsidies. The US federal government's $7,500 tax credit to buyers of Tesla cars would be halved In January 2019 and phased out a year later. The impact of lower fiscal incentives would be offset, in part, by EVs falling prices relative to conventional vehicles—in addition to lower battery prices, EVs benefitted from fewer components than conventional vehicles.

"Range anxiety"—the threat of running out of battery charge—was seen as a major obstacle to the market penetration of battery-powered EVs. However, by 2018, these concerns were dissipating. Improved battery technology had doubled the average range of EVs between 2015 and 2018. Secondly, the density of charging stations was increasing rapidly. By the end of 2017, there were 210,000 publicly available charging points in China, 43,000 in the US, 33,000 in Netherlands, and 24,000 in Germany.

Although battery-powered electric propulsion was the leading zero-emission technology available to automakers, it was not the only one: fuel cells offered an alternative. Several automakers had developed prototypes of fuel-cell cars, but in 2018 only Toyota was producing cars powered by fuel cells. The dependence of fuel cell vehicles on a network of hydrogen fueling stations was the main disadvantage of this technology.

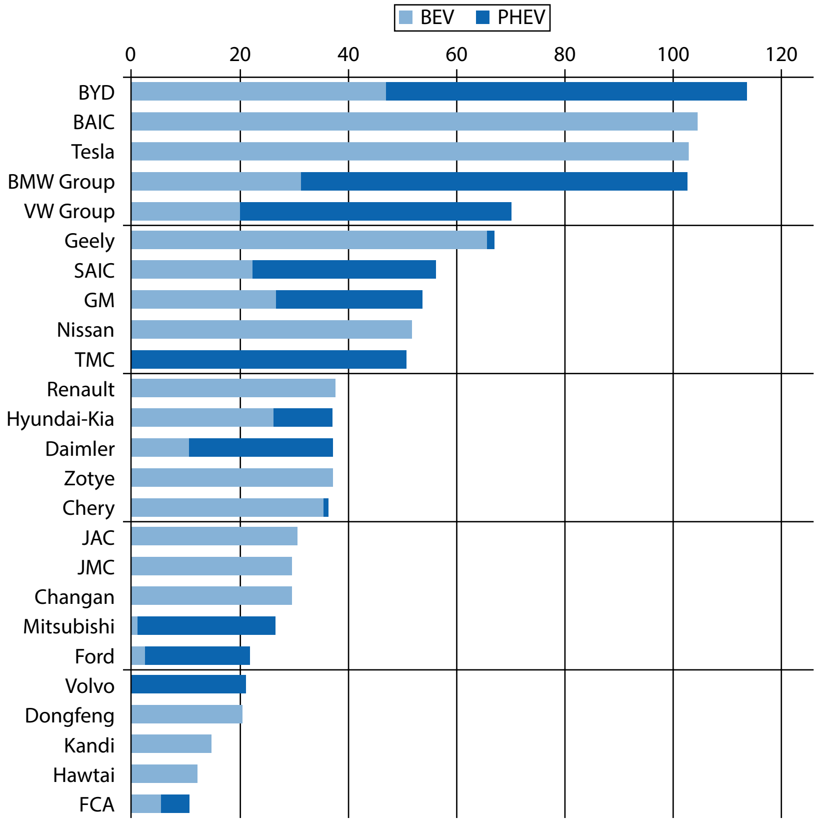
Figure 1 shows the leading suppliers of EVs in 2017.

Tesla Motors, 2003–2018

Elon Musk is a South-African-born, serial entrepreneur, who moved to Canada at the age of 17. He cofounded Zip2, a developer of Web-based publishing software, and then PayPal, which earned him $165 million when it was acquired by eBay. His next start-ups were SpaceX, which became the world's leading satellite launch company, and SolarCity, which aimed to become "the Walmart of solar panel installations."

Tesla Motors Inc., founded in 2003, was named after Nikola Tesla, a pioneer of electric motors and electrical power systems. In 2004, Musk became its lead shareholder

FIGURE 1 World's leading suppliers of plug-in electric vehicles, 2017 (thousands of units)



and chairman, and then took over as CEO in 2008. Two years later, Tesla Motors' shares began trading on the NASDAQ market.

The Tesla Roadster, launched in 2007, was a sensation. Priced at $109,000, it was a luxury sports car that could accelerate from 0 to 60 miles per hour in less than four seconds and had a range of 260 miles on a single charge. It immediately became a favorite among Hollywood celebrities and Silicon Valley entrepreneurs. The battery pack was built by Tesla from Panasonic lithium-ion cells, car assembly was by Lotus in the UK, and the car was delivered direct to the final customer without using dealers. Although only 2500 Roadsters were produced between 2007 and 2012, the huge publicity the car attracted is credited with changing public perceptions of electric cars.

