

# ENGINEERING AND THE FINAL FRONTIER: SPACE TRAVEL

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BLUEPRINTS TO BLASTOFF

ENGINEERING INNOVATIONS  
DEVELOPED DURING  
WARTIME:

THE EVOLUTION OF  
ENGINEERING

Fig. 1

Fig. 2

Fig. 4

# Legacy Gazette



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# Legacy Gazette



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# THE EVOLUTION OF ENGINEERING

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In today's world, engineering is everywhere: from the structures we rely on every day (like roads, bridges, and buildings) to the advanced technologies that power our communication systems, from healthcare to transportation. Engineers design, create, and maintain the systems and devices that make our modern lives possible. However, recent advances did not come out of thin air—they are the culmination of centuries of innovation and ingenuity. From the towering pyramids of ancient Egypt to the Roman aqueducts that resolved water supply problems, the history of engineering is extraordinary, and it is impossible to fully understand engineering today if we don't understand the past.

The origins of the field engineer can be traced back to ancient civilizations. At that time, though there isn't direct evidence that they accepted the term "engineering" as we understand it today, they were engaged in sophisticated design and technique innovation. One of the most notable figures in the early history of engineering is Imhotep, who is often regarded as the first engineer in history. Imhotep lived in ancient Egypt around 2650–2600 BCE and served as an architect, physician, and high priest (The Editors of Encyclopaedia Britannica, 2019). His most famous achievement is designing and constructing the Step Pyramid at Saqqara, the world's first large-scale cut-stone monument. This innovation was groundbreaking for its time. Imhotep's pioneering techniques, such as curving the stone columns and creating stone beams and lintels, are all first attempts that have significantly influenced the development of Egyptian architecture and culture (CloudCalc, Inc., 2014). In addition, primarily from around 3000 BCE onwards, early civilizations constructed infrastructure (e.g. irrigation and agriculture) and urban planning (drainage systems and standardized building practices)

suggesting how they have incorporated engineering aspects to fulfill their particular needs (National Geographic Society, 2022).

The profession of engineer was first widely-recognized in the Renaissance period, though that definition of engineer is closer to "artist-engineer," where engineers combine their knowledge of mathematics and physics with artists skills like drawing and design. In this era, beyond the traditional architecture engineer that ancient civilizations practiced, society also saw advancements in mechanical invention and biomedical engineering. One important figure who significantly contributed to both areas during this period is Leonardo da Vinci. da Vinci's detailed anatomical drawings, such as the Vitruvian Man, were groundbreaking (IEEE Pulse, 2015). He meticulously studied human anatomy, dissecting bodies to understand muscle structure, blood flow, and respiratory physiology, laying the foundation for future research. da Vinci also designed numerous mechanical devices, many of which were ahead of their time, including flying machines, an early version of a helicopter, and various mechanical devices, such as gears, pulleys, and levers, that pushed the boundaries of what was possible (Roets, 2021).

The next milestone of engineering happened during the industrial revolution, through the need for efficient production methods and rapid growth. During this time, engineering branched into much more detailed specializations: civil, mechanical, and electrical engineering emerged as distinct disciplines (Smith, 2024). Civil engineering became a critical discipline as urbanization accelerated and the need for robust bridges, roads, canals, and buildings became paramount. Some iconic structures from this period, like Thames Tunnel and the Brooklyn Bridge, are still in use. Mechanical engineering also gained prominence during this period due to development of the steam engine. Such innovation completely revolutionized industries, leading to significantly increased output and productivity. Lastly, the discovery of electricity spurred significant innovations, including the telegraph and early electric motors which marked the beginning of electrical engineering, setting the stage for future technological advancements that continue to shape our world today (Gavin Electrical Engineering Ltd., n.d.). Modern engineering concentrations have



Become much more specialized and interdisciplinary. The 20th century saw clear specialization within engineering disciplines, with new fields such as aerospace, chemical, and computer engineering emerging. Engineers began to focus on highly specialized areas, applying their expertise to solve increasingly complex problems (Prados, 1998). Carried with the maturity of these engineering disciplines, it led to the most recent definition and work of engineers. It has evolved into an interdisciplinary field that has a distinct specialization, integrating knowledge from various domains to address complex global challenges.

In conclusion, in each era and time, depending on the needs of society, engineering has been evolving. It has been important and will continue to be a cornerstone in addressing societal challenges.

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# BLUEPRINTS TO BLASTOFF:

DISCUSSIONS ABOUT SPACE



# Space Economy 101

**“Space explorations are receiving an unprecedented level of private investments, which makes it appealing to the venture capital market.”**

What is the space economy? As defined by the Organization for Economic Co-operation and Development, it is “the full range of activities and the use of resources that create value and benefits to human beings in the course of exploring, researching, understanding, managing, and utilizing space” (OECD, n.d.). To be specific, the currently deployed space infrastructures allow new services to be developed, which then enable new applications in various sectors to contribute to economic and societal benefits. Sectors that can benefit from the space economy include meteorology, energy, telecommunications, insurance, transport, urban development, and more.

