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UNITED NATIONS COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE (UNCOPUOS)

Economic Effects of Future Investment in Space Exploration

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December 2023

Introduction

Over the past half-century, space has evolved from an untrodden final frontier to one of the fastest-growing sectors of the global economy.[1] Space is now the cornerstone of many industries, with the reliance on spaceborne assets growing in many market sectors, from cellular phones to retail to even the use of credit cards.[2] However, there is a rocket-sized elephant in the room when the space sector is brought up in conversation: space exploration. From the days of the Soviet-American space race to now, the need for space exploration has been questioned worldwide, the main criticism being its economic infeasibility. Why spend billions exploring the stars when people are starving at home? Pragmatic, realpolitik arguments like these permeate society, often leading to under-funded space programs worldwide. No one can deny how expensive space exploration is: the National Aeronautics and Space Administration's (NASA) Space Launch System (SLS), the current mainstay rocket of the agency's Artemis manned lunar program, is estimated to cost over $4.1 billion per launch[3] (NASA Office of the Inspector General, 2021). This is one of the most expensive examples of the eye-watering price of space exploration. However, even spacecraft half that price fails to garner economic support from private and public sources. If it is so expensive, why do governments support space exploration programs? What are the benefits of space exploration, and why should the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) recommend that nations fund space exploration with the limited funds available?[4] The answer is complicated, and delegates to the UNCOPUOS should be diligent in their research and understanding of the advantages, risks, costs, and virtue of recommending space exploration as a viable economic option for nations across the globe.

"Spinoff" Technology

The first days of space exploration began in the late 1950s when television itself had yet to be a mainstay in the Western household.[5] It evolved with the Soviet-American arms race, fueled by geopolitical and ideological tensions. The USSR and US dedicated massive amounts of money to stockpile nuclear warheads, missiles, and other weapons of mass destruction.[6] Soon, both nations had enough nuclear weapons to destroy each other and the world tens of times over, and the number of weapons became a moot point, unlikely to tip the scale in either direction. When scientists on both sides of the Iron Curtain argued that intercontinental ballistic missiles began to have capabilities beyond Earth's atmosphere, both nations looked to the stars as the tiebreaker to the deadlocked arms race.[7]

When the US Congress commissioned NASA and its headquarters, a small warehouse in Langley, Virginia, in 1958, they mandated that the new bureaucracy disseminate its innovations as widely as possible. Though many cutting-edge technologies that defined the space race were top secret, the Technology Transfer Program was created in 1964 to make this a reality. Being NASA's longest continuously operated mission, the Technology Transfer Program specializes in making innovations created by NASA for space exploration available for commercial

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[1] Aisha Williams, "Investing in the Final Frontier: Advancing Sustainability through Space Innovation," *Nasdaq*,
[2] Aisha Williams, "Investing in the Final Frontier: Advancing Sustainability through Space Innovation," *Nasdaq*,.
[3] "Space Launch System: Cost Transparency Monitor Program Affordability," U.S. GAO, September 7, 2023,
[4] Robert.Wickramatunga, "COPUOS," n.d., https://www.unoosa.org/oosa/en/ourwork/copuos/index.html.
[5] "The Space Review: National Space Rhetoric of Eisenhower, Kennedy, and NASA," April 20, 2020,
[6] "Milestones: 1961–1968 - Office of the Historian."
[7] "Milestones: 1961–1968 - Office of the Historian."

application.[8] These innovations are affectionately known as "Spinoffs." In 1976, NASA began to document known Spinoff technologies in an annual publication of the same name.[9] Since its inception, Spinoff has documented an average of fifty commercial technologies a year that were created for space exploration. According to an official statement by US Alternate Representative Kevin Conole under Agenda Item 10 at the 65th UNCOPUOS (2022), more than 2,000 Spinoff technologies have been officially documented since records began in 1976.[10]

Just as space exploration technology began as a "spinoff" of weapon and military technology, many proponents of the practice argue that the economic benefits of space exploration are in the technologies created in pursuit of safer, more efficient, and more capable spacecraft.[11] In the same statement, Representative Conole mentioned air-purifier and air quality sensor technology, created as a result of decades of research on the International Space Station (ISS), intending to keep air fresh for the multinational astronauts and cosmonauts aboard the ISS, was used to help fight the COVID-19 Pandemic back on earth,[12] slowing the spread of the virus. Spinoff technology covers various markets, from everyday items such as cordless compact vacuums and memory foam to life-altering technology such as cochlear implants and ventricular assist devices. Without space exploration and the necessary technological innovation, proponents argue, these products would not exist.

