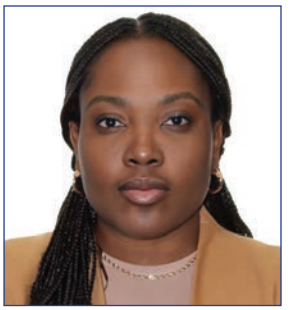
Supported by the Office of Space Commerce, NOAA, U.S. Department of Commerce

The ASCEND Diverse Dozen and the Office of Space Commerce (OSC) share the common interest in growing the commercial space economy and the diversity of the space workforce that supports it. OSC's mission is to increase awareness of commercial space opportunities, as well as challenges that must be addressed to promote further market growth and investment. OSC recognizes the challenge of attracting a more robust and diverse base of skilled workers into the space industry to meet growing demands for talent and innovation.

AIAA

NOAA

Nifemi Awe // CANADA
PwC Canada



Earth Rules, Space Frontier: A Sustainability Blueprint for Our Cosmic Journey

"Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" – Gro Harlem Brundtland

Space for All Humankind, But First, a Sustainable Space Environment

Beyond the boundaries of planet Earth, our responsibility echoes across the stars. Article I of the Outer Space Treaty (OST) recognizes outer space as the province of all humankind and guarantees the exploration and use of space for the benefit of all; while Article IV OST preserves the exclusive use of space for peaceful purposes.

These important provisions, including other provisions of the OST, have wielded great benefits to humankind. For example, satellite data aids our observation of Earth as we monitor changes to the Earth's environment in charting a sustainable part to protect Earth. Satellites also support humankind in several other ways including communications, navigation, disaster prevention, etc.

However, the blessings of space do not come without challenges. The exponential increase in space activities has led to a corresponding rise in space debris. According to the European Space Agency, there are about 35,750 debris objects tracked by space surveillance networks, with more than 640 estimated breakups, explosions, collisions, or anomalous events resulting in fragmentation [1]. The continuous increase in space debris poses significant risks to satellites, threatens existing assets, and complicates future missions [2]. The emissions from satellite launches, including orbital debris, continue to raise crucial space sustainability issues, for which the OST's overall lens on the peaceful exploration of space for the benefit of all is inadequate to address.

Addressing these issues raises important questions, including how we can enhance the regulatory landscape for the long-term sustainability of space for present and future generations.

One Nation at a Time: Strengthening National Laws for Long-Term Space Sustainability

Acknowledging the difficulty in either negotiating a new multilateral treaty or amending the existing Outer Space Treaty to address the growing issues of space sustainability posed by the risks of space debris and other hazards, I opine that national laws and policies offer a viable solution to the challenges, providing a framework to regulate the activities of private actors, incentivize sustainable practices, and enforce accountability.

Article VI of the Outer Space Treaty holds state actors internationally responsible for the activities of their non-state actors in space. As a result, state actors have employed legal and policy instruments to regulate these activities, ensuring compliance with their Article VI obligation to authorize and continuously supervise the actions of their private actors in space.

The Article VI mandate underscores the essential role of state actors in strengthening national space laws and policies to foster sustainable space exploration. This includes implementing and enhancing regulations to ensure satellite launches by private actors are conducted responsibly and sustainably. Furthermore, it emphasizes the need for non-state actors to be accountable for space debris removal, ensuring long-term stewardship of the outer space environment.

By expanding on the approach undertaken by state actors to fulfill their international obligations and regulate the activities of private actors, national space laws can be pivotal in addressing space sustainability through several mechanisms:

1. Regulating Space Junk

Countries may enact laws requiring spacecraft operators to take measures to mitigate space debris. The United States Federal Communications Commission (FCC) adopted a first-ever rule mandating non-geostationary satellite operators to have plans for deorbiting their satellites at the end of their operational life to minimize debris from collision risks [3]. Regulations and guidelines like this help reduce the amount of debris generated by satellites launched into space.