The space economy has a bright future as global interest and investments continue to rise. Space explorations are receiving an unprecedented level of private investments, which makes it appealing to the venture capital market. Space-related commercial activities are also expanding worldwide. From the ones based on smallsats/cubesats to micro-launchers and space flight, the commercial activities can potentially generate a huge amount of revenue. In fact, the industry is valued at \$469 billion in 2021, and some analysts claim that the space industry could be the next trillion-dollar industry by 2040 (Brukardt, 2022).

A vibrant space economy does not only benefit space explorations itself – a lot of other industries can also gain from innovative space applications. For example, pharmaceutical companies can build labs in space stations to study cell growth; semiconductor companies can try to optimize their manufacturing process in extraterrestrial factories by controlling different factors such as the lack of gravity or air (Brukardt, 2022).

The space economy is traditionally dominated by government agencies like NASA. Yet, as technologies advance in manufacturing, propulsion, and launch, venturing into space became much cheaper, which led to the rise of private companies such as SpaceX and Blue Origin. These actors are still working towards launching more often and with lower costs. In 2021, the cost for heavy launches in low-Earth orbit (LEO) experienced a greater than 95 percent decrease, dropping from \$65,000 per kilogram to \$1,500 per kilogram (Brukardt, 2022). Innovations like 3-D printing and computer-aided design (CAD) contribute to reducing the costs as they streamline the manufacturing process. Engineers have also developed usable components for launch vehicles, promoting sustainability and reducing costs at the same time. They also aim to minimize the size of the satellites while maximizing the gains. With the use of lighter solar panels and more efficient batteries, small commercial satellites that cost \$100,000 or less started to outnumber larger government ones which cost up to one billion dollars (Brukardt, 2022).

Even as high school students, we have opportunities to engage with the space economy. For example, students can design rockets or rovers using everyday materials; students with coding experience can also program small satellites or analyze data from space-based sensors. They can also participate in behind-the-scenes tours of payload processing facilities, launch pads and other key facilities. NASA and various other space organizations also offer programs for youth interested in a space career (Spaceports: Launching the Next Generation of STEM Talent, 2024).

## Diving into NASA

The National Aeronautics and Space Administration, or NASA, has always been a driving force in space exploration. In this section, we will dive into its history – its milestones, challenges and successes, as well as the opportunities it offers for high school students.

In response to the Soviet Union's space achievements (specifically, the launch of satellite Sputnik 1), NASA was established on July 29, 1958 and began its operation on October 1st of the same year. It has taken on a series of core missions, including (but not limited to) Project Mercury, Project Gemini, and The Apollo Program. Project Mercury is the first human space program in the United States. Its objectives are as follows:

1. Place a manned spacecraft in orbital flight around the earth.
2. Investigate man's performance capabilities and his ability to function in the environment of space
3. Recover the man and the spacecraft safely (NASA, n.d.)

With the contributions of more than 2,000,000 people from various government agencies and the selection of seven men to the nation's first voyagers, the project was completed in a five-year period of dynamic activities. Upon completion, the program successfully sent six astronauts into space on six flights in total.

After the five-year Project Gemini, which is primarily designed to test equipment and train astronauts for a future Apollo program,



\*File:National Aeronautics and Space Administration - The Starry Night by Vincent van Gogh.jpg - Wikimedia Commons. 15 Feb 2024, 15:28 UTC. 23 Aug 2024, 13:28 - <https://commons.wikimedia.org/w/index.php?title=File:National Aeronautics and Space Administration - The Starry Night by Vincent van Gogh.jpg&oldid=851994888>.



NASA took another huge step in space exploration – as Neil Armstrong’s famous quote goes, “That’s one small step for a man. One giant leap for mankind” (Launius & Hunley, n.d.). Its objectives went beyond the national interests of the United States. Instead, its goals include establishing the technology that would meet the national interest of other countries and developing human capabilities to work in the lunar environment. The spacecraft Apollo has three major components: the command module (CM), the service module (SM) and the lunar module (LM). The command module is the crew’s quarters and flight control section; the service module is responsible for propulsion and spacecraft support system; the lunar module, as its name suggests, is responsible for taking two of the crew to the surface of the Moon, supporting them it, and returning them to the CSM in lunar orbit.

In addition to its huge contributions to space explorations, NASA also provides valuable opportunities for high schoolers to engage with the space industry. For example, NASA has a paid internship program (Office of STEM Engagement Internship) that allows high school and college level students to work with mentors who are research scientists or engineers. The internship can be part time or full time with flexible working locations (NASA facilities or remote). While only U.S. citizens are eligible for this internship, NASA also has an International Internship program for anyone across the globe with a strong passion for space exploration and the U.S. space program. More details can be found on their website (NASA, n.d.).

## How hard is it actually to build a spacecraft?

Building a spacecraft is no child’s play. It’s a massive project that involves some of the toughest engineering challenges known to humankind. A prime example is NASA’s Perseverance rover, which successfully landed on Mars in 2021. This cutting-edge technology demonstrates the complexity required to do such astounding things as exploring the universe.

First of all, the Perseverance rover is nothing like no other rover. It’s a machine built with ingenuity designed to traverse the Martian surface and search for signs of past life using the autonomous navigation technology that lets it drive itself around obstacles. Think of it as a baymax-like off-road vehicle, but on another planet, with no room for error.