International Space Station National Laboratory

History was made on a chilly day in early December 1998, 254 miles above the surface of the Earth. The Russian Zarya module and the American Unity module rendezvoused to form the initial segment of the ISS.[13] Two years later, Expedition 1, carrying two Russian cosmonauts and one American astronaut, boarded the station to become the first crew of this new permanent human outpost in space.[14] Since Expedition 1, 15 other modules joined Zarya and Unity, and over 273 individuals from 21 different countries have operated the station over its current 25-year lifespan.[15] The station is set to depart its home in low Earth orbit (LEO) in 2030, with commercial companies expected to fill the void with multiple space stations after its departure.[16]

The station has always been, first and foremost, a laboratory. Initially used for government-funded projects, the US Congress designated the ISS as a national laboratory to enable the space-based research and development community to access a wide range of commercial, academic, and government users.[17] This opened the ISS as a platform for schools, companies, and other organizations from various nations. In 2011, a non-profit organization called the Center for Advancement of Science in Space (CASIS) was established to manage all ISS National Laboratory (ISS NL) investigations on the ISS.[18] The ISS NL sponsors the scientific investigations sent to the station as astronauts conduct the investigations.

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[8] "NASA Technology Transfer Portal Home."
[9] "About Spinoff | NASA Spinoff," n.d., https://spinoff.nasa.gov/spinoff.
[10] "Spin-off Benefits of Space Technology," U.S. Mission International Organizations Vienna, August 8, 2022,
[11] Munévar, "The Standard Case for and against Space Exploration."
[12] Guzman, "Using Microgravity to Combat COVID-19 - NASA."
[13] "History and Timeline of the ISS," n.d., https://www.issnationallab.org/about/iss-timeline/.
[14] Admin, "This Day in History: Expedition 1 Becomes First Crew to Live and Work Aboard Space Station."
[15] Garcia, "Station Reaches 25 Years in Orbit, Crew Continues Advanced Space Research."
[16] Guzman, "NASA Seeks Input for Commercial Low Earth Orbit Destinations - NASA."
[17] "International Space Station - NASA," NASA, n.d., https://www.nasa.gov/international-space-station/.
[18] "About the ISS National Lab," n.d., https://www.issnationallab.org/about/about-the-iss-national-lab/.

An example of a recent focus of many of the R&D efforts of organizations sponsored by the ISS NL is in-space manufacturing, which takes advantage of the microgravity environment in space to manufacture objects that are difficult or impossible to create on Earth.[19] In response to this growing focus, NASA set up the In Space Production Applications (InSPA) program in 2022 to award ISS NL investigations that can advance progress toward in-space manufacturing.[20] There are several in-space manufacturing technology demonstrations aboard the ISS and even more are being prepared to debut on the international stage.

Manufacturing objects in space has several advantages. Firstly, the cost of launching a massive payload is exorbitant, and sometimes is the reason why some experiments or expeditions are not approved. Instead, sending up materials over time and constructing them in space can mitigate the cost. Additionally, companies around the world are interested in "microgravity manufacturing," which they contend will help them "discover new products, enhance their current offerings, or decrease development timelines."[21] Hundreds of patents have already been filed concerning microgravity, so the prospects of this sci-fi story of economic growth are rooted in realism and optimism.

There are, however, many obstacles and opponents to microgravity manufacturing. Along with cost and necessity (i.e., is it possible to do the same thing on Earth for less money?), industry experts worry that the space-based industry will not merge with the Earth-based industry's ecosystem. The space-based parts of the companies, experts warn, cannot be a "distant partner that provides occasional advice."[22] For the economics of space exploration to make fiscal sense, the global economy must not see the space-based industry as a subsidiary of a more crucial Earth-based industry: they must be supported by each other and grow with one another. The UNCOPUOS must evaluate ways international legislation can ease the integration of these two sectors into one cohesive industry while protecting against dangerous monopolies that could form due to increased interactions between large-scale industries. This protection is essential, as the only companies that can access space as an economic asset at first will be large-scale, multi-billion dollar transnational corporations.