2. Promoting Sustainable Practices and Incentivizing Private Sector Compliance

The law remains an important vehicle to promote sustainable practices among private space actors. The U.S. National Space Policy safeguards that space operations are guided by principles promoting the long-term sustainability of space activities [4]. In addition to laws and policies, funding for space sustainability projects will advance the activities of private space actors toward innovation and sustainable space practices and incentivize compliance with national space laws. The UK Space Agency recently announced funding for initiatives aimed at prolonging the life of satellites to promote space sustainability for future generations [5]. Also, the United States offers an experimental permit with relaxed conditions for restricted activities to give reusable suborbital launch operators the possibility and flexibility to conduct tests without having to obtain a normal license [6]. These initiatives encourage regulatory compliance, innovation, and adoption of environmentally friendly practices in space.

3. Licensing and Oversight

In line with the Article VI obligation on state actors, regulatory bodies can implement stringent licensing procedures to ensure compliance with sustainability standards. In India, the Indian Space Research Organisation has established guidelines

for licensing and oversight of satellite operations. One of the functions of the Department of Space under the Indian Space Policy is the establishment of a framework for safe and sustainable space operations [7]. Other countries with national space laws also have detailed provisions regulating licensing and oversight over the activities of their non-state actors in fulfilling its Article VI OST obligation.

4. International Collaboration

It is crucial for national laws to align with international treaties and agreements, fostering global cooperation. The United Nations Committee on the Peaceful Uses of Outer Space has developed guidelines for the long-term sustainability of outer space activities [8], which many countries should incorporate into their national legislation. This harmonization of laws ensures a coordinated approach to space sustainability.

5. Enforcement of Liability

Article VII of the Outer Space Treaty and the Convention on International Liability for Damage Caused by Space Objects (the Liability Convention) hold countries liable for damages caused by their space objects, incentivizing responsible behavior. Several countries like the United States, the United Kingdom, France, and Australia have enacted national space laws/policies that guide the liability of private actors for their activities in space. However, many other nations, particularly developing countries either lack robust framework for liability in their space policies or do not have a space policy in place. Clear laws and policies on liability for damage caused by space activities can encourage operators to adhere to best practices, incentivizing responsible behavior.

6. Enhancing Space Sustainability Data Reporting

As space activities increase, space sustainability data has become crucial for managing investment risks and seizing opportunities. According to the 2023 PwC Global Investor Survey, investors want to know how companies are managing sustainability and emerging technologies, but they lack confidence in reported data [9]. Currently, there is minimal publicly accessible data on the sustainability performance of many private space actors showing the effect of their activities on the space environment and the threats of space junk on their investments and infrastructure in space. A crucial piece to attaining long-term space sustainably relies on accurate space sustainability data. Therefore, in addition to driving space sustainability through national laws on responsible behavior, debris removal, and sustainable space launches, it is important to incorporate within national space laws, guidance on international sustainability reporting frameworks/standards applicable to private space actors as part of the continuing supervision requirement of state actors in Article VI OST.

The challenges of space sustainability are immense but not insurmountable. National space laws provide a robust framework to address these issues, from regulating space debris and promoting sustainable practices to enforcing liability, encouraging international collaboration and enhancing the reporting of space sustainability data. As space activities continue to expand, the role of national space laws becomes increasingly vital. Through thoughtful regulation, incentivization, and international cooperation, we can navigate the challenges of space sustainability and secure a safe and prosperous future in space.

[1] “How many space debris objects are currently in orbit”, online: The European Space Agency<https://www.esa.int/Space_Safety/Clean_Space/How_many_space_debris_objects_are_currently_in_orbit>

[2] “Space Debris”, online: NASA <www.nasa.gov/headquarters/library/find/bibliographies/space-debris/>

[3] ‘Space Innovation IB Docket No. 22-2771 Mitigation of Orbital Debris in the New Space Age IB Docket No. 18-313’ (Released Sep 30, 2022), FCC-22-74A1_Rcd.pdf

[4] “National Policy of the United States of America” (December 2020), online (pdf): <https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/National-Space-Policy.pdf>

[5] “Satellites could become more sustainable, thanks to the new UK Space Agency funding” (February 2024), online: <www.gov.uk/government/news/satellites-could-become-more-sustainable-thanks-to-new-uk-space-agency-funding>

[6] “Experimental permits for Reusable Suborbital Rockets” (Updated January 2024), online: Federal Aviation Administration <https://www.faa.gov/space/licenses/experimental-permits-reusable-suborbital-rockets>