Moreover, the high-stakes on the journey to Mars is closely dependent on landing safely, which requires precise engineering designs. The process starts with a supersonic parachute that slows down the spacecraft as it hurtles toward the Martian atmosphere. But that’s just the beginning. Next comes a rocket-powered descent stage that takes over, ensuring the rover doesn’t plummet uncontrollably. At last, the Sky Crane system is at work, lowering Perseverance gently onto the surface.

Creating such an engineering marvel demands a highly skilled and multi-talented team. Mechanical, electrical, software, and aerospace engineers work in the same team, each bringing their expertise in a certain specialization. At the same time, interdisciplinary researchers also play crucial roles by combining the strengths of multiple types of engineering to withstand the harsh environments of space and the surface of Mars.

And that’s not all the challenges. Once Perseverance lands, communicating with a rover millions of kilometers away is no small undertaking.



**Perseverance Rover"**

File:PIA23499-Mars2020Rover-FirstTestDrive-20191217a.jpg," Wikimedia Commons. 17 Aug 2024, 22:14 UTC. 23 Aug 2024, 13:31 -<<https://commons.wikimedia.org/w/index.php?title=File:PIA23499-Mars2020Rover-FirstTestDrive-20191217a.jpg&oldid=911282573>>.

It requires a network of antennas and advanced software to send and receive data informatics. The rover needs to operate autonomously, making decisions on its own due to the time delay in communications.

Ultimately, the success of Perseverance is not just about advanced technology but also the collaboration during the pre-build processes. NASA had a tradition of collaborating with universities, private companies, and international aerospace institutions to bring these missions to success. It is the long-term collaborations that drive innovation and push the boundaries of what's possible. Overall, building a spacecraft like Perseverance is an unprecedented challenge that combines technical merit, engineers of diverse backgrounds, and teamwork from all parties of the industry. So, next time you marvel at a rover exploring Mars, remember the incredible journey and the countless hours of dedication that made it possible.

## The Role of Billionaires in Space Exploration

Billionaires such as Elon Musk, Jeff Bezos, and Richard Branson are shaping the future of space exploration through their private companies: SpaceX, Blue Origin, and Virgin Galactic, respectively. Their heavy investments are driving advancements in private space travel, with promises to make it more affordable and to open new grounds for humanity.

Elon Musk’s SpaceX has already achieved major milestones, including green, reusable rockets and missions to the International Space Station. Jeff Bezos’s Blue Origin focused on developing sustainability technology allegedly to lower the cost of space travel. Meanwhile, Richard Branson’s Virgin Galactic aimed to explore commercial space tourism.

Despite these advancements, concerns arise about the concentration of space exploration power in the hands of a few wealthy individuals instead of public, state-run institutions. Critics argue that this shift of both role and responsibility to private companies could lead to potential monopolies and raise questions about the motivations behind their investments. Are these efforts purely altruistic, or are they driven by personal profit that will eventually be at the cost of the public?

The debate extends to the potential repercussions of private control over space travel. Issues such as a lack of regulation, ethical



considerations, and the difficulty to find a balance between scientific research and commercial interests. While the contributions of these billionaires are undeniable, the future of space exploration will require a balance between private innovation and public interest to ensure that the benefits of these advancements are shared responsibly.

# Private companies in space – should we be scared?

## As private companies push boundaries, company owners are more likely than governments to disregard regulations in the face of immense profits

The entry of private companies into space exploration brings both innovation and concern. On one hand, companies like SpaceX reduce costs, and accelerate technical advancements that were once the sole domain of nations. On the other hand, this commercial intrusion has the potential to lead to new, unforeseen issues: space privatization, safety risks, and environmental impacts. As private companies push boundaries, company owners are more likely than governments to disregard regulations in the face of immense profits. Innovation without oversight will be crucial to ensure space remains a realm of collective progress, not corporate dominance.

Whether it be the renowned SpaceX taking people to space in their private aircrafts or Relativity Space designing increasingly advanced vehicles, business in space is largely molded by many of the corporate rules we have on Earth. Technological innovations still drive profit, whether it be advancing satellite systems or creating 3D printers for more niche uses. We still have ethical concerns over how to balance profit with sustainability—instead of decreasing pollution, though, we have now switched over to limiting space debris. Our current business in space is still run by people, who, after all, have a common business mindset. However, once we put this corporate mindset in an emerging industry like the space field, this common variable becomes an unpredictable one. Should private companies really be allowed to ‘interfere’ in our space race? Are they even interfering at all?

Before we jump into the role of businesses in space, let’s touch on the situation with some basic economic terms. From spacecraft to celestial trips, the companies that are currently running the show do not have to contend with many competitors—this classifies the industry as an oligopoly, namely an economic situation where few large companies dominate. This is primarily due to resources. This year alone, a spacecraft company called Virgin Galactic Holdings reported a loss of 94 million, with only a revenue of 4 million (Virgin Galactic, 2024). This company clearly had strong funding to begin with—to put this into perspective, most companies only receive between \$500,000 and \$2 million from investors when they first launch their business (Rutan, 2023). That 2 million upper bound is only 2% of what Virgin Galactic lost! From this example, we can tell that research is costly, the resources are hard to obtain, and the stakes are high. While the United States government could afford to spend 73.2 billion on the space field in 2023 alone, the average company won’t even have a hundredth of that amount (Statista, 2024).

