Interplanetary Travel: The Engineering Design Process

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Which STEM Career or Company did You Select, and Why?

"That's one small step for man, one giant leap for mankind." - Neil Armstrong

The latter half of the 20th century is characterized by an unshakable drive towards space travel. The Space Race captivated international audiences as citizens longingly dreamt of gleaming space shuttles and a man on the moon. Elon Musk, billionaire CEO of the aerospace company Space Exploration Technologies Corporation (SpaceX), shares an equally arduous goal. Musk is working towards affordable interplanetary travel and the eventual development of a civilization on Mars (Eldrige, 2021, para. 2). As humanity continues unrelenting innovation and advancement, we are approaching a future where interplanetary exploration and habitation is an inevitability.

We admire SpaceX's aerospace engineers who are paving the way to make spaceflight economical and commercial. Being the first privately funded company to send a spacecraft to the International Space Station (Ben-Itzhak, 2022, para. 7), it is clear that SpaceX is revolutionary. We value SpaceX's tenacity and ingenuity, specifically their ability to use the result of countless failures to improve designs and create a more robust spacecraft.

Falcon 9 Boosters landing after launching and entering the orbit.

How do Professionals in this Career or Company Apply Steps of the Engineering Design Process?

The initial step of the engineering design process is describing the issue to be solved. In the case of SpaceX, the problem is making cost-effective spacefaring a reality. These engineers then must identify the constraints, including the high costs of manufacturing, and launching a rocket.

Research is the next crucial step of the engineering design process. This may involve looking into pre-existing technologies, talking to experts, or evaluating different approaches as they have been theorized or applied in the past. Once these limitations are identified, the engineers can start the brainstorming process. No idea is off limits, and Musk favors those who are able to think outside the realm of what appears possible.

The most notable idea aerospace engineers adopted is reusability. Non-reusable rockets are not economically sustainable if space travel were to become commercial. In 2011, Elon Musk announced the SpaceX Reusable Launch System Development Program ("SpaceX reusable launch system development program", 2022, para. 2). The primary objective was to create a rocket that could send a payload into orbit and then return to Earth to a desired landing point. ("Falcon 9 first-stage landing tests", 2022, para. 19). Six years after the announcement, SpaceX was able to achieve this astonishing feat in 2015 after successfully landing their Falcon 9 (Logsdon, 2020, para. 4).

This success was achieved through rigorous trial and error, "I think it's very important to have a feedback loop, where you're constantly thinking about what you've done and how you could be doing it better" (Ulanoff, 2012, para. 3) Musk describes a crucial part of the engineering design process. After brainstorming, aerospace engineers at SpaceX are tasked with honing in on a promising solution. Building, prototyping, testing, design and unavoidable failure occur next. It is only after this failure, that refinements occur based on the data collected, leading to innovation.

The first prototype vehicle, Grasshopper, went through low altitude testing where it was retired after eight successful flights in 2013 (Howell, 2016, para. 1). This success led to SpaceX creating the first generation of Falcon 9 rockets, which aerospace engineers equipped for power descent. Originally, the landing accuracy of the rocket was 10km off, this greatly improved by 2018, achieving a landing accuracy of 10m (Art of Engineering, 2019). Throughout this period, SpaceX endured many public failures such as the catastrophic explosions. Despite this, the engineers stuck through, and used what they had learnt from these failures to arrive at a solution.

Grasshopper, SpaceX's first self-landing prototype.

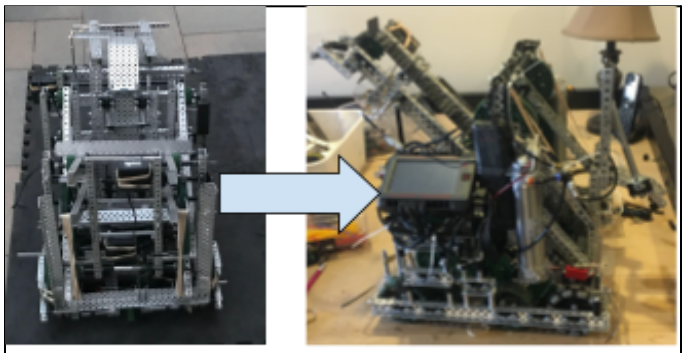
Starship, SpaceX's most recent reusable rocket. Notice the evolution!

How Does the Professional Approach to Engineering Design Match or Differ from the Approach Used by Your Team?

SpaceX and our team, 3150A, share a similar approach to the engineering design process. Our design process also starts with identifying what obstacles our robot will need to overcome and how we want it to perform in matches. This includes developing ideas for subsystems to collect rings, components to score goals, figuring out the correct gear ratio, etc. SpaceX's rockets build upon pre-existing

technologies and improve it, such as with the first reusable rocket, the Space Shuttle Columbia, which was launched in 1981 (Howell, 2021, para. 1). Similarly, our team's engineering design process involves analyzing other robots, pointing out which attributes work successfully, and figuring out how to improve upon and incorporate them into our design. These ideas are then made into Computer-aided designs, before the prototyping process starts.

Just like SpaceX, our team recognizes that a lot of the time concepts only work in theory, therefore we use in-depth experimentation before arriving at a feasible solution. In fact, our team has designed and built five separate robots before finding one that worked optimally. Just as SpaceX has had explosions and failed launches, we have had motors burn out, and code malfunction. The most vital aspect which we share is that we do not let these errors dictate the success of our team, rather we use them as an opportunity to improve.



From one of our first prototypes to our more recent robots, we've made a lot of progress through learning from our mistakes.

How has Participation in VEX Robotics Prepared You for a Future Career?

VEX Robotics encourages individuals to approach challenges with an open mind, and experiment with unconventional designs. We quickly learned that there are countless ways to solve a problem, and were motivated to use teamwork and scientific reasoning to arrive at a feasible solution. The value of VEX lies in the mindset which it develops. Learning to brainstorm creatively, persevere through trial and error, and persist through hardship in order to reach the best possible product. This mentality, integral to the engineering design process, can be seen throughout the aspects of STEM. From healthcare professionals to aerospace engineers, VEX teaches us to employ the thought process of various STEM careers. We are taught that failure should be embraced as an opportunity to build upon past knowledge, allowing us to progress. Overall, the skills VEX offers allows us to become self-assured STEM innovators.

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