Economic burden of space exploration

However beneficial space exploration has been since its inception over six decades ago, it is challenging to consider its enormous cost. Only 11 countries can conduct orbital rocket launches: the US, Russia, China, Japan, India, Iran, North Korea, South Korea, Israel, Ukraine, and France (which launches on behalf of the European Space Agency).[23] Of these countries, only the US, Russia, and China have active capabilities to send humans to space. This limitation is due to the massive cost of maintaining space launch infrastructure.[24]

The Russian space program, known as Roscosmos, is an excellent example of the taxing burden of space exploration. Roscosmos is the successor organization to the Soviet Space

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[19] Carsten Hirschberg et al., "Microgravity Manufacturing and R&D in Space | McKinsey," accessed December 22, 2023, https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/the-potential-of-microgravity-how-companies-across-sectors-can-venture-into-space.
[20] NASA, "In Space Production Applications - NASA."
[21] Hirschberg et al., "Microgravity Manufacturing and R&D in Space | McKinsey."
[22] Hirschberg et al., "Microgravity Manufacturing and R&D in Space | McKinsey."
[23] "- INTERNATIONAL SPACE EXPLORATION PROGRAMS," n.d.,
[24] "How Space Exploration Is Fueling the Fourth Industrial Revolution | Brookings."

Program, the oldest space program in the world until it disbanded in 1991.[25] Despite its deep heritage and long history, Roscosmos does not operate on the cutting edge of space travel technology.[26] It operates rockets based on designs made during the space race's height. Its only manned spacecraft model, the Soyuz, was initially designed to compete with the American Apollo capsule of the 1960s and 70s. Despite their many attempts to replace the Soyuz and their many Cold War-era rockets, most of these replacement programs have been canceled due to their enormous development costs.[27]

The Russians are not the only ones who have halted innovations in space exploration due to cost concerns. In 2010, the US government, in the wake of the 2008 recession, enacted legislation to speed up the already planned retirement of the 30-year-old Space Shuttle program, as well as the cancellation of the Constellation program (a program aimed to land astronauts back on the moon by 2020, which already had a prototype rocket built and flown).[28] This cut was done to avoid the projected cost increase that the Constellation program would bring. However, the early retirement of the Space Shuttle program in 2011 came with many consequences, such as NASA laying off 8,000 people who worked on the program and a 9-year gap where the US had to rely on the Russian Soyuz vehicle to send humans into orbit.[29] The US regained its human launch capability in 2020 when the American company SpaceX's Dragon 2 capsule finally became operational, but government support for space exploration remains minimal.[30]

"A New Era in Commercial Space Exploration"[31]

Currently, 95% of all revenue earned in space is from the *space-for-earth* sector.[32] Like microgravity manufacturing, cell phone satellites, space tourism, and internet infrastructure, space-for-earth is a robust sector of the global economy that is projected to continue growth patterns in the foreseeable future. Even before private companies could launch their spacecraft, the government would contract out weight on spacecraft launches to private companies. In 2012, the first non-government-owned spacecraft was launched, and it made the space-for-earth sector more accessible and less expensive to companies around the world. It has also made possible the second area where revenue is earned in space, the *space-for-space* sector, which involves mining asteroids and natural satellites for materials to construct living and working environments in space.[33] The sector only accounts for 5% of space revenue, but the commercial era of space exploration promises to facilitate a sweeping increase in its value, eventually outpacing the terrestrial economy as a whole.[34] Of course, developing a complete economic sector in space presents some issues in light of the Outer Space Treaty, which prevents ownership in space.