Moreover, private companies see further barriers: being a new industry, business in space relies on being at the forefront of innovation. This is in a way dependent on time: the later a company joins the space race, the more likely they are to fall behind. The companies they are competing with clearly have great resources, and how much market share they capture is dependent on how productive they are with their time. It’s a race in space, but it’s also a race against time.

Knowing this situation, we can tell that innovation from private companies is driving our space industry forward: competition from other companies allow businesses to try cutting-edge technologies that traditional space agencies might be slower to adopt. For instance, SpaceX and Virgin Galactic are pioneering advancements in rocket reusability and miniaturized satellite technologies, which could reduce launch costs and increase the frequency of space missions (Mirzai, 2023). By driving this technological progress, companies are not only making space more accessible but also opening collaboration in the industry. While NASA, a sector of the US government that deals in space innovations, may bear much of the credit for its landings, those could not have been possible without partners like SpaceX and Blue Origin—private companies that designed the landing systems (NASA, 2024). Commercial companies are able to lower costs and lower production time, so much so that they have displaced many government functions already; NASA itself admitted that its budget now relies heavily on private companies (Sheetz, 2019).

On the other hand, regulations and safety frameworks can have trouble keeping up with this fast-paced innovation. Companies are different from governmental organizations because they face pressure from their shareholders, news outlets, and their customers to constantly sell. With private companies leading space exploration, they have to find a balance between safety compliance and profit—and this line is not so clear-cut, especially considering how new the space industry is. Yet, despite this ethical contention, many companies have been driving good even in space, knowing that leading in the industry also includes leading with safety.

All in all, there is a role for business in our space race; the fact that business is commonly viewed as negative belies the fact that business can also bring benefits in its pursuit for profit. Whether that be innovation, partnerships, or progress that far exceeds governmental organizations, businesses can and will remain at the forefront of our space exploration.

# An Environmental Perspective

## Environmental Impacts of Space Exploration Conducted by Private Space Organizations

Driven by commercial objectives, for-profit space companies—such as SpaceX, Blue Origin, and Virgin Galactic—that are a part of the billionaire race have accelerated the pace of rocket launches. As of July 28th 2024, SpaceX has already launched 76 rockets this year and aims for 148 by the end of the year. Goals in space tourism and very frequent launches can have extensive impacts on the environment.

From a carbon emission perspective, Dr. Michael Mann, the director of the Earth System Science Center at Pennsylvania State University, states that “the carbon expenditure for one long-haul plane flight is roughly one to three tons of CO<sub>2</sub> per passenger. A rocket launch costs about 200 to 300 tons of CO<sub>2</sub>, shared by four passengers or so. So basically it's 20 to 60 times as much carbon per individual.” Despite being relatively few in number compared to the myriads of flights that take off daily, the rockets already launched and those planned for the future contribute exponentially increasing levels of CO<sub>2</sub> emissions.

Another way that rocket launching would be harmful to the environment is the air pollutants being emitted during the process, which is determined by the composition of propellants used. For example, SpaceX's Falcon 9 launching system uses liquid oxygen and kerosene as propellants and mainly emits carbon dioxide, water vapor, carbon monoxide, hydroxyl, nitrogen oxides, and black carbon. Among those major emissions includes greenhouse gasses such as carbon dioxide and water vapor, and particles that contribute to air pollution such as the black carbon. On the other hand, space tourism and the quest for multi-planetary travel could potentially intrude surrounding ecosystems of the launching sites, produce space debris, harm the ozone layer, and more.

However, some companies and policies put effort into sustainability in various ways. For example, SpaceX's Starship claims to use one of the most environmentally friendly fuel combinations available, including liquid oxygen and liquid methane, which are said to be nontoxic to the environment when debris and fuel are dropped in the ocean. Yet methane still contributes to global warming as a greenhouse gas and Starship still dumps ‘garbage’ into the ocean. Blue Origin claims to have a sustainable supply chain where they reduce, reuse, and recycle materials as well as work with distributors who value renewable energy. Space technologies developed by private organizations exploring space could also be used to mitigate climate change.

In conclusion, it is critical to consider the environmental perspective of the billionaire race because of the influence such individuals, companies, and even a possible field of space tourism can exert. As Rebecca Solnit wrote in her article published in The Guardian, “the 1% aren't just the biggest climate wreckers, they also greatly influence how the world responds to the crisis.” Ultimately, it is essential for us to promote sustainable space exploration while enjoying the advancement these technologies bring us.

## Feature in feature – Elon Musk's SpaceX Journey

In October 2000, Elon Musk was fired from PayPal – the very company he founded. Even though it was to Musk's surprise, it has given him opportunities to pursue a much more ambitious mission (also a childhood dream for him) – space exploration. Since NASA successfully sent Neil Armstrong on the moon, the enthusiasm and funding the space industry received dropped significantly. As Musk embarks on his journey of Mars colonization, the first issue he had to solve was the lack of money.

Building rockets is a costly job. Musk first went to French aeroengineers, who told him the rocket would cost 100 million dollars, which is far above the 30 million dollars Musk made from PayPal. Musk then turned to Russia, since the fall of the Soviet Union led to treaties that required Russia to decommission thousands of missiles. Yet, Musk had a hard time negotiating with the Russians – they were unwilling to disclose the relevant information. As the price Russia offered was twice as high as Musk wanted, he started to consider building rockets himself. He realized that the current manufacturers spend way too much on the raw materials, which means if he can streamline the process he would save a lot of money. Even in SpaceX's very early stage when they only had 100 employees to build rockets, Musk never hesitated to move the work that any expensive third-parties would do into his own factories.

