

SpaceX – Innovation Assessment A

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Contents

- Background
- History of SpaceX
- SpaceX Internal Structures & Management
- Innovation & Technologies
- The extent of SpaceX success
- Conclusion & summary of Satell's Typology



Background

- Elon Musk is the founder of SpaceX, he was born and raised in Pretoria, South Africa until he moved to Canada and then America at the age of 18 where he studied at the university of Pennsylvania. He started his business career early after developing and building his first computer game at the age of 12 which he then sold to the “Office & Technology Magazine” for \$500! (1)
- His use of “tech” in his business career continued as he then co-established and sold two businesses, Zip2 and PayPal, which netted him personally \$22 million and \$175.8 million respectively. He is now reportedly the second wealthiest person in the world with a personal fortune of \$192 million.
- 2002 Musk founded SpaceX



History of SpaceX

- In 2001 Elon Musk joined a non-profit organisation called “Mars Society” it is here that Musk conceptualised “Mars Oasis”, a project to land a miniature greenhouse containing seeds and dehydrated gel on Mars (2). Musk vision here was simple “beam back the images to earth and get peoples interest back into space”.(2a)
- To do this Musk needed a rocket, his idea was to buy an ICBM (Inter-continental ballistic missile) minus the war head from the Russians, when he visited the Russian company Kosmotras who built ICBM’s he was discounted as a novice and returned to the States empty handed. On his second visit to Russia Kosmotras offered him one ICBM at a cost of \$8 million, Musk rejected this and decided that the only way to achieve his goal was to build his own reusable rocket, SpaceX was born!
- In 2002 Musk founded SpaceX, he put \$100 million of his own personal wealth into the initial start up of the company and the design and building of the Falcon 1 rocket began, although Musk reflects on these early days by comparing his new company to the established Aeronautics companies as “a school kid having a fight with Sumo wrestlers” (2b)

History (cont.)

- To ensure that SpaceX could be commercially viable the process of building rockets would need to be done more efficiently and at a lower cost, with this philosophy SpaceX makes the component parts & builds the vast majority of their rockets under one roof! An ex-Boeing establishment near Los Angeles. The company employs 1400 technicians and engineers, many of these are ex NASA (National Aeronautics and Space Administration) as well as ex Astronauts which has brought massive expertise and experience to the company.
- In 2006 SpaceX launched its first Falcon 1 rocket, it failed to reach orbit as did the following two rockets, however with the third failure a “2 second” timing problem was discovered and rectified, the fourth Falcon 1 flight, some 8 weeks later, was a complete success. This was the turning point for SpaceX, Musk admitted that if the fourth rocket had failed the dream would have been over as they did not have the resources for a fifth launch.
- Following the successful launch of the fourth Falcon 1 rocket in 2008 NASA handed SpaceX a \$1.6 billion contract to SpaceX to perform 12 cargo flights to International Space Station (ISS)

History (cont.)

- By 2010 SpaceX had developed and launched the Falcon 9, a 9-engine rocket complete with a cargo pod named “Dragon”, the rocket orbited the earth twice and landed in the Atlantic Ocean before being recovered. The Dragon cargo pod was build with “windows”, SpaceX intention was clear, one day they would be carrying a human cargo. (3)
- In 2011 NASA’s Space Shuttle was retired and in 2012 SpaceX successfully docked a Dragon cargo capsule with the ISS carried by a Falcon 9 rocket before the capsule returned back to earth.
- In terms of how far SpaceX has developed in the Aeronautics marketplace, they are now ranked second in the world, only Boeing Defence, Space & Security are ranked higher. (4)
This demonstrates how well SpaceX has used the best available technologies and innovation to achieve the goal of reaching space.

SpaceX Internal Structures & Management

- In terms of internal structures and management processes, SpaceX has adopted several strategies to foster innovation and efficiency. These include:
 1. Modern collaboration tools: SpaceX has replaced traditional control boards and committees with modern collaboration tools such as Jama, enabling more efficient communication and collaboration among team members.
 2. Data-driven decision-making: Technicians on the shop floor use data and models to better understand the rocket's inner workings during manufacturing and assembly, leading to improvements in efficiency and quality.
 3. Effective project management: SpaceX emphasizes the importance of project management skills, such as communication and leadership, in achieving positive project outcomes. Elon Musk, the CEO, has demonstrated these traits, enabling the company to consistently deliver on its ambitious goals.
 4. Strong leadership: Elon Musk's vision and leadership have been instrumental in driving the company's innovative culture. His ability to communicate the company's mission and inspire the team has played a crucial role in its success.