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[25] Logsdon, "Roskosmos | Definition, Headquarters, ISS, History, & Facts."
[26] Logsdon, "Roskosmos | Definition, Headquarters, ISS, History, & Facts."
[27] Logsdon, "Roskosmos | Definition, Headquarters, ISS, History, & Facts."
[28] Reuters, "Senate Plan Puts off Space Shuttle Retirement."
[29] "Redefining How NASA Gets into Space," National Air and Space Museum, n.d., https://airandspace.si.edu/stories/editorial/redefining-how-nasa-gets-space.
[30] "Redefining How NASA Gets into Space," National Air and Space Museum, n.d., https://airandspace.si.edu/stories/editorial/redefining-how-nasa-gets-space.
[31] Quote from SpaceX CEO, Elon Musk
[32] Matthew Weinzierl and Mehak Sarang, "The Commercial Space Age Is Here," *Harvard Business Review*, February 12, 2021, https://hbr.org/2021/02/the-commercial-space-age-is-here.
[33] Weinzierl and Sarang, "The Commercial Space Age Is Here."
[34] Weinzierl and Sarang, "The Commercial Space Age Is Here."

Although it has only been twelve years, new developments such as space tourism and the space-for-space sector give the UNCOPUOS much to discuss.

More Launches, More Opportunities

Before 2012, spaceflight was limited to those few nations with space programs. Nations without the means or state capacity for space exploration were almost wholly excluded from space exploration or any of the economic benefits that resulted from it. With the advent of commercial spaceflight, nations without the requisite capabilities can now benefit from space exploration. One example is Nigeria, which has a space program facing difficulties getting off the ground.[35] The Nigeria Space Program aimed to establish a private-public partnership where the government would subsidize the first missions to space to develop and perfect the technology. Once that threshold was reached, they would begin to commercialize the systems and products produced during the first stage and continue until their space-to-earth economic sector was self-sufficient.[36] The NSP, however, faced many issues and difficulties, has yet to clear the first stage, and has not been able to reap the benefits of the billions of dollars spent on space exploration.

Regardless, they have utilized space exploration to benefit their country and population. In early 2023, the US-based commercial company SpaceX announced that they commenced the operation of their satellite internet system Starlink in Nigeria.[37] Isa Patami, the Communications Minister of Nigeria, announced that Starlink was accessible across 100% of Nigeria's territory three years ahead of schedule in January 2023.[38] SpaceX's deal with Nigeria allowed the country access to satellite internet infrastructure without a fully operational space program, which may help take pressure off the space program to produce successes as quickly as possible. Although Starlink is too expensive for a large portion of the Nigerian population,[39] it has given Nigeria access to technology they would only have access to after the progression of its space program, which is easily a decade away. Additionally, the prices of Starlink and other space-to-earth services are projected to decrease as SpaceX expands its services as its operations become more efficient, so for nations without space programs, utilizing commercial space exploration as a less expensive means of investing in the space-to-earth sector is promising for the future development and sustainability of space exploration as an economic venture.

Compared with the expenses resulting from a successful space program, the commercial option is set to become a dominant actor in the space industry. India, which recently landed an unmanned spacecraft on the Moon – the first nation in the "Global South" to do so – had a $1.89 billion budget for space exploration in 2020. This is a bargain compared to the United States, which ran $29.2 billion in 2022 but is double the amount the entire African continent spends on space exploration (just over USD 500 million in 2022). For nations that cannot or will not

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[35] Chukwuma Muanya, "24yrs after, Nigeria's Space Programme Loses Traction despite Yearly Allocations | The Guardian Nigeria News - Nigeria and World News — Nigeria — The Guardian Nigeria News – Nigeria and World News," August 23, 2023, https://guardian.ng/news/24yrs-after-nigerias-space-programme-loses-traction-despite-yearly-allocations/.

[36] Muanya, "24yrs after, Nigeria's Space Programme Loses Traction despite Yearly Allocations | The Guardian Nigeria News."

[37] Abdulkareem Mojeed, "SpaceX Announces Nigerian Operation, First in Africa," *Premium Times Nigeria* (blog), January 31, 2023, https://www.premiumtimesng.com/business/business-news/578939-spacex-announces-nigerian-operation-first-in-africa.html.

[38] Mojeed, "SpaceX Announces Nigerian Operation, First in Africa."