Musk's efforts have paid off. SpaceX had a successful Initial Public Offering (IPO) and was officially registered as a company in 2002. Musk finally had enough money to build rockets. While his original plan of launching in the Air Force base in California did not work out (the Air Force kept changing the launch date of their satellite; Musk can only launch his missiles after the satellite for safety purposes), Musk chose an ideal launching pad – Kwajalein, part of the Marshall Islands. With great confidence, he launched his first rocket, Falcon 1, with a fully functioning satellite. Things didn't go as he expected – only 33 seconds after the launch, the engine caught on fire and exploded. It turns out that the culprit was a single corroded bolt that the team had failed to see during inspections.

The second and third launch did not work out either. It was disastrous for the whole team, not only because their years of efforts did not pay off, but also because SpaceX was running out of money. Musk had one last chance to save his company. He got his Paypal co-founder Peter Thiel to invest 20 million dollars in his company (which is only enough to keep a few months' operations). The SpaceX team was ready for another launch – if they failed again, the company would perish. Despite a ‘little’ accident (the first launch did not go well but the rocket was still intact), Musk finally had a successful fourth launch, which made SpaceX the first commercial company in history to design, build and launch a liquid-fueled rocket to orbit. This was SpaceX's turning point. The company then went on to win a \$1.6 billion Commercial Resupply Services (CRS) contract from NASA, which is rare given it is a lot smaller in scale compared to competitors in the market. Musk has succeeded in taking his first step to colonizing Mars. His journey was not a smooth one, but his perseverance and passion for space exploration made him the legendary man we see today,

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# ENGINEERING INNOVATIONS DEVELOPED DURING WARTIME: THEIR LASTING IMPACT

War has often served as a catalyst for rapid technological advancements, driven by the urgent need for new tools, weapons, and systems to gain strategic advantages. Many of these innovations have found lasting applications in civilian life, influencing various fields from transportation to space exploration.

The V-2 rocket, developed by Nazi Germany during World War II, stands as a landmark in the history of engineering. Spearheaded by engineer Wernher von Braun, the V-2—short for *Vergeltungswaffe Zwei* (Vengeance Weapon Two)—was the world's first large-scale liquid-propellant rocket vehicle and the first long-range ballistic missile, capable of delivering a one-ton warhead over 320 kilometers (200 miles). During the war, it was used primarily to target civilians in Allied countries. However, its creation also marked the beginning of a new era in rocket technology.[1]

The V-2 was the first rocket to reach the edge of space, achieving altitudes of over 80 kilometers (49.7 miles) during test flights. After the war, the United States and the Soviet Union—both key members of the Allied war effort against Germany and the other Axis powers—sought to bolster their technological capabilities by importing German rocket expertise.

In September 1945, the United States managed to bring Wernher von Braun and over 100 key personnel from the V-2 program into the country as part of Operation Paperclip. Their expertise was instrumental to the development of the U.S. space program, particularly in the development of rockets like the Redstone, which launched the first American satellite and first American astronaut.

The Soviet Union's successful launch of Sputnik I in 1957, the world's first artificial satellite, ignited the Space Race between the United States and the Soviet Union. The rapid development of the United States' space program during this era can in large part be attributed to von Braun and his team as he continued to improve upon the innovations he introduced with V-2. This paved the way for launch vehicles capable of placing satellites into orbit, enabling advanced communication, weather forecasting, global positioning systems (GPS), and scientific research.[2]

Furthermore, continued advancements in ballistic missile technology played a crucial role in the success of the Apollo missions. Von Braun's team, building upon their wartime experience, designed the Saturn V rocket, which allowed humanity to land on the moon and remains one of the most powerful rockets ever built. This achievement is a testament to how wartime innovations can lead to extraordinary accomplishments in peacetime, transforming the V-2's legacy to one of exploration and discovery.

However, the V-2's staggering influence has been seen in the military space as well, resulting in profound and often troubling consequences. The development of intercontinental ballistic missiles (ICBMs) during the Cold War, for instance, is a direct continuation of the technology pioneered by the V-2. ICBMs are capable of delivering nuclear warheads over vast distances, which made them central to the nuclear arms race between the United States and the Soviet Union. The existence of these weapons continues to be a source of global tension, as they provide nations with the capability to launch devastating attacks with little warning. In recent years, the dual-use nature of ballistic missile technology has extended into the realm of space. While space exploration offers tremendous potential for scientific advancement, the weaponization of space carries significant risks. The possibility of a new arms race in space, where nations stockpile satellites and rockets for military purposes, could lead to a scenario reminiscent of the Cold War, with potentially catastrophic consequences.[3]

The controversial creation of the U.S. Space Force (USSF) in 2019 speaks to the dual nature of the V-2's lasting legacy, as it is intended to protect critical infrastructure such as satellite communications and GPS vital for both civilian and military operations. Proponents emphasize that a dedicated force is necessary to maintain U.S. dominance in space and address emerging threats like anti-satellite weapons. On the other hand, critics argue that the U.S. Air Force has historically managed space-related missions effectively. Ultimately, the debate reflects differing perspectives on national security priorities and the increasing importance of space in the modern era, which has only been made possible by continual advancements in ballistic missile

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# SPACE EXPLORATION

Space exploration is a testament to human curiosity and our drive to explore the unknown. As we push the boundaries of what is possible, advancements in robotics offer promising tools for navigating the challenging terrains of other planets, such as Mars. Wheeled-legged robots in particular are poised to revolutionize locomotion on rough, foreign terrain. These new hybrid designs could offer a way to circumvent the drawbacks of pure wheeled and legged locomotion, resulting in a more adaptable and capable solution for future space missions and allowing us to explore more diverse and rugged landscapes.