[7] “Indian Space Policy” (2023), online (pdf): <www.isro.gov.in/media_isro/pdf/IndianSpacePolicy2023.pdf>

[8] “Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space” (2021), online (pdf): United Nations Office for Outer Space Affairs <https://www.unoosa.org/documents/pdf/PromotingSpaceSustainability/Publication_Final_English_June2021.pdf>

[9] James Chalmers and Nadja Picard, “PwC’s Global Investor Survey 2023: Trust, tech and transformation: Navigating investor priorities” (November 2023), online: PwC Global <https://www.pwc.com/gx/en/issues/c-suite-insights/global-investor-survey.html>

Priyanka Dhopade // NEW ZEALAND

University of Auckland

In Search of Equilibrium: Rethinking Growth and Sustainability in Space

Present Day

The global space industry is worth $546 billion USD and expected to triple in the next decade. Growth is currently driven by commercial demand for satellite data services, while future growth may be driven by the lunar economy, in-space manufacturing, and mining, among others. We can easily deduce the economic returns on these developments to a futuristic, thriving space economy. Yet we are unable to extrapolate the environmental and sociocultural impacts that are already surfacing. It has taken decades to develop effective regulations [1] for space debris mitigation, and we still have a long way to go. Already, more than 80% of objects in Earth's orbits are junk.

Our Unsustainable Trajectory

The year is 2070, and we have done nothing to regulate the global space economy. Our orbits are crowded and polluted, and existing satellite operators must pay exorbitant insurance and collision avoidance fees. Services we took for granted, like GPS, broadband Internet, and Earth observation data, are more expensive and unreliable than ever. Many high-tech sectors that relied on space data have collapsed, including agriculture, and the economy is under pressure. There is an imminent threat of war as orbital resources are controlled by the Big Four: the United States, China, Russia, and India. Taxpayers are funding orbital cleanup – a futile activity, since debris generation outpaces its removal.

Our climate action has slowed because of time-consuming land-based data collection, and we have regressed on most of our sustainable development goals. Our ozone layer has depleted significantly due to the "Launch Rush" of the 2030s, when we launched rockets daily and re-entered gigatons of objects into Earth's atmosphere. Radiation-induced illnesses are the new health crisis. Injuries and deaths from crashing space junk are so routine that they no longer make headlines. We are no closer to understanding the origins of life in the universe because ground-based telescopes can no longer see through the bright megaconstellations traversing the sky. In-space telescopes and laboratories have long been destroyed by space debris.

Our ancestors looked to the stars with wonder, but we now look to them with fear and regret.

The Fallacy of Unconstrained Growth

We will have paid a heavy price for a multitrillion-dollar global space industry. This is the crux of the problem: we do not have a clear grasp on the true cost-benefit ratio of this industry, nor do we fully understand the consequences of such unconstrained growth and progress. So we cannot rely solely on technical solutions to solve this problem.

As we grapple with the repercussions of unsustainable practices on and off Earth, we must reconsider our values, and the basis for this uncontrolled trajectory. We can scrutinize our colonial aspirations of settling, conquering, and extracting from space. These aspirations are historically rooted in the pursuit of resource exploitation and territorial expansion, with no regard for people or the environment.

Shifting the Paradigm

Instead, we can take integrated and intergenerational approaches to managing our terrestrial and space environments. We can learn from indigenous societies around the world, including Māori in Aotearoa, on balancing economic priorities with shared values [2,3]. Many Māori tribes refer to local geographical entities like rivers and mountains as their ancestors – an immutable part of their genealogy (i.e., "whakapapa" or to give history). This strong spiritual connection contributes to sophisticated environmental monitoring, intergenerational planning, and even provision of legal personhood to such entities, like the Whanganui River [4]. Such balanced approaches are increasingly implemented [5] in national climate change actions.

We can also learn from the lessons of many global sectors, such as mining, energy, and plastics. Their unrestrained growth caused extensive environmental damage, biodiversity loss, and violation of indigenous rights. Following significant public and political pressures, these sectors have learned costly lessons. They are now adopting more sustainable practices to mitigate their impact, like continuous monitoring and adherence to environmental standards, technological innovations, and incorporating indigenous knowledge.

