The impact investor

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FREMONT AND SPARKS

Elon Musk is trying to change more worlds than one. Despite his gifts, failure is most definitely an option

IT WAS not, in the end, the much anticipated take-off that took your breath away. It was the landings. Eight minutes after they had lifted the first SpaceX Falcon Heavy off its pad at Cape Canaveral on February 6th, two of its three boosters returned. Preceded by the flames of their rockets, followed by their sonic booms, the slender towers touched down on neighbouring landing pads a fraction of a second apart. After such power, such delicacy.

Up above the atmosphere, the rocket's second stage opened its fairing to reveal its cargo: a red roadster made by Tesla, a company which, like SpaceX, is run by Elon Musk. The dummy sitting at its wheel wore a SpaceX spacesuit, David Bowie played on the stereo, the motto from "The Hitchhiker's Guide to the Galaxy"—"Don't panic!"—was displayed proudly on the dashboard. In the background, the great blue disk of the Earth receded. Down below, a million geeks swooned.

Topping off an extraordinary technical achievement with flamboyance and a touch of silliness is typical of Mr Musk. It should not be mistaken for a lack of seriousness. Mr Musk does not simply want to have fun building rockets and fast cars. Nor is he running two multi-billion-dollar companies just to become rich, or to beat rivals. He wants to open up fundamental opportunities with which he thinks the market would not trouble itself. The purpose of SpaceX is to make humanity an interplanetary species, and thus safe from global catastrophe, by providing it with the means to build a civilisation on Mars. The purpose of Tesla, emblazoned on the wall of its factory in Fremont, California, is: "To accelerate the world's transition to sustainable energy".

Creating either of these companies would be a signal achievement. That the same person should have built and run them in parallel is remarkable. It shows that Mr Musk has special talents as a strategist, manager and source of inspiration, as well as lofty ambitions.

Started in 2002, and with its first successful launch in 2008, SpaceX has come to dominate the commercial-launch market (see chart on next page). In 2017 it launched 18 rockets—more than the rest of America and Europe combined. Its Falcon 9 is easily the cheapest big launcher on the market, in part because it is the only one that can fly its boosters back to Earth for reuse. (Even at SpaceX there are glitches: the third of the Falcon Heavy's boosters hit the sea at 500km an hour, rather than touching down gently on the barge provided for it.)

Tesla, meanwhile, showed that an electric car could be every bit as good as the best petrol car—better, according to many owners—and, in so doing, very quickly established a premium brand. Tesla's Model S, which sells for $70,000 and up, has been the bestselling electric car in America for the past three years. There have been more than half a million orders for its new Model 3, an attempt to capture the mass market that sells at half the price of the Model S.

Both companies beat the incumbents in their industries by combining a clear view of how technology was changing the scope of the possible with a fierce devotion to pushing that technology even further. That is familiar from other Silicon Valley success stories. But the fact that the firms' goals go beyond products and profit set the two companies apart from, say, Jeff Bezos's Amazon or Larry Page's Alphabet. In "The Complacent Class", which laments lost entrepreneurial vigour, Tyler Cowen, an economist, cites Mr Musk as a counter-example, today's "most visible and obvious representative of the idea of major progress in the physical world." The head of one of the biggest private-equity funds in the energy industry says that nobody else is driving either clean technologies or new business models forward as much as Mr Musk: "The world needs Elon Musk!"

But the achievements, the world-historical ambitions and the adulation they ▸▸

have brought do not mean that Mr Musk can count his high-torque photovoltaic astro-chickens just yet. The very next words out of that fund manager's mouth were "Short Tesla." Production of the crucial Model 3 remains badly behind schedule, and the company's finances look stretched. Christian Hoffmann of Thornburg, an investment firm, calls buying Tesla shares on the basis that Mr Musk will quickly solve its problems a "James Bond trade": "He needs to dodge the avalanche, avoid the gunfire, ski off the cliff, pull the ripcord and glide to safety so that he can save the world."

Maybe he can. In 2008 both SpaceX and Tesla were within days of bankruptcy. Now they have a combined value of more than $80 billion. But the chronic problems at Tesla mean that this is Mr Musk's highest-stakes year since then. To appreciate the risk, look at what Mr Musk has, and hasn't, achieved so far, and at the qualities that have allowed him to do so.