The surfaces of celestial bodies like the Moon and Mars are often uneven, rocky, and filled with obstacles that can challenge traditional robotic explorers. Wheeled robots excel on flat terrain, while legged robots are better suited for rugged landscapes. Each has its limitations—wheels struggle on steep or rocky surfaces, and legs can be slow and energy-intensive over long distances—but each also has unique benefits like wheeled locomotion's energy efficiency and legged locomotion's robustness on any terrain. Combining these two methods into a single, wheeled-legged system could provide a versatile solution for exploring varied terrains. This is where innovative designs like the “Wheely” robot come in. Wheely is a small, low-cost robot designed to efficiently switch between wheeled and legged modes, allowing it to handle both smooth and rough surfaces. It can autonomously climb stairs and navigate over obstacles up to 25% of its height, making it well-suited for the kinds of unpredictable terrain that future space missions might encounter. Developed in 2023, Wheely is but a first step toward the proliferation of such robots on Earth, and eventually space.

Looking ahead, these robotic advancements hold potential for a range of applications in space exploration. While the technology is still developing, the ability to navigate diverse and complex terrains could allow robots like Wheely to explore areas that were previously deemed inaccessible or too risky for traditional rovers. This could include scouting out potential sites for future human exploration, gathering detailed data on surface conditions, or identifying resources that could support longer missions. In a future where robots are more autonomous and adaptive, they could become invaluable partners in our quest to explore distant worlds.

With the growing need for autonomous systems, the integration of advanced artificial intelligence, particularly deep reinforcement learning (DRL), represents a significant step toward making these robots more capable and independent. By training robots like Wheely to learn from their environment and adapt to changing conditions, they could be better equipped to handle unforeseen challenges. For instance, if a robot encounters a difficult patch of terrain, it could dynamically switch from using wheels to legs, navigating more carefully to avoid getting stuck or damaged. This kind of adaptability could reduce the risks and costs associated with space missions by minimizing the need for direct human control and allowing robots to respond more quickly to their environment.

While the potential is exciting, there are still many challenges to overcome before robots like Wheely are ready for deployment on planetary surfaces. The complexity of combining wheeled and legged locomotion in one system means there is still much to learn about optimizing control systems and ensuring reliability in the harsh conditions of space. Additionally, while simulation results are promising, real-world testing will be crucial to understanding how these robots perform under actual mission conditions. Future research will need to focus on bridging the gap between simulation and reality, refining these systems to ensure they are robust and reliable enough for the demands of space exploration.

The future of space exploration may very well benefit from these advances in robotics, but it will likely be a step-by-step process, built on careful experimentation, testing, and gradual refinement. Robots like Wheely, with their potential for hybrid locomotion and intelligent control systems, represent an intriguing possibility for future missions. As we continue to develop these technologies, we may find that these robots become valuable tools in our efforts to explore the final frontier, helping us reach further and learn more than we ever thought possible. But for now, it remains a vision—one that will require patience, perseverance, and a commitment to innovation.



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## Join Animal Welfare Alliance (AWA) – Make a Difference for Animals!

Are you passionate about animal welfare? Do you want to be part of a dynamic team dedicated to raising awareness and making a real impact? Animal Welfare Alliance (AWA) is looking for passionate individuals to join our mission!

### Our Mission:

At AWA, we are committed to raising awareness about crucial animal issues, including welfare, animal testing, abuse, the plight of homeless pet owners, stray animals, and promoting animal knowledge. We strive to educate the public and advocate for the rights and well-being of all animals.

Open Positions: We are currently seeking dedicated individuals for various positions, including:

- Website/Media Designer: Help us create engaging and informative online content.
- Recruitment: Bring passionate volunteers and team members to AWA.
- Outreach: Connect with the community and spread our message far and wide.
- Communications: Craft compelling messages and manage our public relations.

Please feel free to reach out about any other possible positions you are interested in!

### Why Join AWA?

- Impact: Be a part of meaningful work that makes a difference in the lives of animals.
- Community: Join a supportive and passionate team of like-minded individuals.
- Growth: Gain valuable experience and develop new skills in various areas.

How to Apply: If you're ready to make a difference, we want to hear from you! Please fill out the form to apply for positions and join our mission! Email [sophiazhang0088@gmail.com](mailto:sophiazhang0088@gmail.com) for any questions or concerns. Together, we can create a better world for animals.