Internal structures & Management – 7 Key steps

1. **Organisational Structure** - designed to facilitate rapid iteration and open communication, a flat hierarchy allows for more efficient decision-making and encourages collaboration between different teams, ensuring that ideas and solutions can be implemented quickly.
2. **Resource Allocation** - allocates resources strategically to support its innovative initiatives, such as reusable rocket development, Starship system, and satellite internet services, not only financial input but also human resources.
3. **Decision making process** - driven by data and learning from both successes and failures, open communication and a top level “hands on” approach leads to rapid decision making.
4. **Change Management** – culture created that embraces risk taking and learning from failures, employees are provided with support and resources to implement innovative solutions

7 Key steps (cont.)

5. **Talent acquisition and development** – recruits and retains top talent, the organization provides opportunities for employees to develop their skills, collaborate on challenging projects, and contribute to the company's vision.
6. **Performance measurement** - tracks progress on its projects through regular updates, reviews, and data analysis, this enables the company monitor the success of its innovations and adjust its strategies accordingly.
7. **Collaboration and knowledge sharing** - collaboration and knowledge sharing among its employees is encouraged, this allows a culture to exist whereby idea's and best practices can be shared between cross functional teams

Innovation & Technologies

- **Reusable Rockets** - SpaceX's Falcon 9 rockets are designed to be partially reusable, which significantly reduces the cost of space launches.

Technologies involved:

- ☐ Software to control the rocket decent
- ☐ Heatshields
- ☐ Lightweight materials
- ☐ Grid fin system
- ☐ Vertical landing system

According to Greg Satell - SpaceX's reusable rockets create new value by significantly reducing the cost of space launches. This is achieved by developing a novel solution to the problem of rocket reusability, which had been a significant cost driver in the space industry.

Innovations & Technologies (cont.)

- **Autonomous Spaceport Drone Ships** - SpaceX's drone ships are used as landing platforms for its rocket boosters, which can land and be reused for future launches.

Technologies involved:

- ☐ Station keeping engines
- ☐ Control using AI and computer vision
- ☐ Shock absorbing materials
- ☐ Heavy lift drones for the ASDS

According to Greg Satell - SpaceX's drone ships address the unmet need of being able to land rocket boosters on a small platform in the middle of the ocean. By developing autonomous drone ships, SpaceX created a novel solution that allows rocket boosters to be recovered and reused, creating new value by reducing the cost of space launches

Innovations & Technologies (cont.)

- **Merlin Engines** - SpaceX's Merlin engines use a unique design that allows for greater thrust and fuel efficiency compared to traditional rocket engines.

Technologies involved:

- ☐ Full flow staged combustion
- ☐ AM for complex geometries and optimised designs
- ☐ Aluminium – Lithium alloys
- ☐ Throttle ability
- ☐ Reusability

According to Greg Satell - SpaceX's Merlin engines create new value by providing greater thrust and fuel efficiency compared to traditional rocket engines. This is achieved by using a unique design that includes an innovative combustion chamber and regenerative cooling system.

Innovations & Technologies (cont.)

- **Falcon Heavy** - SpaceX's Falcon Heavy rocket is the most powerful operational rocket in the world, capable of carrying large payloads into orbit.

Technologies involved:

- ☐ Reusable boosters
- ☐ Advanced materials
- ☐ Merlin engines
- ☐ Autonomous landing

According to Greg Satell - SpaceX's Falcon Heavy rocket creates new value by providing the capability to launch large payloads into orbit. This addresses the unmet need of being able to launch heavier payloads into space, which was previously limited by the capabilities of existing launch vehicles.

Innovations & Technologies (cont.)

- **Dragon Capsule** - SpaceX's Dragon capsule is a reusable spacecraft designed to carry cargo and astronauts to the International Space Station

Technologies involved:

- ☐ Super Draco engines
- ☐ Reusable
- ☐ PICA-X heat shield
- ☐ Advanced navigation
- ☐ 3-D printing

According to Greg Satell - SpaceX's Dragon capsule creates new value by providing a reusable spacecraft that can carry cargo and eventually astronauts to the International Space Station. This addresses the unmet need of being able to transport supplies and people to the space station in a cost-effective and reliable manner.

Innovations & Technologies (cont.)

- **Starship** - SpaceX's Starship is a next-generation spacecraft that is being designed to take humans to Mars and other destinations in the solar system.

Technologies involved:

- ☐ Stainless steel design
- ☐ PICA-X
- ☐ Autonomous landing
- ☐ Super heavy booster

According to Greg Satell - SpaceX's Starship creates new value by providing a next-generation spacecraft that is being designed to take humans to Mars and other destinations in the solar system. This addresses the unmet need of being able to explore and eventually colonize other planets, which has been a longstanding goal of space exploration.