For the space sector, I believe we can proactively avoid the same traps, the same neoliberal mindsets that have generated the environmental degradation and social inequality we see today.

The Way Forward

Economic models. We need to adopt a systems thinking approach to space sector development. We need circular and regenerative economic models [6] that can incentivize [7] the space industry to adhere to environmental standards and encourage technology development that prioritizes sustainability as a driving force, rather than a limitation.

Co-governance. We need inclusive governance models based on partnership with indigenous groups in countries such as Aotearoa. Space companies that are building launch or ground-based infrastructure can codevelop governing principles [7] with local indigenous groups, which can eventually be extended to the near-Earth and lunar environments, and beyond.

Regulations. We need consistent standards on environmental reporting across the space industry. Pollutants from launches and reentries, and life-cycle emissions [8] from manufacturing need to be monitored and mitigated. We need to better understand the countless applications of satellite data, and invest equal effort into regulating their ethical use, just as we are doing with artificial intelligence.

Our presence in space mirrors our ambitions and fallacies. We are being presented with a choice of priorities for the future of humanity. Let us choose wisely.

References

[1] https://www.fcc.gov/document/fcc-adopts-new-5-year-rule-deorbiting-satellites-0

[2] https://www.tandfonline.com/doi/full/10.1080/17449626.2015.1010099\

[3] https://www.sciencedirect.com/science/article/pii/S0094576523003600?via%3Dihub

[4] https://www.parliament.nz/en/get-involved/features/innovative-bill-protects-whanganui-river-with-legal-personhood/

[5] https://environment.govt.nz/publications/exploring-an-indigenous-worldview-framework-for-the-national-climate-change-adaptation-plan/

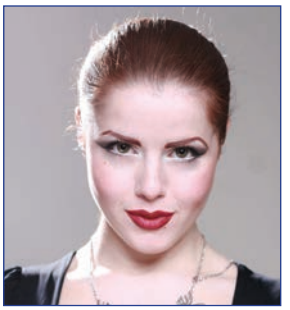
[6] https://medium.com/@moribajah/a-personal-vision-for-a-circular-space-economy-18eb45ab0c3a

[7] https://www.ascend.events/wp-content/uploads/2023/07/2021-ASCEND-Diverse-Dozen-Steer.pdf

[8] https://www.sciencedirect.com/science/article/pii/S0959652623030275?via%3Dihub

Martina Dimoska // NORTH MACEDONIA

International Space Alliance



A Balkan Perspective: Balancing Growth Through Responsible Space Sustainability in Emerging Regions

The effects of space exploration are all around us — they're in our pockets, homes, bedrooms, kitchens, and cities. Satellites help us navigate using GPS and provide remote sensing to protect crops, and predict and respond to natural disasters like floods, hurricanes, and wildfires. Space innovations are found in our phone cameras; memory foam shoes, pillows, and mattresses; and non-stick cookware. Despite this, there remains a big disconnect between space exploration and our daily life for many.

Some regions still lack access to these advancements due to their developmental stage. For instance, the Balkan Peninsula, a developing region, continues to face pervasive corruption, broken processes that have resulted in dysfunctional systems and the widespread "brain drain." These effects have led to an exodus of skilled workers who are migrating toward better opportunities. To start an admirable space exploration expansion within the region, it's crucial to deploy capable individuals strategically and prioritize sustainability over irresponsible expansion.

Amidst all the problems that developing regions like the Balkans are facing, there's a sustainable silver lining. If developing countries choose to invest their resources and talent toward becoming emerging space nations, their advancements can showcase further significance far exceeding innovation. Significant space development can demonstrate capabilities by learning from past mistakes whilst establishing pioneering, environmentally conscious, and ethical strategies, setting a strong example for corruption-prone regions. This initial success could set a precedent, potentially influencing and improving standards in other sectors where best practices are rare due to a plethora of issues such as corruption, favoring sustainable development over negligent growth.

The Way Forward Is Threefold

1. Capacity Building: Education, Technology Transfer, Collaboration

Implementing strategies to address the brain-drain epidemic prepares regional peers for the global space workforce through education and training, investing in human capital to close the skill gap. Early STEAM and space education promotion encourages creativity and responsible use of space.