Model S was the first car Tesla built at the GM-Toyota joint-venture plant in Fremont, California, a plant that Tesla acquired from Toyota for $42 million. It was a four-door, five-seater sedan, with an additional seat to accommodate two children. It offered different battery sizes (up to 85 KWh). It's launch price was between $52,400 and $72,400. The car's electronics featured a touchscreen that controlled almost all the car's functions, eliminating the need for most knobs and other controls. Its software allowed the driver to adjust the car's suspension and steering behavior and allowed Tesla to remotely monitor performance, diagnose problems, and provide updates to expand functionality. In order to control its interface with customers, Tesla rejected the traditional franchised dealer model, and set up its own directly managed retail showrooms, mainly in downtown locations. This direct sales model conflicted with the laws of several US states. These laws required retail sales of automobiles to be undertaken through independent dealers. As a result, Tesla was unable to open retail outlets in six states, including Texas.

The Tesla S was launched in 2013 to a torrent of rave reviews. It won *Motor Trend*'s Car of the Year for 2013, *Consumer Reports* gave it the highest customer satisfaction score for any car it had tested, and it was awarded the National Highway Traffic Safety Administration's highest safety rating.[7]

Model X, a sedan/SUV crossover built upon the same platform as Model S, was launched in September 2015 with a base price of $79,500. Like the Model S, it received superlative reviews; however, the difficulties that Tesla encountered in its manufacture, including problems with its falcon-wing doors, were warning signs of the much bigger manufacturing problems that would plague the Model 3.

Model 3 would take Tesla from being a niche producer of luxury cars to a volume manufacturer. However, this transition tested Tesla—and its leader—to the limit. Introduced in July 2017, problems at the Gigafactory in ramping up the production of battery packs and assembly difficulties at Fremont resulted in Tesla's target of producing 10,000 vehicles a week being deferred to December 2018. During the latter half of 2017, just 2686 Model 3s were produced; during the first half of 2018, this increased to 28,215. By the middle of 2018, very few of the more than 400,000 people who has each paid $1,000 for a place on the waiting list for a Model 3 had received their car.

In addition to EVs, Tesla has two other lines of business:

- Energy Storage. Tesla's Powerwall was a 7 kWh battery pack for home storage of electrical power. In 2016, this was superseded by the 13.5 kWh Powerwall 2. During 2017, Tesla's Powerwall accounted for almost 80% of power storage installations under California's Self-Generation Incentive Program.[8] Tesla also produced large-scale battery storage for grid storage. Tesla's power storage batteries are particularly useful for bridging asymmetries in the demand and supply of power from solar and wind generation.
- Solar Energy Systems. SolarCity installs solar energy systems in residential and commercial properties. Most of the residential systems are supplied on 20-year leases that allow customers to take advantage of federal tax credits. In October 2016, Tesla introduced its Solar Roof—photovoltaic glass roofing tiles produced at Tesla's Gigafactory 2 in Buffalo, New York.

During the first half of 2018, energy generation and storage revenues were $784m compared to $6092m from automotive.

Tesla's Technology

Tesla regards itself as a technological leader within EVs:

> Our core competencies are powertrain engineering, vehicle engineering, innovative manufacturing and energy storage. Our core intellectual property includes our electric powertrain, our ability to design a vehicle that utilizes the unique advantages of an electric powertrain and our development of self-driving technologies. Our powertrain consists of our battery pack, power electronics, motor, gearbox and control software. We offer several powertrain variants for our vehicles that incorporate years of research and development. In addition, we have designed our vehicles to incorporate the latest advances in consumer technologies, such as mobile computing, sensing, displays, and connectivity.[9]

However, for the most part, Tesla's cars combined existing automotive, electric motor, and battery technologies with few radically new innovations. In electric motors, for example, the technology was mature and Tesla's advances (including several of its patents) related to refinements in design (e.g., a liquid-cooled rotor). However, the critical technical advantages of Tesla's electric motors related to their overall integration within the electrical powertrain and the software that managed that system.

Batteries

Electrical storage was the most formidable challenge facing electrical vehicle manufacturers. The lithium-ion battery was first introduced in 1991 and became the dominant type of battery for rechargeable mobile devices. By 2005, all the automakers developing EVs had adopted lithium-ion batteries because of their superior power density. To power electric cars, lithium-ion cells are combined into modules, which are then assembled into battery packs. Battery packs are controlled by software that monitors and manages their charging, usage, balancing, and temperature.