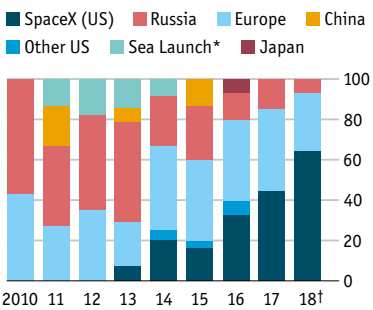
Lightly Seared on the Reality Grill

Of the two goals, colonising Mars and contributing to the greening of the Earth, the second sounds more plausible, not least because it is widely shared. But SpaceX is in much better shape than Tesla. The firm is privately held (Mr Musk, who has a controlling stake, says it will remain so). In 2015 Google and Fidelity invested $1bn, and subsequent filings put the firm's value at over $21bn.

SpaceX has a commitment to modular design, vertical integration and continual improvement not previously seen in the space business. The Falcon Heavy, for example, used 28 Merlin engines, all of them built from scratch at the company's plant in California, all of them much more powerful than the Merlins that powered the first Falcon 9 in 2012. The firm's achievements have established it as a satellite launcher and as a logistics company, with

Hyperspace bypass

Commercial launch market, % of total



*Russia, US, Norway and Ukraine †Forecast

Source: SpaceX

its reusable Dragon spacecraft providing supplies to the International Space Station. This business will expand when, probably some time next year, the Dragon is certified to ferry astronauts up there, too.

The innovation is continuing—which is just as well, because within a few years it may face serious competition from Blue Origin, a rocket company owned by Mr Bezos which is likely to prove more sprightly, and more ambitious than those SpaceX has faced to date. Treating the Falcon rockets as cash cows, SpaceX is moving its development efforts on to an even larger (and possibly also cheaper) launcher, known as the BFR, and a constellation of thousands of communication satellites, an undertaking that would exploit its ability to get things into space cheaply so as to provide high-speed internet access all around the world. Morgan Stanley, an investment bank, reckons that could bring the company's value up to $50bn—though it will require mastering a new manufacturing challenge and facing new competitors.

Tesla is already worth more than that: roughly $60bn. That is more or less the same value as GM, which makes 80 times as many cars. In 2004 Mr Musk took a big stake in Tesla, founded the year before, and became chairman; in 2008, when the company faced closure, he became CEO. It went public two years later and quickly became the world's leading electric-car company; last year it produced over 100,000 vehicles. At the Model 3's launch Mr Musk claimed that, by the end of 2017, it would be churning out 5,000 a week.

It wasn't. In fact it was nowhere near it. It made just under 2,500 Model 3s, half that promised week's worth, in the entire fourth quarter of 2017. It now says it will hit 5,000 a week later this year; a previous claim that it would go on to 10,000 a week by the end of the year has been dropped. Meanwhile, it faces ever stiffer competition. The world's established carmakers are getting into the electric game. Other new entrants include Alphabet, which owns Waymo, an autonomous-car firm that began as part of Google.

Given all this, many think Tesla's valuation unsustainable. Mr Musk sometimes seems to see their point. "This market cap is higher than we have any right to deserve," he said when speaking to an audience of state governors in July 2017, soon after the company's valuation first topped that of Ford. To reassure shareholders of Mr Musk's commitment, in January Tesla proposed a new pay plan that ties all his earnings to strict milestones for revenues, annual profits (of which, so far, it has made none at all) and market capitalisation. The last of these sets a target of $650bn by 2028. That is roughly the current value of the world's largest ten carmakers combined.

To accomplish such rapid growth—all but unheard of in a company its size—Tesla has to become more than just the successful mass-market car company it still isn't. It has to become an industry in and of itself, providing better, battery-powered alternatives to the internal-combustion engine wherever it is found, from lawnmowers to juggernauts, and also selling battery-stor-

Elon's just this guy, you know...