As regional space actors collaborate, they enhance the international footprint, potentially uniting the Balkans once again. This time, their goal has a greater purpose — to establish a sustainable space terrain while maintaining distinct regional approaches. By working together with important bodies to enhance strategic alliances in the region, Balkan countries can improve their collective space capabilities. These include joint projects, data sharing, and technology transfer to accelerate progress in space exploration while also considering the environmental footprint.

By emphasizing sustainable methods and learning from existing space nations, the Balkans can positively contribute to the global space sector. They can more easily implement guidelines and criteria for ethical design, launch, and end-of-life disposal of research, projects, and missions that are based on the knowledge of well-established space agencies, but without the layers of bureaucracy that hinder more mature space agencies.

2. Addressing Space Sustainability Challenges, Integrating Environmentalism in Space Activities

The Balkan region is in a unique position on the innovation stage with rich natural resources, manpower, and the ability to learn and modify from mature space programs to launch its own innovative and collaborative space force. Given these unique positions, the Balkan region can take an educated stance in substantiality and become a leader in industry and environmental protection.

In the absence of a regional space industry, emerging space-focused actors can take an informed perspective on sustainability such as promoting conscious utilization and sharing of deployed satellites, preexisting insights, research, and resources in the realm of space exploration or embracing green space technologies and biodegradable materials that could position the Balkans as a pioneer in ecological sustainability. These practices can significantly boost local economic growth and regional development, minimize environmental impact, and drive innovation in green technology, positioning the Balkans as both an early adopter and an example setter.

3. Policy Frameworks, Space Diplomacy, and Public Engagement

It's vital to create regional and national policies that balance sustainability and growth. By acting responsibly and incorporating tools such as environmental impact studies, collaboration with surrounding nations and creating regional accords can improve the regional industry stability. Being collaboratively involved in global forums and notable entities can help maintain safety and prevent regional conflicts. Success stories that improve society without compromising the environment, celebrating notable achievements, and enhancing educational capabilities are all effective ways to raise public awareness on space sustainability.

The Balkans comprise many civilizations, ethnic groups, and religious beliefs. We have the opportunity to unlearn, restart, reignite, and remake — if we put more emphasis on unity rather than division, forging a path toward greater regional understanding and contributing toward a collective global progress.

In redefining growth and sustainability in space, we can pivot toward a future where innovation meets responsibility, ensuring that our exploration of the cosmos enhances rather than compromises life on Earth.

References

1. Space Generation Advisory Council (SGAC). North Macedonia.
2. "The Green Agenda for the Western Balkans: Opportunities for North Macedonia." IDSCS. December 22, 2022.
3. "Green Agenda for the Western Balkans." Aspen Institute Deutschland.
4. UNOOSA Capacity Building in Space Technology for Developing Countries
5. UNOOSA Guidelines for the long-term sustainability of outer space activities of the Committee on the Peaceful Uses of Outer Space
6. UNCTAD Exploring space technologies for sustainable development
7. European Institute on Space Policy Emerging Spacefaring Nations
8. United Nations Sustainable Development Goals (SDGs)
9. UN Supporting SDGs in North Macedonia
10. Space & Technology Sustainability - International Space Alliance

Jose Figueroa // PUERTO RICO / USA

Aqua/Sky Launch Innovations (ASLI)

A Radiant Path Forward for Puerto Rico: The Case for Sustainable Rocket Launch Platforms

In the vast expanse of the Puerto Rico Trench lies an opportunity for dramatic change, one that transcends boundaries and propels us toward a sustainable future in aerospace technology. Imagine a flotilla of submersible launch platforms, gently lowering into the sea, carrying not just rockets laden with payloads of satellites and scientific instruments, but also the hopes and aspirations of a nation. This is the vision I hold dear—a vision of establishing the world's premier ecofriendly rocket launch facility in the former Roosevelt Roads Naval Station in the town of Ceiba, Puerto Rico.

Beneath the azure veil of the Caribbean, where the Puerto Rico Trench plummets into the abyss, a vision of mankind's future unfolds. Here, in the cradle of Earth's deepest Atlantic scar, we dare to dream of rockets rising from the sea—a marriage of submarine stealth and celestial ambition. Our leviathans of progress descend into the depths, carrying not just the cold metal of rockets and satellites, but the very essence of our species' drive to explore.