[39] Mojeed, "SpaceX Announces Nigerian Operation, First in Africa."

commit billions of dollars to space exploration, the commercial sector is a viable entry into the space economy and its benefits. Of course, utilizing private companies for space means that nations have less control over the benefits should that company go bankrupt, cancel a program, or fail to provide agreed-upon services, though there is hope that increased competition from dozens of commercial space programs will ensure quality products and prevent prices from rising.[40]

The Fastest-Growing Product of Space Exploration: Space Tourism

Although some still regard space tourism – the commercial flight of individuals into space for recreational purposes – as only existing in the pages of Jules Vern and Arthur C. Clark. Commercial space exploration has made space tourism a reality and a controversial practice that defines many of the debates surrounding commercial space exploration. Earth-based tourism is already one of the largest economic sectors, generating $7.2 trillion, almost 10% of the global Gross Domestic Product (GDP) in 2015.[41] Expanding tourism to the final frontier promises a similar trend. Currently, the price for a Virgin Galactic recreational spaceflight ticket is around $450,000, making it available only to the wealthiest adrenaline junkies. Obviously, this is not a viable price to expand space tourism to the general public, but prices are forecast to drop, and the technology from the practice will soon reach a more widespread market.

One significant benefit of space tourism is that the technology used to shoot billionaires to space is the same that could be utilized to replace intercontinental air flights with faster space flights. Instead of spending ten hours to fly from New York to Tokyo, space travel could more than halve the time.[42] Although likely too expensive for the average traveler, the spaceflight market for intercontinental travel was valued at $20 billion per annum, making it one of the most lucrative uses of space travel in the near future. With business magnates and wealthy travelers already paying $20,000 for a ticket to fly across the world, experts believe that a ticket priced at double that figure would have substantial demand.[43]

Space tourism, however, has a cost much higher than the tickets. According to a study conducted by MIT, UCL, and the University of Cambridge, space tourism could "undo decades of work to repair the ozone layer."[44] Additionally, replacing long-distance aviation with spaceflight, although a lucrative market, is much more harmful to the environment than regular aviation.[45] The study notes that "soot from space tourism is 500 times more damaging to the environment than soot from all other sources."[46] Launching a spacecraft is not the only harmful part of the venture. When spacecraft reenter the Earth's atmosphere, temperatures reach levels that cause trails of plasma to follow the craft and release dangerous nitrogen oxides into the atmosphere.[47] Like the economic side of space tourism, there has been little to no effect on the

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[40] Forbes Technology Council, "Eight Ways Commercial Space Travel Will Change Things," July 6, 2018, https://www.forbes.com/sites/forbestechcouncil/2018/07/06/eight-ways-commercial-space-travel-will-change-things/?sh=66463a5c1961.

[41] Asli Tasci, "Opinion: Space Tourism - Pros & Cons," Pegasus Magazine, 2016, https://www.ucf.edu/pegasus/space-tourism/.

[42] Chris Isidore, "Space Tourism Won't Be Affordable for the Masses Any Time Soon," CNN Business, accessed December 22, 2023, https://www.cnn.com/2021/07/14/tech/affordable-space-flights/index.html.

[43] Isidore, "Space Tourism Won't Be Affordable for the Masses Any Time Soon."

[44] Geographical Staff, "A Rise in Space Tourism Poses Serious Risks to Earth," Geographical, August 17, 2022, https://geographical.co.uk/climate-change/space-tourism-climate-impact.

[45] Geographical Staff, "A Rise in Space Tourism Poses Serious Risks to Earth."

[46] Geographical Staff, "A Rise in Space Tourism Poses Serious Risks to Earth."

[47] Geographical Staff, "A Rise in Space Tourism Poses Serious Risks to Earth."

ozone layer. However, with increasing profits and the economic viability of the practice, environmental degradation will closely follow each dollar made in the industry. The vast majority of the scientific community agrees that the acceleration of space tourism if left unchecked, will irreversibly expedite the climate crisis. Any debate about space tourism and space exploration, in general, must include its environmental effects.

The Outer Space Treaty: Time for Change?