Selected events

Elon Musk moves from South Africa to Canada

Moves to America, studies at University of Pennsylvania

He and his brother start Zip2

Moves to California

Compaq acquires **Zip2** for $341m; Musk gets $22m

Founds **X.com**, an online payments business

X.com merges with **Confinity**, which owns money transfer service PayPal

Musk replaced as **PayPal** CEO

PayPal sold to **eBay** for $1.5bn; Musk gets $165m

Musk founds SPACEX

Founds SolarCity with two cousins

TESLA

Leads series A investment round in **Tesla Motors**; becomes chairman

First **Falcon 1** launch attempt fails

Fourth **Falcon 1** launch succeeds

Launches its first Roadster; Musk becomes CEO

First **Falcon 9** launch succeeds

IPO raises $226m

Starts deliveries of Model S sedan

Issues $2bn in bonds to pay for Gigafactory

Unveils "**Hyperloop**" transportation concept

Announces OpenAI a not-for-profit research company

First successful landing of **Falcon 9** first stage

Falcon 9 flight explodes

Launches Model X SUV

Unveils Model 3. Announces it will acquire **SolarCity** for $2.6bn in stock

Founds *NEURALINK* a mind-computer interface company

Creates THE BORING COMPANY

Tesla car sent into space

First **Falcon Heavy** launch succeeds

Cumulative sales reach 250,000 units

Source: *The Economist*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Why should anyone believe such hubris? One argument is that electric vehicles, designed and built the Tesla way, are both better and potentially much more profitable than the alternatives. A recent tear-down analysis by McKinsey, a consultancy, concluded that electric cars designed from scratch are much better (for example, on range and interior room) than those that are modified versions of petrol-fired cars and still made on existing production lines. And by keeping a great deal of its cars' engineering in-house, as SpaceX does with its rockets, Tesla may stand to be much more profitable than its current competitors. Jeffrey Osborne of Cowen, an investment bank, calculates that 80% of the value of a Tesla is created in its manufacturing plant in Fremont, some three to four times the share for a typical passenger car.

What is more, electric-car factories could be a lot more productive than those for internal-combustion engines; whereas a conventional car has about 2,000 components in its drive chain, a Model S has fewer than 20. Mr Musk says that these advantages mean he can create a "machine that makes machines" qualitatively better than anyone else's. But the so-far-pitiful production of the Model 3 suggests that, at best, that machine is proving hard to bed in. It also means Tesla is not getting the revenues it based its spending plans on.

The "gigafactory", a battery plant in which Tesla and Panasonic are investing $5bn, also has its problems. The investment is based on the idea that Tesla needs economies of scale in its battery business only achievable in a factory that is highly automated and utterly huge. Mr Musk says the gigafactory—near the town of Sparks, Nevada—will be, by footprint, the biggest building in the world (see page 61).

Romit Shah of Nomura/Instinet, a bank, estimates that in late 2014, when the gigafactory was announced, global battery demand for electric vehicles was about 12 gigawatt-hours a year. Nomura thinks the gigafactory alone will have 40GWh of capacity by the end of this year. In 2016 Tesla bought SolarCity, a solar-power and home-energy-storage firm that Mr Musk had helped two of his cousins set up, for $2.6bn. One of the reasons was to soak up some of this huge supply of batteries. (Another was that SolarCity was drowning in debt; the bail-out of the CEO's side-gig was controversial, but Tesla shareholders ended up backing it by a large margin.) Storage, not cars, may be the biggest market for batteries long-term: it was not an accident that the company changed its name from Tesla Motors to just Tesla last year.

Getting the gigafactory up to its promised speed and scale is vital to Mr Musk's plans. It has proved frustratingly difficult. A visit to Sparks late last year found J.B. Straubel, a co-founder of Tesla and now its chief technical officer, completely consumed with the automation efforts: "Ramping up such a complicated machine," he says, "on this unprecedented timescale, has never been done before." Last October Mr Musk tweeted that the project was in "Production hell, -8th circle".

A Series Of Unlikely Explanations

While Mr Straubel struggles in hell, Tesla burns money as the Falcon Heavy burns kerosene. Barclays, a bank, reckons that Tesla will consume $4.2bn this year. With just $3.4bn in cash at the end of 2017 Mr Musk will almost certainly need another injection of funds by the middle of the year—and maybe more later. Mr Osborne of Cowen reckons Tesla's capital expenditures will amount to $20bn-$25bn between 2017 and 2020. Jim Chanos of Kynikos Associates, a prominent short-seller who predicted the collapse of Enron, recently denounced Tesla's history of missing deadlines and targets as meaning that "the equity is worthless."

As yet, though, the shareholders do not seem to agree. Tesla's stock price has held fairly steady; people might even buy more, if offered. They invest because, as a SpaceX insider puts it: "They believe in Elon." When he says, as he did on February 7th, "If we can send a roadster to the asteroid belt we can solve Model 3 production," many happily accept the non sequitur.