As global interest in space exploration surges and Puerto Rico seeks economic revitalization, we stand at a unique crossroads. This vision isn't mere science fiction—it's a viable solution to several pressing challenges in space exploration and Puerto Rican economic development.

The concept, dubbed the Oceanic Rocket Catapult and Autolauncher, adapts submarine signal ejector technology to launch rockets from beneath the ocean's surface. A submerged tube cradles the rocket at a predetermined depth. A solid propellant motor initiates the launch, or seawater injection could provide initial thrust. As the rocket breaches the surface in a geyser of foam and fury, its main engines ignite, leaving behind a trail of fire and steam—the newest addition to a constellation, rising from the sea.

This innovative approach offers several significant advantages:

1. ***Environmental Protection***: Underwater launches significantly reduce noise and environmental impact compared to traditional rocket launches.
2. ***Natural Boost***: The Puerto Rico Trench provides 95% of Earth's rotational speed, offering a natural slingshot effect that reduces fuel requirements and increases payload capacity.
3. ***Mobile Launch Sites***: The ocean becomes our launchpad, providing flexibility and reducing risks associated with fixed terrestrial launch sites.
4. ***Economic Revitalization***: This project could transform Puerto Rico into a hub for the booming space industry, creating high-skilled jobs and attracting global investment.

Critics might argue that the technical challenges are too great, or that the environmental risks outweigh the benefits. However, with careful engineering and strict environmental safeguards, these concerns can be addressed. The potential rewards—both for Puerto Rico and for the advancement of space exploration—far outweigh the risks.

This project aligns with the growing trend of private space ventures and the increasing need for sustainable space access. As companies like SpaceX and Blue Origin push boundaries, our underwater launch facility would position Puerto Rico at the forefront of this new space race.

The economic impact could be transformative. The aerospace industry is projected to reach $1 trillion by 2040. By establishing this unique launch capability, Puerto Rico could capture a significant portion of this growing market, creating thousands of direct and indirect jobs.

For too long, Puerto Rico has been caught in a cycle of economic struggles and natural disasters. This project offers a chance to break that cycle, leveraging the island's unique geographic advantages to become a leader in one of the most exciting industries of the 21st century.

The path forward requires support from both Puerto Rican and U.S. federal governments for feasibility studies and environmental assessments. Private aerospace companies should be engaged to refine the technology and explore partnerships. Local universities can develop specialized programs to train the necessary workforce.

As we stand on this precipice of innovation, we have the chance to launch not just rockets, but a new era of prosperity for Puerto Rico. In the depths of the Puerto Rico Trench, amidst the silence of the deep and the whisper of possibility, we will find our answer. Here, where the old world of Earth meets the new frontier of space, we can forge a path to the stars that honors the cradle of our birth.

In this aquatic spaceport, Puerto Rico doesn't merely recover—it transcends, becoming a nexus where terrestrial ambition and celestial opportunity collide in a nova of prosperity. We turn to the ocean as our gateway to the stars, relying on the very nature of our blue planet to propel us into the cosmos. It's time to take the plunge and reach for the stars—from the seas of home.

Amir Gohardani // UNITED STATES
Springs of Dreams Corporation

Unlocking Curiosity Through a Mindset Shift in Learning and Problem-Solving

As children our curiosity allows us to explore the surrounding world, only to occasionally get stifled once we become adults. For future space sustainability efforts to thrive even further, we need to unlock the curiosity of future generations through learning and unconventional approaches to problem-solving. Without a mindset shift as industrial leaders or educators, we risk stepping into the same old circles and limiting the capabilities of future generations to address our space-sector-related challenges.

The Challenges at Hand

For more than a decade, I have spearheaded science, technology, engineering, and mathematics (STEM) efforts for the nonprofit organization I cofounded. This experience has allowed me to have a front seat to see that space-related topics are truly inspiring to middle school students and their future careers. Interestingly, many of the same students with space dreams abandon those career plans in high school. I have often sought the rationale for these decisions, and even though they are not exclusive to everyone, many students either struggle with mathematics or the sciences or fear the complexity of these subjects at college and university levels [1]. On top of these challenges, the pandemic also contributed to learning difficulties [2]. According to data related to the international assessment of 15-year-old students published in December 2023 by the Program for International Student Assessment (PISA), the United States lags behind many other countries, particularly in mathematics, affecting economic competitiveness and workforce strength [3]. With emerging hurdles to overcome in areas such as space sustainability – that in its simplest and broadest form refers to ensuring that humankind can use outer space now and in the future with environmentally friendly methods that do not exhaust resources irreversibly to limit or prevent space activities for future generations – there is work left to be done.