Each of the leading automakers partnered with a battery producer to develop and supply batteries for their electric cars: Renault–Nissan with NEC, General Motors with LG Chemical, BMW with Samsung SDI. With the exception of Chinese EV giant, BYD, the automakers were unwilling to backward integrate into lithium-ion batteries.

Although most of the automakers sought to develop customized lithium-ion cells for their battery packs, Tesla used the standard 18650 lithium-ion cell, which it bought from Panasonic. This off-the-shelf lithium-ion cell is used in laptop computers and many other portable devices. Because of their small size, a large number were required. The Tesla S with an 85 kWh battery pack uses 7104 lithium-ion battery cells in 16 modules wired in series and weighs 1200 lb (540 kg). By contrast, the Nissan Leaf uses a much bigger cell: its 24 kWh battery pack comprises 192 cells in 48 modules and weighs 403 lb (182 kg).[10]

The paradox of Tesla's battery technology is that in using standard lithium cells, it has achieved superior performance from its battery packs. The key to this lies in Tesla's configuration of its cells and modules and the software for managing battery performance.

In July 2014, Tesla announced an agreement with Panasonic to build the world's biggest manufacturing plant for lithium-ion batteries. The "Gigafactory," built near Reno, Nevada, has the capacity to manufacture 35 gigawatt-hours of battery cells and 50 gigawatt-hours of battery packs. The $5 billion cost was shared between Tesla and Panasonic, with the state of Nevada providing $1.25 billion in grants and tax breaks. Tesla's goal was to ensure sufficient supply of battery packs for its cars and to reduce the cost of batteries from about $260 per kilowatt-hour in 2015 to $120 by 2020.

During 2017, the Gigafactory began producing a new cell, the "2170," which referred to the cell's size: 21 mm in diameter and 70 mm long, compared to the 18650 with its 18 mm diameter and 65 mm length. The new cell was used in the Model 3 whose 50 kWh battery pack comprises 2976 of these cells. Shortly afterward, Samsung SDI launched its own battery pack using the larger 2170 cell.

At the end of 2012, one third of Tesla's patents and patent applications related to batteries and another 28% to battery charging.[11] Tesla's battery patents were mainly concerned with the configuration of batteries, their cooling and temperature management, and systems for their monitoring and management. Although Tesla closely monitored developments in battery chemistry, very few of its patents related to the design or chemistry of lithium-ion cells. Hence, amidst excitement over Tesla's prospects in supplying battery packs for stationary power storage, *Scientific American* noted that, first, Tesla possessed no breakthrough technology in batteries and, secondly, it was doubtful whether Tesla's cost advantage in battery packs was sustainable.[12]

Battery Charging

In battery charging, Tesla's Supercharger stations offered—until recently—the world's fastest recharging of EV batteries: delivering up to 120 kWh of direct current directly to the battery, a 30-minute Supercharger permitted about 170 miles' driving, whereas a 30-minute charge from a standard public charging station would allow about 10 miles' driving. The speed of the Supercharger is a result of the architecture of Tesla's car battery packs, the high-voltage cables that feed the battery, and the computer system that managed the charging process. In June 2015, Tesla had 64 patents relating to its charging system.

At the beginning of March 2018, Tesla had 480 Supercharger stations in the US and 698 elsewhere. The total number of public charging stations in the US was about 21,000.

There were two competing technical standards for fast charging: the CHAdeMO standard, supported by Nissan, Mitsubishi, and Toyota and the SAE J1772 standard, supported by GM, Ford, Volkswagen, and BMW. Tesla's proprietary system was not compatible with either: hence, to use the large number of CHAdeMO and SAE charging stations, Tesla owners needed special adapters. In the US in January 2018, the Tesla's 390 Supercharger stations were outnumbered by 1651 CHAdeMO and 1438 SAE charging stations—though Tesla possessed the greatest number of charging points.

The different networks of charging stations had different systems of payment. In the US, the biggest network of fast-charging stations was owned by ChargePoint, which required users to purchase an annual subscription. Networks of charging stations were also operated by electricity providers: in China, the leading provider of charging stations was the State Grid. In Europe, the Ionity network was backed by BMW, Mercedes, Ford, and Volkswagen. In 2018, several European charging networks were introducing ultra-fast 350 kW chargers.