His power to inspire is not limited to the public and his investors. It attracts bright people to his companies, where they work with a passion which matches his own (and may well feel his temper all the same). Mr Straubel insists that "the mission really matters—that's why we're working so hard." Gwynne Shotwell, SpaceX's chief operating officer, says Mr Musk's extreme goals for SpaceX are "incredibly invigorating" and help her recruit the very best pros-

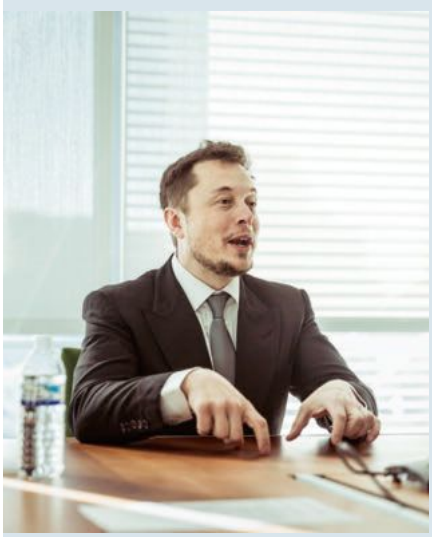
The Boring Company

Tunnel vision

HAWTHORNE

Digging into Elon Musk's newest project reveals his management style

ELON MUSK can seem flakily up himself. His newish tunnelling business appears to be a case in point. The project has a cute name (the Boring Company), a wacky way of raising money (an "Initial Hat Offering" raised almost $1m by selling baseball caps), a physicist-knows-best approach to a social problem (putting private cars on high-speed underground trolleys to reduce urban congestion) and a quirky, memorable goal (to produce a tunnelling machine that goes faster than a snail, in this case a snail called Gary). But it also showcases the techniques that have made Mr Musk a success.



Very Little Gravitas Indeed

Chris Anderson, the curator of TED, a non-profit organisation that spreads ideas, says that Mr Musk is "uniquely good at system-design thinking". He reduces thorny problems to what he sees as their essence—typically expressed in terms of physics—and then extends his analysis to technologies, business systems, human psychology and design in an attempt to solve the issue.

In the case of tunnelling he found that current machines are much slower than physics suggested they could be. The solution, he decided, was standardisation and fixed prices, removing the option for passing extra costs up the chain. That is quite like the genesis of SpaceX, where he observed that launches were much more costly than physics required and prescribed similar solutions.

He then created a culture that emphasised experimentation, rapid learning and incremental improvements, along with a system of sticks and carrots that pushed people to squeeze out inefficiencies. Thus pushed, managers at the Boring Company have found a way to convert the muck tunnelling leaves behind into something like cinderblocks.

City planning is the field in which the idea of a "wicked problem"—one resistant to any definitive solution because of contradictory requirements—was first invented. Its practitioners are highly sceptical of technofixes. But Mr Musk's employees are fired up, which is just the way he likes them.

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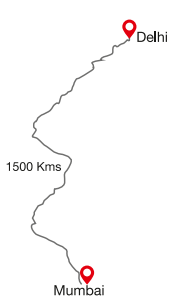

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pects: "We rarely lose a candidate." Outside observers agree. Vinod Khosla, a Silicon Valley venture capitalist, says "Elon's mission is motivating so many people. This is common at small social enterprises, but very rare at scale."

But Mr Musk's companies rely on more than just his ideas and allure. Two other attributes stand out: his approach to risk and his embrace of complexity.

His way with risk is unlike that of his Silicon Valley peers, according to Amy Wilkinson of Stanford. She says entrepreneurs rarely take big risks on another venture after they have scored a stonking success. The few that become serial entrepreneurs typically stay within the same industry.

Mr Musk, having sold his first company, Zip2, to Compaq for $341m in 1999, ploughed the gains straight into X.com, an online bank that later become PayPal. Within 18 months of selling that to eBay for $1.5bn he had invested almost all his gains in Tesla and SpaceX. He takes on more risk with each new round of financing.

A risk-taking boss does not mean a cavalier company. Ms Shotwell points to a dichotomy in attitudes to risk at SpaceX. It is in many ways a very unified operation. Most of the managers and engineers have desks in the manufacturing facility, in among production experts and line workers. People circulate easily, trying out new ideas and learning from colleagues who, in a more traditional structure, they might never meet. But the designers and engineers are encouraged to be mavericks, whereas the operations and manufacturing teams are most definitely not. A former senior executive says that Mr Musk takes the risks he thinks he has to, but does not run extra ones just to cut corners. Another insider describes him as "a risk taker for himself, but a risk mitigator for everyone around him".