[https://docs.google.com/forms/d/e/1FAIpQLSeGfoiV3-KRUVhPqNi\\_QptcVXYc0GB\\_NQhD7L2GIB9ulhm8Hg/viewform](https://docs.google.com/forms/d/e/1FAIpQLSeGfoiV3-KRUVhPqNi_QptcVXYc0GB_NQhD7L2GIB9ulhm8Hg/viewform)

## FutureVoice

FutureVoice is developing an application to help singers who are transitioning from one voice to another. In just the first few weeks, we've already developed a foundational plan and have gathered connections with professionals in voice to aid with our design. Our vision is to create a guiding light for the many LGBTQ+ singers, especially youth. With a passionate team, we're poised to have a large impact on singers. Email [ericxiyin@gmail.com](mailto:ericxiyin@gmail.com) for more info.

## Youth of Letters's

Youth of Letters's mission is to uplift teenage voices through written expression. We celebrate the transcending of convention and steadfast rules. By teens and for teens, we embrace all styles and genres of writing, and hold firm to the belief that every voice deserves to be heard. Our stories are our lifelines, our souls, our loaded guns, as George Orwell phrases. We welcome you. To new writers, let's stretch our wings. To existing writers, let's continue to soar.

We're looking for people who would enjoy and succeed at:

- Filtering through submissions
- Putting the issue together
- Marketing/PR (though I can probably do this myself if needed as well)
- Someone to expand our reach to the global scale
- Editors for that specialize in various submission types (prose, poetry, essay, etc.)

Email [rachelyin11@gmail.com](mailto:rachelyin11@gmail.com) for more info.

## HealingPain Foundation

Say you have a health problem. You might be able to easily book an appointment at a doctor's office and get it diagnosed. The doctor might prescribe a medication, and you may be able to easily go to the pharmacy and pick it up. The medication might work exceptionally well and life might go back to normal for you. However, this isn't the case for everyone. Some people can't afford to go to the doctor's office and get their problem checked out, or they might not have access to transportation that would allow them to go to the appropriate specialist. Others might not be able to afford the medication that is prescribed for them. HealingPain Foundation provides free care packages to people suffering from a health problem who might not be able to receive optimal care for a variety of reasons. The care package has a variety of items and over-the-counter medications that might relieve some of the pain. All one needs to do is simply go to our website and request one, and it would be delivered right to their house!

We are looking for a

- Social media manager to create and maintain the organization website, LinkedIn, IG, and other platforms
- Someone who is good at technology
- Someone who can set up consistent engaging content 3-4 hrs. a week
- Operations manager
  - To help create care package prototype
  - to source bulk goods & delivery options
  - to assist in creating operating plan
- Someone who has experience with or interest in ordering commercial products
- Someone who can handle a heightened workload initially over the summer, 3-4 hrs a week after operating plan is complete

Email [sudeepch@icloud.com](mailto:sudeepch@icloud.com) for more info.

## Unboxed

Unboxed provides services and products to track and improve people's mental health through our gamified wellness tracker as well as our boxes. Customers access our tracker by downloading the app (coding still in progress) from the app store and start monitoring their emotional, mental, and physical activities. Our services and products can be purchased from the app as well as our website. The business has attracted 500 followers and around \$1000 in revenue within the last 6 weeks.

Join our startup team and unbox your feelings with unboxed!

Currently, we are looking for:

- 2 R&D Managers
  - Develop new products/offerings
  - Help code the website (store for the boxes) as well as the wellness tracker
  - Need to be proficient in HTML, Java (react)
  - Add on is to be proficient in Swift
  - Manage research engineers
  - Analyze market trends/competitors
  - Report to CTO and CMO
- Senior Research Engineers
  - Mainly coders
  - Need to be proficient in HTML, Java (react), Swift
  - Benefit is to be good with Figma
  - Report to CTO and R&D Managers
- 2 Senior Operation Managers
  - Help package and ship boxes
  - Manage inventory etc.
  - Report to COO
- 2 Senior Marketing Managers
  - Help with market our product as well as our app when it launches
  - Social media marketing
  - Benefit is to be a good artist (drawing, music, video editing, etc.)
  - Report to CMO
- 1 Senior Financials Manager
  - Create and manage budgets
  - Provide regular financial reports
  - Financial planning
  - Report to CFO
- 1 Senior Accounting Manager
  - Oversee all accounting operations as well as payroll in the future
  - Report to CFO

If you are interested, fill out the google form (<https://forms.gle/pTyRZYV7EgGp4rz48>) and contact [unboxed.org@gmail.com](mailto:unboxed.org@gmail.com) for any questions.

## AI Vanguard

We are dedicated to promoting ethical AI development with AI Vanguard. We've impacted the AI community by fostering critical discussions and innovative brainstorming sessions through our program. To continue, we seek support from like-minded individuals. Your contribution can help us expand our reach, organize more events, and develop educational resources. Are you interested in joining our mission? Email [averyupdike@gmail.com](mailto:averyupdike@gmail.com) for more info.

Hi, I'm Cindy Tian, and I am seeking peers who share the same goals/ideas to start a non-profit organization together. I currently attend a boarding high school in Connecticut, and I live in Beijing. The vision of this organization is to help alleviate the stress of low-income people with disabilities. Some of the approaches I have been considering are creating music with scientific therapeutic effects, like meditating music that triggers the prefrontal cortex or the hippocampus, which inactivates when too much stress exposure occurs. Or do workshops/sessions once in a while using different methods. With a passionate team, we're poised to achieve as many people as possible creatively and effectively with our unique specialties. Let's connect to discuss how we're innovating. I would be happy to discuss this with you. Feel free to share any comments/thoughts you have regarding this email. Email [ctian0664@outlook.com](mailto:ctian0664@outlook.com) for more info.