The Suggested Path Forward

Without addressing the problems of the U.S. space sector, there is a looming risk of aerospace workforce shortage and significant shortcomings in addressing future needs such as space sustainability [4]. Curiosity plays a vital role in this context since, in a crushed state, it serves as a roadblock for high-performing and adaptive organizations [5]. Fear, assumptions, technology, and the environment collectively impact curiosity [6], and given that all these factors leave their traces in performance, new windows of opportunities open. To address some of the challenges of the space sector, leaders in academia and the broader aerospace industry have opportunities to make a difference through the following three steps:

1) Recognition of the challenges
2) Adoption of a mindset shift for learning and problem-solving
3) Process enhancement

Recognition of the Challenges

Since fear can stifle curiosity along with assumptions, the environment, and technology, it is vital to acknowledge such possibilities. Mathematics or science phobia, assumptions about what it requires to work in the space sector, and unfamiliarity with technologies or the actual space working environment individually and collectively can lead to the dissuasion of career plans in the space sector. I have been in countless conversations with students and working professionals mentioning these as their primary concerns for pursuing opportunities in the space sector.

Adoption of a Mindset Shift for Learning and Problem-Solving

With known challenges that partially reflect the curiosity dilemma and dissuasions to explore the unexplored, academic and industrial leaders can tap into two immediate courses of action. The first is a mindset shift that allows criticism to rethink how we previously have educated the workforce in the space sector and how we solve problems. Problem-solving becomes limited without out-of-the-box thinking, and therefore curiosity is an essential ingredient. To trigger the curiosity among learners, we need to strive for a learner-centered approach that recognizes the learners' shortcomings and allows for additional growth.

Process Enhancement

The onset of improving the process for unlocking curiosity in learners allows for significant progress over time. Through such efforts, taking active steps to address the unknown is helpful. This is, in fact, the premise for my duties as the

host of Space Talk with the American Astronautical Society [7], where I discuss space-related topics with prominent scholars and aerospace leaders. In my conversations, I strive to eliminate assumptions about technologies and working in the space industry. Moreover, as it relates to science and mathematics phobia, for example, topics such as space sustainability have proved that there are many areas, including law, economy, policy, and security, where the workforce can make significant contributions. Unleashing the curiosity of the current and future members of the aerospace workforce allows for unprecedented ways to address the challenges at hand. Through constant process improvements and adaptation for problem-solving and learning, we bring a more all-inclusive approach to advancing and making positive changes in the space industry.

References

[1] Gohardani, Omid, Gohardani, Amir S., Dokter, E., Macario, Kyla. Aeronautical Engineering and Aerospace Engineering: A Learner-Centered Teaching Perspective in Higher Education. Journal of College Science Teaching 44, No. 1 (2014): 64-71.

[2] Gohardani, Amir S. A Post-Pandemic Plan for Aerospace Education, Aerospace America, July/August 2022. [https://aerospaceamerica.aiaa.org/departments/a-post-pandemic-plan-for-aerospace-education/]

[3] Codella Low, C. Recent International Assessment Scores Mark Worrying Trend in U.S.' Global Competitiveness. U.S. Department of Commerce, December 2023.

[4] Gohardani, Amir S. Rx for The Workforce, Aerospace America, September 2018.

[5] Gino, Francesca. The Business Case for Curiosity. Harvard Business Review, September-October 2018.

[6] Hamilton, Diane. Cracking the Curiosity Code: The Key to Unlocking Human Potential, ISBN-10: 164237346X, January 2019.

[7] Gohardani, Amir S. Space Talk, American Astronautical Society, 2024.