Self-Driving Cars

Tesla's first version of Autopilot, its semi-autonomous driving system, was offered as an option for the Tesla S in October 2013. Then from October 2016, all Tesla vehicles were equipped with the sensing and computing hardware for future fully-autonomous operation, with the software becoming available as it developed. Tesla was a latecomer to autonomous driving: other car manufacturers began testing driverless systems several years earlier: Ford and BMW since 2005, VW since 2010, GM since 2011. By 2018, at least 30 companies were developing their own driverless car systems. While Tesla's rivals were experimenting with fully autonomous driving systems, Tesla's emphasis was on gaining experience through collecting and analyzing the vast quantities of data generated by its Autopilot system on its entire fleet of cars: "The aggregate of such data and learnings, which we refer to as our 'neural net,' is able to collect and analyze more high-quality data than ever before, enabling us to roll out a series of new autopilot features in 2018 and beyond."[13] As a result of its distinctive approach, assessments of different companies' progress in bringing fully autonomous driving to market viewed Tesla as lagging behind its rivals: Navigant Research placed Ford, GM, Renault-Nissan, and Daimler as leaders, with Tesla a distant 12th.[14] *Investor's Business Daily* observed that: "Tesla largely has eschewed self-driving alliances and acquisitions in favor of developing its Autopilot feature, which has some autonomous capabilities. Although the company has amassed a vast trove of data from Autopilot usage that could improve performance, Tesla is now seen at risk of falling behind other carmakers on rolling out full autonomy."[15] Tesla's preference for radar over lidar sensors was viewed as a particular weakness of its self-driving technology.

Tesla Opens Its Patents

Early on, Tesla had rigorously protected its intellectual property. Its 2012 Annual Report stated:

> Our success depends, at least in part, on our ability to protect our core technology and intellectual property. To accomplish this, we rely on a combination of patents, patent applications, trade secrets - including know-how employee and third party non-disclosure agreements, copyright laws, trademarks, intellectual property licenses and other contractual rights to establish and protect our proprietary rights in our technology.[16]

Hence the amazement when, on June 12, 2014, Elon announced:

> Tesla Motors was created to accelerate the advent of sustainable transport. If we clear a path to the creation of compelling electric vehicles, but then lay intellectual property landmines behind us to inhibit others, we are acting in a manner contrary to that goal. Tesla will not initiate patent lawsuits against anyone who, in good faith, wants to use our technology.[17]

The announcement was followed by a flurry of speculation as to the reasons why Tesla would want to relinquish its most important source of competitive advantage in the intensifying battle for leadership in EVs. Tesla's motivation was unclear. Was it Elon Musk's personal commitment to saving the plant from fossil-fueled vehicles, or a calculated judgment that Tesla's interest would be better served by speeding the development of an EV infrastructure rather than by holding on to its proprietary technologies? Certainly, diffusing its technology would help Tesla influence technical standards and dominant designs with regard to batteries, charging technology, electric powertrains, and control systems. Writing in the *Harvard Business Review*, Paul Nunes and Joshua Bellin emphasized Tesla's strategic position as an innovator within its ecosystem; by adopting an open-source approach to its technology, Tesla could strengthen its centrality within its ecosystem.[18]

Professor Karl Ulrich of Wharton Business School emphasized the limits of Tesla's patent portfolio: "I don't believe Tesla is giving up much of substance here. Their patents most likely did not actually protect against others creating similar vehicles."[19] This observation was reinforced by the recognition that Tesla's patent portfolio was smaller than those of most major auto companies (Table 1). Tesla's strengths were much more in the know-how needed to combine existing technologies in order to optimize vehicle performance, design, add-on features, and the overall user experience. Figure 2 shows the annual numbers of patents received by Tesla.