The most famous restriction of the 1967 Outer Space Treaty, the basis of international space law, is that no nation may own any part of space, including planets and natural satellites.[48] This means that no nation, and by extension no private person nor enterprise, may possess property in space. Artificial satellites and other crafts launched into space retain the ownership of the nation or corporation that launched them. However, that is as much ownership as anyone may have beyond Earth's atmosphere. While this provision has likely prevented a war over the final frontier, this overarching rule has gained steep opposition over the past decades. Four nations – the US, United Arab Emirates, Luxembourg, and Japan – have passed laws allowing private ownership in space in direct violation of the Outer Space Treaty.[49] While against international law, these laws might signal the beginning of a new, more realistic practice as humanity moves closer to Lunar colonies and other permanent communities in LEO and beyond. Some scholars have presumed that the four nations might collaborate to support an "international licensing regime" that will dictate and oversee extraterrestrial holdings.[50] These same scholars argue that the spirit of the Outer Space Treaty should still regulate obtuse property claims. For example, ownership of an entire celestial body would still be illegal.[51]

International law derives its legitimacy from the world, or a vast majority of it, adhering to the laws and punishing violators of those laws. If the world slowly begins to chip away at the law, the letter loses its legitimacy, and violations can no longer be levied as every nation would be guilty of something. The Outer Space Treaty risks losing legitimacy due to this problem. Four nations – two of which have major space programs – have violated the Outer Space Treaty. The UNCOPUOS should consider a reconvention of nations to discuss an amendment or rewriting of a basic set of laws for outer space before the current treaty is considered a dead letter and international space law is left without a recognized founding document.

The Impacts of the Industrial Revolution on Space Exploration

Ever since the Industrial Revolution, the way humans traveled and traversed the world, whether for work, leisure, or economic gains, has completely changed over a relatively small 250-year period. For many years, a transnational train ride was the limit of travel; in the modern day and age, not only is transcontinental travel an option, but interstellar travel may soon become a reality. With global space exploration efforts on the rise, the reality of the space tourism sector becoming a prominent form of transportation may only be a few years away. While space

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[48] "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty)" (1967), https://media.nti.org/documents/outer_space_treaty.pdf

[49] Morgan M. DePagter, "'Who Dares, Wins:' How Property Rights in Space Could Be Dictated by the Countries Willing to Make the First Move," *Chicago Journal of International Law*, 2023.

[50] Morgan M. DePagter, "'Who Dares, Wins:' How Property Rights in Space Could Be Dictated by the Countries Willing to Make the First Move."

[51] Morgan M. DePagter, "'Who Dares, Wins:' How Property Rights in Space Could Be Dictated by the Countries Willing to Make the First Move."

transportation and tourism sound like a fantastic idea on paper, it begs the question of how sustainable this practice is. Given the current environmental effects that current modes of transportation pose to the world, it is valid to consider the potential impacts of space travel on Earth's already threatened environment and atmosphere. Considering the current known impacts humans have on space and the Earth's atmosphere, such as the vast amount of space debris humans produce via rocket launches and other space exploration endeavors, as well as worldwide pollution caused by humanities day-to-day actions, all must be taken into account before greenlighting the developments of space tourism and travel.

There is no debate that ever since the Industrial Revolution and the development of various transportation methods, Greenhouse Gas (GHG) emissions have steadily risen. With GHG emissions on the rise due to the continued use of coal, oil, and gas, this has created a long-lasting domino effect called the greenhouse gas effect, which has caused an increase of on average 0.07°C (0.13°F) every decade according to a report conducted by the world economic forum. While this number may seem small, it has caused many long-lasting effects that may be detrimental to human survival on Earth over time. During a General Assembly High-Level Meeting in March of 2019, the former president of the United Nations General Assembly (UNGA), María Fernanda Espinosa Garcés (Ecuador), stated, "We are the last generation that can prevent irreparable damage to our planet" and stressed that "11 years are all that remain to avert catastrophe." With this alarming statistic in mind, organizations such as NASA have begun the search for humanity's so-called "next Earth." With only six years left on the clock, at the beginning of 2023, NASA utilized data from its Transiting Exoplanet Survey Satellite and successfully identified an Earth-sized planet that has the potential to sustain human life. Discoveries such as this are groundbreaking; however, they should only be a last resort for humanity, and other venues must be explored to ensure the future of coming generations.