Innovations & Technologies (cont.)

- **Raptor Engine** - SpaceX's Raptor engine is a methane-fuelled engine that is being developed for use on the Starship spacecraft.

Technologies involved:

- ☐ Use of Methane fuel
- ☐ 3-D printing
- ☐ Regenerative cooling
- ☐ Thrust Vector control

According to Greg Satell - SpaceX's Raptor engine creates new value by providing a methane-fuelled engine that is being developed for use on the Starship spacecraft. This addresses the unmet need of being able to use more efficient and sustainable fuels for space travel.

Innovations & Technologies (cont.)

- **Starlink** - SpaceX's Starlink is a satellite internet service that uses a constellation of small satellites to provide high-speed internet access to remote areas around the world.

Technologies involved:

- ☐ Other innovations to make launch cheap such as reusable rockets
- ☐ Low earth orbit for low latency
- ☐ Ion thrusters
- ☐ Phased array antennas
- ☐ Autonomous operation

According to Greg Satell - SpaceX's Starlink creates new value by providing high-speed internet access to remote areas around the world. This addresses the unmet need of being able to provide reliable internet access to people in areas where traditional infrastructure is lacking.

Innovations & Technologies (cont.)

- **Mars colonisation** - SpaceX's ultimate goal is to colonise Mars and make humanity a multi-planetary species, which would be a significant step forward for space exploration and human progress.

Technologies involved:

- ☐ Starship rocket and super heavy rocket
- ☐ Raptor engine
- ☐ Life support systems
- ☐ AI
- ☐ Planetary microbe protection

According to Greg Satell - SpaceX's goal of colonising Mars creates new value by addressing the unmet need of being able to expand humanity's reach beyond Earth and ensure the survival of the human species in the event of a planetary disaster. This is achieved by developing a novel solution to the problem of long-term human habitation on another planet, which has never been done before.

The extent of SpaceX success

- One of SpaceX's most notable accomplishments has been its development of reusable rockets, which significantly reduces the cost of launching payloads into space. The company has successfully landed and reused the first stages of its Falcon 9 rocket multiple times and has also landed and re-used the fairings that protect the payload during launch.
- Overall, SpaceX's achievements have significantly advanced the field of space exploration and have demonstrated the potential for private companies to make major contributions to the industry.

The extent of SpaceX success (cont.)

- SpaceX has achieved many milestones since its inception in 2002. Here are some of the notable ones:
1. First privately funded liquid-propellant rocket to reach orbit: In 2008, SpaceX became the first privately-funded company to launch a liquid-propellant rocket, Falcon 1, into orbit. This was a significant milestone in the commercial space industry, as it demonstrated that private companies could compete with government agencies in space exploration.
 2. First privately funded company to send a spacecraft to the International Space Station: In 2012, SpaceX launched its Dragon spacecraft and became the first privately-funded company to send a spacecraft to the International Space Station (ISS). The Dragon spacecraft delivered cargo to the ISS and returned to Earth with scientific experiments.
 3. First landing of a rocket's first stage: In December 2015, SpaceX achieved the first landing of a rocket's first stage after delivering its payload to orbit. This marked a breakthrough in reusable rocket technology, which significantly reduces the cost of space launches.

The extent of SpaceX success (cont.)

4. First reuse of a rocket: In March 2017, SpaceX successfully launched and landed a Falcon 9 rocket that had previously been used for a previous mission. This marked the first time that a rocket had been reused for an orbital mission.
 5. First launch of Falcon Heavy: In February 2018, SpaceX successfully launched its Falcon Heavy rocket, which is currently the world's most powerful operational rocket. The launch was significant because it demonstrated SpaceX's ability to launch heavy payloads into space, such as satellites or even spacecraft designed for human exploration.
 6. First launch of Crew Dragon: In May 2020, SpaceX successfully launched its Crew Dragon spacecraft with two NASA astronauts on board. This marked the first time since 2011 that astronauts had launched from U.S. soil, and the first time ever that a privately-developed spacecraft had carried astronauts into orbit.
- Overall, these milestones demonstrate SpaceX's significant contributions to the field of space exploration and its innovative approach to space technology.

