SPACE
{Editorial Insights}

SPACE IS THE BOUNDLESS ARENA FOR TRANSFORMATION

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Abstract: Portions of the space industry are moving at light speed, with benefits for Earth, and for new innovations in industry, while in other areas there are shifts that need to occur. This editorial explores the transformational impact of space exploration on industry from the perspective of an industry expert for human spaceflight training and engineering. As such, advances that are possible in human spaceflight training and engineering are discussed, thereafter space engineering transformations with benefits to Earth, and last, industry transformations in a selection of sectors including healthcare, orbital downmass services, materials, law and finance, and space tourism. The author concludes with a discussion of our shared duty preparing for this future, extending from global contributions to the individual.

Keywords: Microgravity Laboratory, Sub-Payload Hovering Explorer, Sub-Payload Orbital Downmass, PLSS, Space Education, Space Tourism

Space exploration has long been a frontier that captivates the human imagination, inspiring generations to look beyond the confines of Earth and into the infinite possibilities above. As a provider of astronaut training and all kinds of related engineering, I stand at a unique intersection of human potential and technological advancement, where every mission is not just, as Neil Armstrong said on his 1969 moon walk, “one small step for a man” but truly “one giant leap for all mankind” (Navy Times, 2019). Space is a boundless arena for innovation, collaboration, and transformation that will redefine industries and our global civilization.

It might seem like a science fiction, but it isn’t. Within ten years there will be outposts on the moon and Mars (Sankaran, 2025; Musk, 2025). Before even 2030, commercial space anticipates landing on Mars more than 100 times (Musk, 2025). Within two years the first commercial hotel may open in space (Darkunde, 2025). Even if these timelines slip, the trajectory remains the same. Think about what this means. Gen Z children will have the option to go to space for work or pleasure, and every generation thereafter will see low earth orbit and beyond as a potential job site, habitat, and vacation spot. The world as we all know it, is about to make a quantum leap into a new paradigm.

Preparing Minds and Bodies for the Cosmos

On earth, the workforce preparations are happening already, albeit with some elements of the space sector racing ahead, while others are struggling to keep up. Training astronauts, for example, has been a multidimensional challenge, blending the physical rigor of elite athleticism with the intellectual demands of cutting-edge science and engineering. These space travelers have been polymaths—scientists, engineers, doctors, and pilots—prepared to adapt to the unknown. But gone are the days where one must have something akin to a PhD in nuclear physics and the stamina of Captain America to be a space traveler. Now, anyone can go to space. Astronaut candidate selection also needs to be broadened. Astronauts no longer need to be elite test pilots or research scientists. It is time for astronaut candidates to come from skilled labor categories like mechanics and electricians. An astronaut workforce is needed immediately to pilot and repair space vehicles and build and maintain the first space habitats. Scientists can resume a focus on space research and travel to space like the space tourists, without the all-encompassing training that astronauts continuously maintain. The space sector needs this diverse workforce and division of labor. If we look at the proposed missions of governments and commercial space, at least 600 astronauts are needed in the next five years, but only 150 astronauts exist worldwide. Only a third of these are American astronauts, and almost two retire every year (Astronaut, 2024).

By the formal definition, an astronaut is certified in extravehicular activity, which are those maneuvers in the vacuum of space using a spacesuit (FAA, 2021). The certification remains important, because astronauts are the only space travelers able to function in the vacuum of space, meaning outside the space station, such as to fix a thruster broken by a pesky one-inch speck of space debris, or random meteor fragment. While we all generally understand what a spacesuit is, that highly complex vehicle of life support and protective gear against the extremes of space can take years of training to master, as well as training in the suit on the space vehicle and the lunar or planetary surface. Once an astronaut is certified, they then continue to train for their specific mission, and with team members in the microgravity laboratory. It is important to understand, if you need one astronaut for the mission, you train at least three additional. One to be the backup in the space vehicle in case the primary is incapacitated, two standing by at the last minutes to launch as possible replacements. Those that do not go forward manage the mission from the ground, rehearsing maneuvers on earth that will guide the astronaut that will do that same maneuver in space.

The neutral buoyancy laboratory (NBL), also called a microgravity laboratory, is where astronaut candidates train to use a spacesuit, and on space vehicles or things like lunar surfaces. My staff has been helping train NASA and Partner Nations' astronauts at the NBL in Houston since 1997, so we have decades of lessons learned about this industry. The reality is there are too few such facilities around the world, and all of them are too small to accommodate the current needs of commercial space, let alone government ambitions. Training timelines can also be made more efficient. So much like the rocket sector now is split between government and commercial players, we will be building private microgravity laboratories to increase the number of certified astronauts.

As missions extend further from Earth, the need for physical and psychological resilience only grows. Future training will also have to focus on equipping astronauts to thrive rather than just survive in extraterrestrial environments. A critical dimension of astronaut training will involve cultivating long-term psychological resilience. Extended missions, such as those to Mars or deep-

space stations, demand unparalleled mental fortitude. Techniques like mindfulness-based stress reduction, immersive team-building exercises, and advanced neurofeedback systems will become integral. These strategies aim to sustain motivation, enhance adaptability, and mitigate the effects of isolation and confined environments. Biological enhancements will also play a role. Humans will need better tools to withstand radiation, low gravity, and other space-related stresses.