Tesla's Future

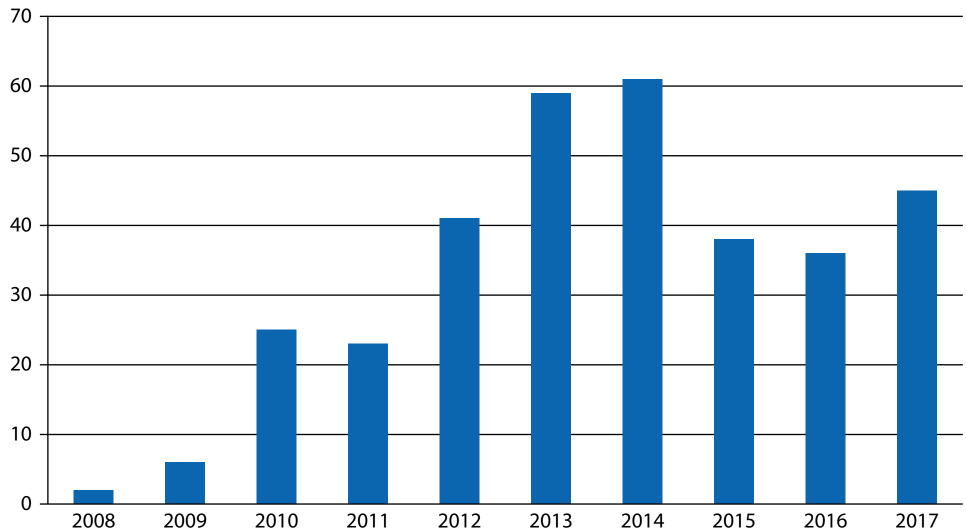
During the first half of 2018, Tesla's dominant priority was resolving its operational difficulties. At its Nevada Gigafactory and Fremont auto plant, employees worked

TABLE 1 Automobile companies' numbers of patents relating to electric vehicles, 2012 and 2014

Company	2012[a]	2014[b]
General Motors	686	370
Toyota	663	201
Honda	662	255
Ford	446	459
Nissan	238	102
Daimler	194	48
Tesla Motors	172	84
Hyundai	109	n.a.
BMW	41	n.a.

Notes:
[a] M. Rimmer, "Tesla Motors: Intellectual Property, Open Innovation, and the Carbon Crisis," Australian National University College of Law (September 2014).
[b] Includes only patents that specifically mention "electric vehicles." http://www.ipwatchdog.com/2015/09/02/electric-vehicle-innovation-america-tops-japan/id=61178/, accessed March 8, 2018.

FIGURE 2 Patents awarded to Tesla Motors Inc. and Tesla Inc., 2008–2017



desperately to boost the output of its battery packs and Model 3 cars. During most of June, Elon Musk was sleeping at the factory amidst "production hell" as the company struggled to achieve its weekly production target of 5000 Model 3s. Unless Tesla could deliver cars to its waiting list of about 360,000 customers, there was a risk they might request refunds on their $1000 deposits and defect to the other major automakers that were launching new models of BEVs. Table 2 shows just a few of some of the BEVs available early in 2018. Competition in the sector would continue to

TABLE 2 Tesla's rivals: Some of the battery-electric cars available in March 2018

Model (base model)	Type	Base price	Range
Tesla 3	5-seat compact sedan	$35,000	220 miles
Tesla X90D	Crossover SUV	$93,500	257 miles
Tesla S70	5-seat +2 compact sedan	$72,700	234 miles
Nissan Leaf	5-seat compact sedan	$29,990	150 miles
GM Chevrolet Bolt	5-seat compact sedan	$36,620	238 miles
Kia Soul EVi	subcompact, crossover SUV	$32,250	90 miles
Smart Fortwo (Daimler)	2-seat city car	$25,750	80 miles
Mitsubishi i-MiEV	4-seat sub-compact sedan	$23,845	80 miles
BMW i3	5-seat compact sedan	$42,400	114 miles
Ford Focus Electric	5-seat compact sedan	$29,120	73 miles
FIAT 500e	5-seat compact sedan	$32,995	84 miles
Jaguar I-PACE	Crossover SUV	$69,500	240 miles
BYD e6	5-seat compact sedan	$35,000	250 miles

increase—all the world's major automakers were committed to increasing the number of BEV models they offered. Moreover, several of the world's leading producers of BEVs—BYD, BAIC, and ZD, in particular—had yet to establish themselves in Western markets.

Given these short-term priorities and the financial constraints that Tesla faced, the company might have been expected to limit the scope of its longer term projects. However, during summer 2018, Tesla showed little sign of moderating its ambitions. Internationally, it sought to broaden its presence in Europe and Asia. It was expected to announce a European Gigafactory to manufacture battery packs and assemble Tesla cars. In China, where Tesla has 15 retail outlets, it planned to open an assembly plant by 2020. Tesla's vertical integration strategy makes international expansion especially challenging—it has to develop its own retail network and charging network and, if it is to produce within its overseas markets, it also needs to develop battery plants. At the end of June 2018, it had just 347 retail stores worldwide.

Tesla was also committed to introducing a heavy-duty truck. The Tesla Semi, with a hauling capacity of 40 tons and range of 500 miles, will begin production in 2019. By January 2018 preorders had been received from Walmart, PepsiCo, Anheuser-Busch, Sysco, UPS, DHL, and several other companies.