Looked at like that, his risk-taking may fit with his greater purpose; a gamble, perhaps a self-sacrifice, undertaken as part of his urge to fend off catastrophe. His faith in technological progress is, unusually for Silicon Valley, explicitly tinged with darkness: he is a paranoid optimist. Thus Tesla offers amazing air filters on the basis that they will help passengers "survive a military grade bio attack".

As befits a paranoid optimist, his broad hopes for the future are also tied up with fears. Some, such as climate catastrophe, are fairly widespread, some are more unusual—the need for civilisation to be backed up to another planet, just in case. He has been one of the loudest voices warning Silicon Valley and the world of the threats posed by out-of-control artificial intelligence (AI) and has set up a not-for-profit outfit devoted to lessening it.

Mr Musk's second defining characteristic is the willing embrace of complexity. "Complexity will happen inside or outside the organisation," says Antonio Gracias of Valor, a venture capitalist who sits on the boards of both Tesla and SpaceX. "Elon's view is that if you have it inside, you can manage it better…and can build faster, cheaper and to higher specifications." His approach echoes that of Andy Grove, a legendary former boss of Intel whose investments in integrated chipmaking turned the firm into a global powerhouse. It eliminates the "margin stacking" enjoyed by layers of suppliers and allows a continuous improvement of what the companies offer. Understanding all the linkages and dependencies in such a system is a huge challenge; so far, Mr Musk has met it.

This systems thinking can be strategic; you can see it in the way SolarCity has provided more in-house demand for the gigafactory, or in SpaceX's plans to use its launch capability to create a vast new constellation of satellites. But it figures in the smallest decisions as well as the biggest. Spurning the received opinion that micromanagement is a bad trait in bosses, Mr Musk prides himself on being a "nanomanager". "Unlike other CEOs he'll really walk through the technology with you," says a veteran engineer at one of his firms. Mr Gracias says he is the best zoom-in manager he has seen: "Elon can be at the macro, see everything that's highly disruptive, and then can zoom all the way down to the micro, down to the door handle."

One worry is that such intense focus, divided between two companies, cannot last—especially as Mr Musk endlessly plays around with yet more ideas, such as ultra-high-speed intercity travel (a scheme called "hyperloop" which he conceived of in 2013 and is now revisiting), novel tunnelling equipment to solve congestion on the streets (see box on previous page) and mind-computer interfaces to keep humans—or at least cyborgs—a step ahead of the AI menace (a startup called Neuralink). With Tesla seeming to need all the attention it could possibly get, these tangents appear self-indulgent. At the same time, for many of the faithful the endless flow of ideas further burnishes his image.

The Ends of Invention

So Much For Subtlety

Another worry is that Mr Musk's technological insight might let him down. For example, he believes that cameras and ever smarter software will be good enough to make Teslas fully autonomous. This puts a huge demand on the company's AI team, and goes firmly against the technological grain. Other, currently more advanced, autonomous carmakers insist that lidar sensor systems are also vital. If they are right, Tesla will for the first time find itself on the technological back foot, and might even come to look unsafe (which would surely gall Mr Musk deeply).

And then there are the overly ambitious targets. Mr Musk routinely gets his teams to do things no one else can do, but they rarely pull it off by the date he originally set. Do not expect fleets of BFRs to head for Mars at any date he may suggest. Such dates are goads as much as targets. They drive the enthusiasts—and him—even harder. This has often proved forgivable. "Even if he misses his deadline, we are betting that he will still get there first," as one equities analyst puts it. The Falcon Heavy is a case in point. When Mr Musk unveiled the design in 2011, he said it would be on the pad in 2013. The task turned out to be a lot more difficult than that, and continual improvements to the Falcon 9 made it rather less necessary. But SpaceX was making money. Tesla is not.

It may be that Mr Musk's appeal will keep the company's finances together. It may also be that, even in failure, he achieves his goals. Now there is one gigafactory, others may see its merits and build more. Now there is a market for high-quality electric cars, others will expand it. Indeed, if a truly big Silicon Valley fish wanted to do so, and Tesla stumbled badly, buying it might be a good way in.

Asked about a new space race after the Falcon Heavy launch, Mr Musk was enthusiastic: "Races are exciting." They also let pacesetters guide the field. If you start a race in the direction you think people should be going, it may not, in the end, matter if you win.

And if Mr Musk does not personally deal the death blow to the internal-combustion engine, he will always have a gorgeous car in space to console him. ■