James Morton
Hellman
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The Need for Space Colonization

"My God, it's full of stars!" (Kubrick) Looking up at the night sky, humans dream of the universe beyond the unexplored cosmos. The desire to learn and explore is conjoined with humanity's eternal struggle for freedom. Space colonization is that freedom, that escape. It will be the next key progression for humanity. Space colonization is humanity's next step in environmental, economic, and engineering progress. Increasing funding to NASA will benefit the future of space colonization and the world.

Fig. 1. NASA/Cory Houston, *Intuitive Machines 2-Lift Off*, 2025

Space colonization is exploring and establishing bases in space. For much of history, minimal progress was made toward space colonization until the US and the Soviet Union began competing. The space race began with the Soviets launching Sputnik-1, the first satellite in space, and it reinforced a rivalry that led to the development of new rocket technologies and modern-day computers. After the Soviets got the first man in space, the United States decided to land on the moon. This growth propelled the United States and the world into the 21st century. (Archives Editors)

However, after Apollo 11, the US slashed NASA's budget. Despite this, NASA persevered, launching many more human-crewed space missions, developing the space shuttle, and establishing the ISS. (Dreier) As the Soviet Union dissolved, there was no conflict to keep the program alive. Then, commercialization entered the space industry. Companies like SpaceX and Blue Origin now aid NASA in important missions to the moon, ISS, and Mars. With increased help from NASA, missions into space are commonplace. The increase in aid allows for advancements in climate change, economics, and engineering research. This research will support humanity's present on Earth and its future in the stars.

To have strong foundations for space colonization, we need a clean Earth. The climate is an integral part of the Earth's maintenance of life. Space missions to the ISS are needed to provide data to climate researchers, farmers, and botanists. "That Earthward gaze is feeding data and imagery back to scientists, farmers, foresters, and others around the world, making a difference for humanity right now." (NASA Editors 27) Increased NASA funding would allow climate scientists to do more research aboard the ISS through missions and new tools.

NASA is the leading research body in the climate field. Two tools NASA uses for research are ECOSTRESS and OCO-3. ECOSTRESS is focused on temperature changes in

plants, while OCO-3 studies carbon emissions above significant cities. Using these tools, NASA studies how plants and humans interact in the carbon cycle (NASA Editors 28). These tools provide key information to farmers worldwide (NASA Editors 28). Increased funding to NASA would also help climate research, which is key to sustaining the Earth and its food production. Sustaining the climate allows people after us to continue working on space colonization and technology.

This research could also lead to future carbon storage techniques in space, a tool necessary for providing a continuous oxygen supply in long-distance travel (NASA Editors 27). The ESA has already begun researching algae used for carbon storage in space travel (NASA Editors 27). This junction of climate science and space exploration illustrates the importance of current research on the ISS for the future of space colonization. Funding NASA and the ESA provides potential solutions for Earth's climate issues and issues in space.

Climate change is an immediate issue, and more funding would allow scientists to research and hopefully slow climate change through environmental engineering. Addressing the importance of climate change is not just necessary for space colonization but for the future of the planet, and it is a responsibility humans share. The ISS represents the beginning of colonization in orbit and allows for even more potential benefits in aerospace, resource allocation, and especially in economic sectors to the world and the US.

Secondly, we need cheaper and more abundant resources to begin colonizing space further (Swaminathan and Malhotra 4). This issue is also crucial for Earth's progress. One proposed solution is space mining. NASA plans to send autonomous robots to retrieve large amounts of resources from asteroids and the moon. Progress has already started with groups such as Planetary Resources by "designing satellites that have identified about 15,000 asteroids with

significant potential for mining." (Yarlagadda). NASA's contributions to resource data will be integral to commercialization and governmental research. Funding NASA will be paramount for creating the space economy and yielding a better quality of life through space mining.

Asteroid mining and even researching asteroids is expensive (Yarlagadda). Despite this, NASA's OSIRIS-REx mission made collecting a resource sample possible (Yarlagadda). The mission primarily was to determine if asteroid mining would be a worthwhile investment. Moreover, by funding more missions, it would be possible to expand the research around asteroid mining. Space mining will grow Earth's resource pool, and this increased resource pool allows for cheaper development of technology and rockets (Swaminathan and Malhotra 4). Other potential benefits from space mining would be excess resources, which would allow aid to developing countries.

Unfortunately, many countries rely on rare resources for their economy (Yarlagadda). They are rare due to a tiny percentage in the Earth's crust and are difficult to mine when found. Because of this, asteroid mining would obliterate many countries' economies that rely on specific exports like cobalt or platinum. These effects can be counteracted if developed countries regulate the negative impacts of space mining. Developed countries could also provide funding for developing countries' space programs.