However, Elon Musk's ambitions were not limited to Tesla. His other major venture, SpaceX, is world market leader in commercial space launches. The successful launch of its massive Falcon Heavy rocket on February 6, 2018 reinforced its leadership. Other ventures include the Boring Company, which develops innovative solutions to tunneling in order to relieve urban congestion, the "hyperloop" project to develop ultra-high-speed intercity travel, and Neuralink, which seeks to combine human and artificial intelligence.

Conventional business wisdom dictates that sustaining diverse and grandiose long-term ambitious while grappling with short-term operational difficulties is a recipe for disaster. However, Elon Musk had the capacity to deploy his long-term vision to inspire faith in Tesla that dwarfed short-term fears. For example, the impact of Tesla's dismal 4th quarter results announced on February 7, 2018 was dwarfed by the publicity arising from SpaceX's launch of a Tesla Roadster into space just the day before. Fortunately, the quarterly financial data released on August 1, 2018 did not require such gimmickry: despite a net loss of $718m, Tesla's smaller-than-expected cash outflow and projections of profitable upcoming quarters reinforced hopes that Tesla could become a profitable volume manufacturer of cars.

Appendix

TABLE A1 Tesla Inc.: Selected financial data

($ millions)	2017	2016	2015	2014	2013	2012	2011	2010
Revenues	11,758	7000	4046	3198	2013	413	204	117
Gross profit	2222	1599	923	882	456	30	62	31
SG&A expenses	2477	1432	922	603	286	97	52	46
Research & development	1378	834	718	465	232	274	209	93
Operating profit	(1632)	(667)	(717)	(187)	(61)	(394)	(251)	(147)
Net profit	(1961)	(674)	(889)	(294)	(74)	(396)	(254)	(154)
Cash	3368	3393	2286	1906	846	458	255	100
Total assets	28,655	22,664	8067	5849	2417	1114	713	386
Total long-term obligations	15,348	10,923	4145	2772	1075	450	298	93
Cash flow from operating activities	(61)	(124)	(525)	(57)	265	(264)	(114)	(128)
Cash flow from investment activities	(4419)	(1416)	(1674)	(990)	(249)	(207)	(176)	(180)

TABLE A2 Extracts from Tesla's income statements: Years 2015, 2016, and 2017; and first six months of 2018

($ millions)	2018 (to June 30)	2017	2016	2015
Revenues				
Automotive sales	5680	8535	5589	3432
Automotive leasing	413	1107	762	309
Total automotive revenues	6093	9641	6351	3741
Energy generation and storage	784	1116	181	14
Services and other	534	1001	468	291
Total revenues	7411	11,759	7000	4046

(Continues)

TABLE A2 Extracts from Tesla's income statements: Years 2015, 2016, and 2017; and first six months of 2018 (*continued*)

($ millions)	2018 (to June 30)	2017	2016	2015
Cost of revenues				
Automotive sales	4621	6724	4268	2640
Automotive leasing	241	708	482	183
Total automotive cost of revenues	4863	7433	4750	2823
Energy generation and storage	706	875	178	12
Services and other	767	1229	472	287
Total cost of revenues	6336	9536	5401	3123
Gross profit	1075	2222	1599	924
Operating expenses	2294	3855	2267	1640
Loss from operations	(1218)	(1632)	(667)	(717)
Interest income	10	20	9	2
Interest expense	(313)	(471)	(199)	(119)
Other (expense) income, net	13	(125)	111	(42)
Loss before income taxes	(1508)	(2209)	(746)	(876)
Net loss	(1527)	(2241)	(773)	(889)

Notes

1. https://www.tesla.com/blog/secret-tesla-motors-master-plan-just-between-you-and-me?redirect=no, accessed March 6, 2018.
2. https://www.tesla.com/blog/master-plan-part-deux
3. "The Mission of Tesla," (November 18, 2013), http://www.teslamotors.com/en_GB/blog/mission-tesla, accessed July 20, 2015.
4. The 100 megawatt-hour battery was Musk's response to the power crisis that had gripped South Australia early in 2017. Musk promised to have the battery farm up and running within 100 days or supply it free of charge. The project was completed in 62 days. See: "Tesla Delivers the World's Biggest Battery—and Wins a Bet," *Wall Street Journal* (November 23, 2017).
5. "How Elon Musk Does It," *Economist* (February 10, 2018).
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7. Tesla Motors, Inc. 10-K report for 2014: 4.
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