Earth Benefits from Space Industries

The lessons learned from astronaut training and space exploration have always had profound terrestrial applications. Consider the refinements our company made to double the time of the closed-loop personal life-support systems (PLSS) for long-duration space missions. These systems, which recycle water, air, and waste with near-perfect efficiency, could revolutionize resource management on Earth, offering sustainable solutions to water scarcity and urban waste. Already NASA's Environmental Control and Life Support System (ECLSS) demonstrates how innovations designed for space are having significant Earth applications, in this case aiding remote locations or places devastated by natural disaster that do not have access to clean drinking water (ECLSS, 2017). Another example is an artificially intelligent autonomously guided system we created for use in space and environments without GPS. It is now used on drones in Florida for surveying underground water systems.

Mining is another important industry for space, with potentially significant Earth benefits. Space mining operations could one day alleviate the need to further mine the Earth, as well as contribute to fueling space travel to and beyond Mars. We hope to use our sub-payload hovering explorer and other engineering on upcoming missions to the asteroid belt, and to confirm hydrogen fields on the moon. The asteroid belt between Mars and Jupiter alone is believed to contain resources valued by some analysts at an estimated US$700 Quintillion (Ratner, 2019).

When we think space industries, we often think of the advances in robotics, and in-space manufacturing, but agriculture will also benefit from extraterrestrial farming techniques developed for lunar or Martian colonies. Hydroponic and aeroponic systems, essential for growing food in space, are being adapted to urban environments, enhancing food security in densely populated areas. Additionally, advancements in crop genetics, driven by the need for resilient plants in extraterrestrial environments, could lead to higher-yield and drought-resistant crops on Earth.

Industries of Tomorrow, Shaped by Space

Industries worldwide will find themselves irrevocably altered by the expanding space economy. This process has long been underway. We all navigate using map features that are guided by GPS and rely on many other facets of daily life enhanced by satellites. Other impacted industries include healthcare, orbital downmass services, materials, law and finance, and space tourism, just to name a few.

The healthcare industry stands to gain immensely. Research on human health in space is uncovering strategies to enhance physical and mental well-being on Earth. Insights into circadian rhythms and sleep disorders derived from space missions are improving treatments for insomnia and jet lag. Remote medical technologies developed for astronauts, such as robotic surgical systems, are transforming healthcare delivery in underserved regions. Research into bone density loss and muscle atrophy experienced in microgravity has advanced treatments for osteoporosis and age-related muscle degeneration. Similarly, microgravity experiments in protein crystallization

have yielded insights into drug development for conditions like cancer and Alzheimer's disease Crystallizing, 2022).

Don't forget the postal system either. In-space engineering already needs cheaper sub-payload return-to-earth mailers, like our company's SpaceBrake, that can be guided back to a specific location on earth. Providing highly compact sub-payload, low ballistic coefficient, maneuverable within a couple hundred meters, and deployable systems for on-demand reentry at scale will be in of itself a significant global industry as more and more humans and space objects want to skip the wait for a spot on a returning shuttle. These reusable downmass services will provide orbital lifeboats for return of space travelers, bio and scientific payloads, and allow space cargo deliveries.

Space-driven research into materials—such as self-healing polymers and ultra-light composites—will redefine construction, transportation, and energy industries. For instance, the lightweight materials developed for rovers and satellites have applications in wind turbine construction, boosting renewable energy efficiency.

Even industries like law and finance will have new facets. The governance of space, from property rights on the Moon to the ethical implications of space debris, will demand innovative legal frameworks. Meanwhile, insurance and investment firms will pioneer models to manage the risks and rewards of space ventures. The Artemis Accords, an international agreement governing lunar exploration, is an early step in crafting these frameworks, but much work remains.

Last, but by no means least, space tourism, once the domain of adventurous billionaires, will evolve into a sector offering affordable orbital vacations. And on Earth, watching astronauts train and touring space vehicle mockups with virtual reality experiences is very soon to become as common as a trip to your favorite amusement park. Estimates vary on the growth trajectory of the space tourism sector and will continue to evolve as future space milestones are surpassed. By one estimate, in 2024, the global market for Space Tourism was valued at US$1.3 Billion, and was estimated to reach US$6.7 Billion by 2030 (Global, 2025).

Our Shared Duty Preparing for the Future

The future of space is a global endeavor. Nations once on the periphery of space exploration, like India, Brazil, and the United Arab Emirates, are emerging as pivotal players, democratizing access and diversifying perspectives. I had the opportunity to meet with the Abu Dhabi and Dubai leadership, visit their space center, and attend the graduation of their astronauts. I was impressed by the thoughtful contributions they are making to global space intelligence. Their 2020 Hope mission to Mars is still actively studying the atmosphere of the red planet in multiple ways that no other space mission has achieved (Emirates, 2025). This kind of international cooperation will be essential for addressing universal challenges, such as understanding weather patterns that will affect our habitats on Mars and securing critical materials for earth and space construction.

Ultimately, the vision of space I hold as a provider of astronaut services and engineering is one of boundless opportunity and profound responsibility. I have honor and privilege to prepare my customers—astronauts and their crew—for the future. But we all have a roll. Space is not just a destination, but a mirror, reflecting humanity's highest aspirations and deepest flaws. It challenges us to be better stewards of our planet and more thoughtful citizens of the universe. Much is to be done to ensure not just the minimal preparations are in order for the next mission, but that we take the care to make the travel safe for all, and beneficial not just to humanity, but also this planet. As we stand at the threshold of this new era, let us embrace the unknown with curiosity, courage, and compassion. Let us prepare ourselves for the future, not just to explore the universe but to extend

the best of ourselves—our ingenuity, resilience, and empathy—into the cosmos. The future of space is the future of humanity, and it promises to be a journey like no other.

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