Two beneficial impacts of space mining would also increase the quality of life on Earth. The first is that mining operations destroying the environment would cease, and many communities would become less polluted. Rare resource mining on Earth is also a common issue for humanitarians due to the everyday use of child labor, "asteroid mining would reduce the prevalence of inhumane or otherwise illegal practices surrounding human mining operations"(Yarlagadda). Decreased mining on Earth would also reduce child labor use. These

two issues are paramount to protecting the future climate and to future developing nations. It is important to do this to have a sustainable environment where multiple countries work together, leading to a faster, more expansive space colonization effort. These benefits both supersede the cost of space mining and are necessary for Earth's future.

Next, space colonization needs an economy in space to be self-sufficient. Space colonization is expensive, and space mining can offset the cost. Resources from asteroids are the only way to provide the resources necessary for space colonization (Yarlagadda). Increasing funding to NASA is needed to research space mining technology. The better funded this technology is, the larger capacity there is to collect resources to aid the Earth and space colonization.

Finally, increasing NASA funding would support the development of new technology and engineering principles. Research and experiments are an important way to test new ideas. Presently, the ISS is an important station for experiments in low gravity. “Entering its third decade of life, the International Space Station has evolved into a robust scientific laboratory with dozens of research facilities and an array of tools and observational instruments.” (NASA Editors 13). The electromagnetic elevator (EML) is used to explore further the microstructure of materials, especially at high temperatures (NASA Editors 10). Materials science is a critical field in engineering. Increasing NASA funding will allow more ISS research and expand material science. By testing these materials in space, we can further research how materials interact in low gravity to further space colonization.

Another important technology developed for the ISS was a solid-state welding technique called “friction stir welding” (ISECG Editors 19). This technique rotates a tool at high speeds between two surfaces to create a flawless joint. This technique is important in offshore drilling,

armor plating, and rocket manufacturing (ISECG Editors 19). NASA's commitment to innovation has helped advance friction stir welding, making it a crucial application for aerospace. Increased funding for NASA would allow further research into more welding techniques, which will be essential for space colonization and the safe travel of future missions.

Space colonization can be general, but it can also be a specific planet or goal, such as Mars. Mars is our closest red neighbor, about the same size as Earth. More research must be done on habitability and the climate to colonize Mars, while environmental engineering is necessary to provide safe living conditions. NASA is the leading researcher looking for biological material and safe soil on Mars (Yiğit 44). Increasing funding to NASA would allow more research missions to Mars to investigate Mars' habitat further and investigate more environmental engineering techniques.

Terraforming is a way to transform Mars' harsh climate through years of environmental engineering. Unfortunately, many issues exist with terraforming related to food production, travel, water, and energy (Swaminathan and Malhotra 7). However, the biggest issue is that "Although Mars has strong localized crustal magnetic fields distributed primarily in the southern hemisphere, it lacks a global magnetic field." (Yiğit 49) The magnetic field on Earth is an integral part of sustaining life here, as it deflects harmful radiation from the sun.

Other ethical and political issues also exist regarding terraforming and colonization. Whose land is it? What country do the colonists belong to? Do we even have a fundamental right to take control of a planet? Is it worth the years of time and money? (Swaminathan and Malhotra 6) These issues with space colonization need to be solved before colonization can occur. Other issues related to long-distance space travel are also very pressing. Thankfully, research into new propulsion techniques has already begun.

Electronic propulsion is another technology that will change space colonization. It started research 60 years ago but was inhibited by the lack of power generation and only budding computer engineering scene (Levchenko et al. 39). Electronic propulsion provides numerous benefits in space, and allocating funding to groups like NASA allows for testing in the ISS and zero-gravity. A few benefits, as described in Physics Today, are “Higher thrust efficiency produced by higher-power, long-lived electric thrusters to support planned manned expeditions and cargo missions to Mars and possibly other celestial objects.” (Levchenko et al. 47). As stated, it provides a potential solution for long-distance space travel. It will also be cleaner for the Earth. Funding NASA will allow more research and development of these already world-changing technologies to support innovation on Earth and in space.

Overall, the impact of space colonization cannot be understated, and its future impact on the world will be almost alchemical. The climate, economic, and engineering benefits are matched by nothing else. Today's benefits are enough to provide NASA with more funding for more significant projects. The future of space colonization relies on NASA's funding to garner interest and support large-scale missions, such as the Artemis Mission and missions exploring space mining. New propulsion and welding techniques will continue to aid aerospace research and tangential industries.

Space colonization is not inevitable; it will be challenging, but that is why humanity must do it. Despite many budget cuts, NASA's constant determination to proceed with its foundational dream is an inspiration, and its technological advancements are superseded by no other. NASA’s support of the climate, the economy, and engineering are vital reasons for increasing funding. To progress the world into a safer age and to explore the stars, funding NASA is the key stepping stone, and it will be for years to come.

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