Is Space Exploration Sustainable?

Space travel and tourism many years ago was only an idea seen in Sci-Fi movies such as Star Wars and Star Trek; however, due to recent technological developments, it may only be a few more years until Olympus Mons (Mars) becomes the first tourist trap in space. While interplanetary travel is the future, the costs of this form of transportation must be considered. Many commercial entities such as Boeing and Virgin Atlantic are working on spaceports that can potentially create a literal out-of-this-world experience. Since these programs are not currently available, it is hard to calculate the possible costs of this innovative transportation and new form of tourism. Existing pioneers of space travel (noncommercial), such as NASA and other national space programs, can be used as references for the potential costs of each launch to get a reasonable estimate of potential costs. Each nation's space programs use different types of rockets and, therefore, create a variance in launch costs. According to most recent data, each Russian Soyuz-2 rocket costs around $35-$80 million. China's Long March rockets range from $30-$81 million depending on rocket size, while the space newcomer India's most recent rocket costs around $74 million. While these prices seem minuscule in comparison to the cost of the first mission to successfully land a man on the moon (Apollo 11), which was carried out by the US and cost approximately $355 million, none of these costs compare to the current state of the US space program.

Within recent years, Elon Musk's company, SpaceX, has continued to dominate the world of space exploration in the United States. SpaceX has fundamentally changed the nature of spaceflight by developing reusable rocket boosters and spacecraft. By designing rockets and

spacecraft that can be launched, landed, and flown again, SpaceX has drastically reduced the cost of accessing space. A Falcon 9 launch to low Earth orbit costs around $50 million, far less than the $500 million or more charged by competitors with expendable rockets. These lower costs have enabled more rapid launch cadences and new applications like Starlink and SpaceX's broadband satellite constellation. While the environmental impacts of increased launch activity require study, the reusability pioneered by SpaceX points towards more sustainable space transportation in the future. As reusable technology matures, the marginal cost of a launch could decrease to levels comparable with commercial air travel. This development could enable new markets and use cases for affordable space access, changing the space travel and exploration paradigm. With innovative technical design and manufacturing, SpaceX has charted a course toward opening the space frontier for more diverse actors and applications.

While SpaceX has made strides in reusable rocket technology, the space industry must continue innovating to reduce negative impacts on the Earth's environment. Most rocket platforms currently rely on highly toxic, carcinogenic propellants like hydrazine or hydrocarbon fuels that can contribute to air pollution. Though these help lower launch costs, their health and environmental effects must be weighed, in line with Sustainable Development Goal 7's call for clean and fair energy access. As space activities increase, agencies should explore and adopt cleaner propulsion technologies, even if they raise mission expenses initially. Transitioning to bio-derived or synthetic fuels, electrification, nuclear propulsion, or other systems could mitigate pollution and risks to local populations near launch sites. Financial incentives and environmental regulations may be needed to promote these sustainability goals within the commercial space sector. As growth continues, the UN Committee on the Peaceful Uses of Outer Space should put forward guidance and best practices for operators to follow. With proactive measures, space exploration, and utilization benefits can be shared worldwide without inflicting harm. The space industry must remain focused on promoting access and improving environmental and economic sustainability.

Conclusion – Moving Forward

> "This you may say of [humankind]—when theories change and crash, when schools, philosophies, when narrow dark alleys of thought, national, religious, economic, grow and disintegrate, [humanity] reaches, stumbles forward, painfully, mistakenly sometimes. Having stepped forward, [they] may slip back, but only half a step, never the full step back."
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> John Steinbeck, *The Grapes of Wrath*

Space exploration benefits innovation not for the sake of real-world applications but for the sake of innovation itself. The only use the newly-minted high-thrust cryogenic engine has is space travel. Today, it is only used to increase efficiency in the upper layers of Earth's atmosphere. Nevertheless, herein lies the beauty of space exploration: while this technology may not have applications now, it will later. Technology designed for space travel is the key to doors humanity has yet to uncover, and as seen in this guide, it often becomes helpful in many ways that would be impossible to predict when it was manufactured.