We are dedicated to improving student wellness and mental health on campus through my club. By introducing animal therapy and stress workshops, advocating for changes in school policies, and more, I hope to alleviate student stress and anxiety. To maximize our impact, we seek support from like-minded individuals. Your contribution can help us create a more balanced environment for students. Interested in joining our mission? Email [emilyymeng@gmail.com](mailto:emilyymeng@gmail.com) for more info.



## StarMind

StarMind is a nonprofit dedicated to supporting individuals recovering from eating disorders. We've developed a mental health app that integrates astronomy-themed therapeutic elements to provide a unique and effective support tool. In just six months, we've conducted extensive research and collaborated with mental health professionals to create this comprehensive resource. We have already impacted numerous lives by providing an accessible, astronomy-themed mental health app and support through our nonprofit initiatives. Our vision is to revolutionize the approach to eating disorder recovery by combining the awe of the universe with effective therapeutic practices. With a passionate team and the support of our community, we can definitely make a significant impact in the mental health field. Your contribution can help us expand our reach, develop more features, and support more individuals on their recovery journey. Interested in joining our mission?

We need people who can help with:

- **App Development:** Expertise in mobile app development, particularly in building and maintaining apps that require user engagement and data security
- **Nonprofit Management:** Knowledge of running a nonprofit organization, including fundraising and legal requirements
- **Fundraising and Development:** Experience in organizing fundraising campaigns and securing grants and sponsorships
- **Marketing and Outreach:** Skills in digital marketing, social media management, and public relations to effectively promote the app and the nonprofit's mission
- **(Maybe) Mental Health Professionals:** Psychologists, therapists, and counselors with experience in eating disorder treatment to ensure the app's content and tools are effective

We offer:

- **Meaningful Work:** An opportunity to make a significant impact on the lives of individuals recovering from eating disorders
- **Professional Growth:** Opportunities for professional development and growth within a dynamic and supportive team environment
- **Flexible Work Environment:** Options for remote work and flexible hours to accommodate different lifestyles and commitments
- **Collaborative Culture:** A collaborative and inclusive culture that values input from all team members and fosters innovation
- **Recognition and Impact:** A chance to be recognized for their contributions to an important project in the mental health field

Email [sophie.duan888@gmail.com](mailto:sophie.duan888@gmail.com) for more info.

## Programming For All

Programming For All is a nonprofit organization dedicated to creating free educational videos about computer programming for underprivileged children, and our mission is to make education in programming accessible for everyone, no matter their circumstances.

We are currently looking to fill the following positions on our leadership team:

### Vice President

- **Responsibilities:**
  - Collaborate with the president on organization plans
  - Coordinate regular operations
  - Plan and lead fundraising efforts
- **Requirements:**
  - Strong planning skills
  - Experienced in leadership and communication
  - Excited about education

### Secretary

- **Responsibilities:**
  - Coordinate and manage meetings, decisions, and other internal activities
  - Manage communication with third party associates
  - Assist in organizing events and fundraising activities
- **Requirements:**
  - Experience in administrative role
  - Skilled in organization and management
  - Strong communication abilities

### Treasurer

- **Responsibilities:**
  - Maintain records and reports of our finances
  - Direct budgeting financial efforts
  - Assist in fundraising
- **Requirements:**
  - Experience in financial management, preferably in nonprofit
  - Expertise in financial practices
  - Excellent organizational and analytical skills

### Video Editor

- **Responsibilities:**
  - Edit and enhance video content
  - Work with our video hosts on videos
  - Design the whole edit
- **Requirements:**
  - Proven experience in video editing
  - Attention to detail
  - Passionate about education

If you would like to join us to help ensure the next generation has access to vital education, we would love to hear from you. Please email [squidgyberries@outlook.com](mailto:squidgyberries@outlook.com) for further details.



**Miracle Steps Foundation** is dedicated to providing urgent care and support to **NICU babies and their families**. Members will be able to create kits for parents of NICU children, memory boxes, art supplies, and donate baby clothes for preemies for volunteer hours. Your help can create a meaningful impact and bring positive change to those in need.

**Join the executive leadership board!**

**Treasurer:**

- Manage the nonprofit's finances, including budgeting, tracking expenses, and overseeing financial records.
- Ensure transparency and accuracy in financial reporting.
- Handle donations, grants, and other revenue streams, ensuring funds are allocated properly.
- Provide regular financial updates to the leadership team and assist in financial planning for future projects.

**Volunteer Coordinator:**

- Recruit, train, and manage volunteers for various nonprofit activities.
- Organize volunteer schedules and ensure adequate staffing for events, outreach programs, and other initiatives.
- Serve as the primary point of contact for volunteers, addressing their questions and concerns.
- Foster a positive and engaging environment for volunteers to feel motivated and connected to the nonprofit's mission.

Email: **[miraclestepsfoundation@gmail.com](mailto:miraclestepsfoundation@gmail.com)** for more information!