Conclusion

- **SpaceX Market position** – SpaceX has moved from being the “school kid fighting a Sumo wrestler” to the second largest Aeronautics Company in the world
- **Internal Structures & Management Process** - SpaceX's emphasis on innovation, uncertainty, and risk has had a profound impact on its internal structures and management processes. The company has developed an organizational culture and systems that support innovation at all levels, which has enabled it to achieve remarkable success in the aerospace industry. This approach has allowed SpaceX to remain agile and adaptive, positioning the company to continue pushing the boundaries of space technology in the future.
- **Technology** - SpaceX's innovations have enabled them to significantly reduce the cost of space launches, the cost of space travel is still prohibitively expensive for many customers and organisations. Some critics have raised concerns about the safety of SpaceX's reusable rockets and spacecraft, as they rely on cutting-edge technology that has not yet been fully tested or proven to be safe.

Conclusion (cont.)

- **Extent of SpaceX success** – Only four entities had flown a spacecraft to the ISS before, these being the USA, Russia, Japan and the European Space Agency, SpaceX is now the 5th!

SpaceX has been successful in a variety of different ways, and Satell's typology can help us understand some of the strategies that SpaceX has used to achieve that success.

- **Satell's Innovation Matrix** - We'll now explore a summary of the overall success of SpaceX

Overall, SpaceX's success can be attributed to its ability to pursue a variety of different innovation strategies, including efficiency, sustaining, disruptive, and architectural innovations, and to execute on those strategies successfully.

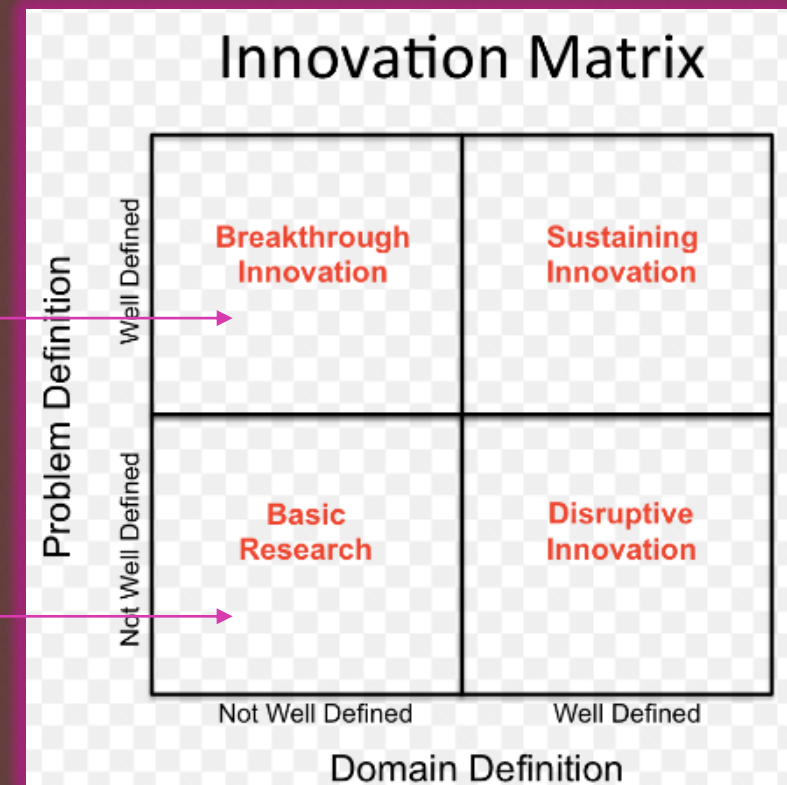
Conclusion (cont.)

- **“Breakthrough Innovation”**

SpaceX has been successful in implementing efficiency innovations. For example, the company has developed reusable rockets, which reduces the cost of space launches by allowing rockets to be reused multiple times.

- **“Basic Research”**

SpaceX has pursued architectural innovations by developing new systems and platforms that enable multiple products or services to work together. For example, the company has developed the Falcon Heavy rocket, which is designed to be able to launch a variety of payloads, including crewed missions to the Moon and Mars.