For better or worse, the human spirit is one of consistent forward progress, and in the twenty-first century, that forward progress is among the stars. It is in this light that discussions about space exploration must be had. Exploring and charting the stars is not a decision driven and motivated by economics. While economics plays a role in its actualization – *how* we do it – the overarching benefit to humankind is *why* we do it. Delegates must understand that certain

intangibles are not visible in expense reports, among all of the context as to how and whether to fund and support space exploration. Space exploration has motivated generations of young engineers, pilots, scientists, philosophers, and artists to think more deeply about Earth's origins, humankind's capabilities, and our universe's limits. As aforementioned, this thinking has a pragmatic purpose, though, with each new development in space exploration, a new generation of young people become advocates, with some dedicating themselves to moving the needle forward in the best way their faculties allow. Little else ensnares the human mind like space and its possibilities, and a commitment to space travel is a commitment to perpetuating that sense of wonder for generations to come.

Guiding Questions for Debate

1. How can governments balance national priorities like healthcare and education with the significant costs associated with space programs?
2. What policies can ensure space exploration benefits all of humanity rather than exacerbating global inequalities?
3. How can private-public partnerships advance space technology while still protecting public interests?
4. What responsible governance models are needed to promote the sustainable, equitable use of space as commercialization increases?

Guiding Questions for position papers

1. What has your nation's level of investment been in space exploration to date? What priorities and rationale guide this funding?
2. How does your nation aim to balance space program costs with other budgetary needs like education, healthcare, etc?
3. What policies regulate the commercial space industry in your country? How does your nation monitor costs, benefits and risks?
4. Is your nation partnering with private companies on space initiatives? What regulations on these partnerships exist?
5. Does your nation have bilateral or multilateral partnerships with other countries on space projects? How could these partnerships be expanded?

RESOURCE REVIEW

United Nations Documents

UN General Assembly Resolution 2222 (XXI)

UN General Assembly Resolution 2222, also known as the Outer Space Treaty, adopted in 1966, represents the foundation of international space law. It establishes outer space as a province of all mankind, prohibits claims of sovereignty over celestial bodies, and holds nations responsible for their space activities. The resolution also requires states to avoid harmful contamination of the space environment. Delegates can use Resolution 2222 as a starting point to understand globally agreed principles governing space activities. However, they may propose amendments or additional protocols to address emerging challenges like space debris, asteroid mining, equitable access to space, and national security concerns. When considering changes, delegates must balance inclusive participation by many nations with establishing a clear regulatory framework acceptable to most UN member states. Amendments that serve a nation's interests but lack broad international support may fail. Resolution 2222 provides a useful framework but may require targeted updates to remain relevant in a changing technological and strategic landscape.

UN General Assembly Resolution 1962 (XVIII)

Adopted in 1963, UNGA Resolution 1962 established key legal principles for states' activities in space, including freedom of exploration and use, prohibition of appropriation of celestial bodies, and holding states responsible for their space activities. Delegates can cite 1962 to affirm principles aligning with their nation's interests while arguing to reinterpret or expand principles needing modernization. For example, delegates could contend the appropriation ban should be revisited given the potential commercial space resource extraction. The strategic use of 1962 allows for justifying policies while respecting the resolution's aim to prevent unilateralist claims on space.

UN General Assembly Resolution 68/74

Adopted in 2013, UNGA Resolution 68/74 encourages countries to establish national space legislation supporting international space principles. It recommends national laws promote international cooperation, transparency, sharing of space benefits, and sustainable space utilization. Delegates can cite 68/74 when affirming the need for national space policies upholding norms like sustainability, transparency, and cooperation. However, they may argue parts of 68/74 are too broad or omit key issues. For example, delegates focused on space security could contend that 68/74 lack recommendations to counter potential threats in space. When citing 68/74, delegates should reaffirm aspects benefiting their national space interests while arguing to expand principles not fully addressing current issues. This allows using 68/74 to justify progressive space policies while respecting its intent to align domestic laws with international space commitments.