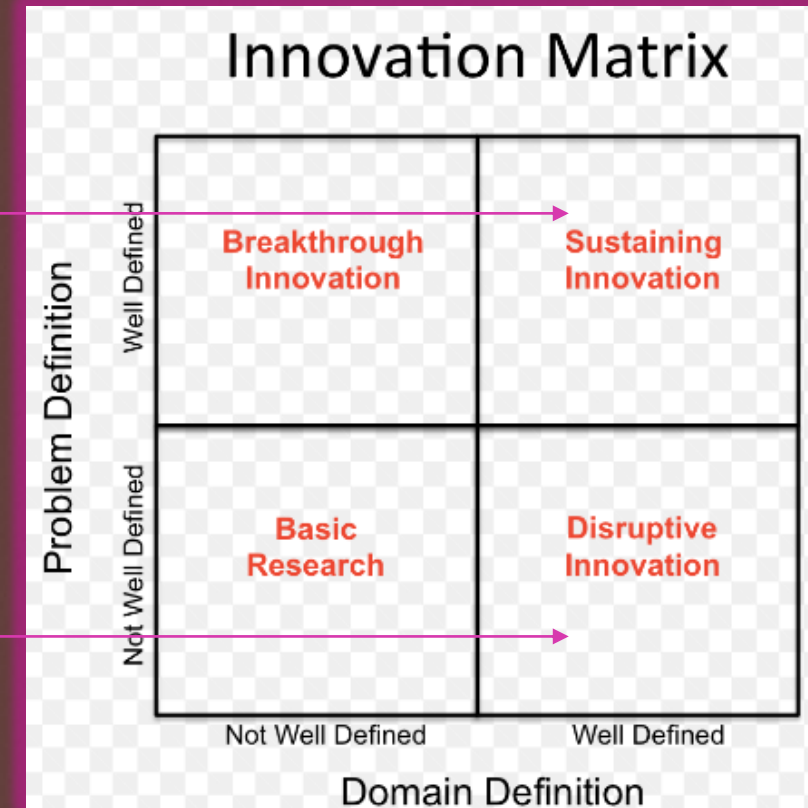
Conclusion (cont.)

- **“Sustaining Innovation”**

SpaceX has also pursued sustaining innovations, such as developing new and improved versions of its Falcon rockets. These innovations have helped the company to maintain its position in the market and continue to meet the needs of its customers.

- **“Disruptive Innovation”**

SpaceX has introduced disruptive innovations, such as the development of the Starlink satellite constellation, which aims to provide high-speed internet access to remote and rural areas. This innovation has the potential to disrupt traditional telecommunications companies and create a new market for satellite internet services.



References

- (1) Wikipedia – Elon Musk, March 27th 2023
- (2a) SpaceX Video – CBS News Production 2012
- (2b) SpaceX Video – CBS News Production 2012
- (3) Wikipedia – SpaceX, March 2023
- Article – The 10 largest Space & Exploration Companies in the world and what they do? Drew Baker, updated 2nd March 2023
- [How Jama Software's Community Became the Best Resource for All Things Jama - Higher Logic](#)
- Greg Satell – Mapping Innovation
- [SpaceX: A History Of Innovation In The Space Industry – EclipseAviation.com](#)
- [SpaceX Innovation for the Space Industry and the World | Veritas Noble](#)
- [8 ways that SpaceX has transformed spaceflight | Space](#)
- [Boeing's software troubles show an engineering culture clash \(qz.com\)](#)

References (cont.)

- [What SpaceX Can Teach Us About Cost Innovation \(hbr.org\)](#)
- [The Commercial Space Age Is Here \(hbr.org\)](#)
- [SpaceX: A History Of Innovation And Space Exploration – EclipseAviation.com](#)
- [SpaceX Innovation for the Space Industry and the World | Veritas Noble](#)
- [SpaceX, Economies of Scale, and a Revolution in Space Access | Harvard Business Publishing Education](#)
- COO of SpaceX talks about willingness to take risks and try new things
<https://edition.cnn.com/2019/03/10/tech/spacex-coo-gwynne-shotwell-profile/index.html>
- Disruptive innovation in space transport - <https://www.thespacereview.com/article/3590/1>
- Criticism of “Innovators Dilemma” with SpaceX
<https://www.washingtonpost.com/news/innovations/wp/2015/11/23/what-the-legendary-clayton-christensen-gets-wrong-about-uber-tesla-and-disruptive-innovation>

References (cont.)

- Dieffenbacher, S. F., 2023. Digital Leadership. [Online]
Available at: <https://digitalleadership.com/blog/types-of-innovation/>
[Accessed March 2023].
- New Space Company, 2023. The History of Space X. [Online]
Available at: <https://newspaceeconomy.ca/2023/02/24/a-short-history-of-spacex/>
[Accessed March 2023].
- SpaceX, 2020. SpaceX. [Online]
Available at: <https://www.spacex.com/mission/index.html>
[Accessed March 2023].
- The Space Bucket, 2021. How SpaceX Has Become So Successful. [Online]
Available at: <https://thespacebucket.com/why-spacex-has-become-so-successful/#:~:text=In%20a%20short%20period%20of%20time%2C%20SpaceX%20has,timeline%2C%20continued%20innovation%2C%20awarded%20contracts%2C%20and%20commercial%20deals.>
[Accessed March 2023].