Kim Macharia // UNITED STATES

Space Prize Foundation

The Unifying Power of Space Sustainability

I often reference space exploration as the gateway drug to the world of STEM when speaking with educators on the importance of introducing students to space science. This framing has allowed me to garner quick buy-in from those who approach the topic of space education with hesitancy. Navigating the pushback that comes from working class communities, however, has been a more daunting challenge. Many industry outsiders struggle to see the value in learning about an industry that they think does not impact them.

As concerns around social inequalities continue to increase, those of us working in emerging industries that have the potential to help foster a more equitable global economy must raise our voices. This requires altering the narrative that the space sector is elite and elusive. This is why I believe that expanding awareness on the ethos of space environmentalism is the most effective way to drastically shift the public's overall perception of the industry and ensure the environmental and economic benefits the industry can provide are felt by as many people as possible. To that end, it is essential that we strive to educate, engage, and empower new actors to participate in space sustainability efforts.

Making space open and accessible to all begins with education. Spaceflight and astronomy are often the top topics students learn about regarding space in a classroom setting. As thrilling as these topics are, they do not necessarily inform students about the countless ways by which space impacts our daily lives. Monitoring and mitigating the effects of climate change are heavily enabled by space technology. Predicting natural disasters and supporting relief efforts is heavily enabled by space technology. Sharing these benefits is how we get the public to care about what space has to offer, and these themes excite learners of all ages. The advancement of space technology has the potential to strengthen communities and contribute toward improving the well-being of our planet, but it's up to us as an industry to inform the public on how humanity can best leverage space technology for good.

Driving action at scale requires engaging broad swaths of the population through strategic outreach and engagement. Large industry-wide initiatives and programs can take us far, but we must also create an ecosystem that supports those who are driven to take a bottoms-up approach to equity. Grassroots movements played a surprising role in bolstering support for U.S. space exploration efforts in the 1960s. Grassroots environmental activism has had an undeniable influence on the progress of the broader environmentalism movement. They have an uncanny ability to inspire individuals to believe that their seemingly small contributions toward a global crisis matter. Adopting the environmentalism movement's approach to collective action could be labeled as needlessly experimental, but given the urgent need for increased action on climate change and for risk mitigation regarding space-based assets, it is time to give credence to methods that have historically played out in a favorable manner.

If we want to empower new actors to engage in the space sector, we need to provide opportunities for them to onboard themselves into the ecosystem. Establishing innovative outreach efforts and entry points is key. Developing accessible apprenticeship and credential programs is one route toward this goal. Another way that I recommend is establishing forums that allow existing blue-collar workers in the sector to speak up about their job and how their role fits into the larger space sustainability narrative. Not only would this inspire more people to consider participating in the space economy, it would also allow new innovative ideas a chance to be considered by those with large influence in the industry as well. Promoting social equity in space goes beyond the notion of "feel-good" politics. When we empower disenfranchised members of society with the opportunity to truly have their voices be heard, all members of our society will reap the benefits.

Our world has never been hungrier for innovative solutions that foster global cooperation. If we can effectively inform, engage, and empower, we then will have a fighting chance to ensure the human-made problems that exist on our planet are not replicated as we expand our presence in space. Furthermore, the space sector would cease to exist without the support of blue-collar labor; therefore, space sustainability will not be as effective until we get more buy-in from individuals whose labor has historically built the foundation of the growing space economy – working-class individuals.

Isabelle Mierau // GERMANY
Space Debris DAO

Economics of Space Sustainability: Incentives and Technological Implementation of Sustainable Space Standards

Adopting space safety and sustainability standards is not a cost but an investment. Economic growth in the space sector is expected to exceed at least $1 trillion by 2030 (i.e., US Chamber of Commerce 2023, World Economic Forum 2024, Morgan Stanley 2024, McKinsey 2024 and others). However, these predictions do not consider hazards that could significantly threaten that growth, particularly space debris.

The Organisation for Economic Co-operation and Development (OECD) predicts that space debris-related costs for satellite operators will account for about 10% of total mission costs, adding hundreds of millions of dollars per mission (2020). This underscores the economic imperative of adopting space safety and sustainability standards to ensure a thriving space industry. If not addressed in time, certain areas will become inaccessible for multi-billion dollar missions. Entire orbits could become too risky to operate in.

Legal Gaps and Transformation

One might assume that regulation will solve the issue. The good news is that many regulatory bodies and agencies already recognized the urgency of preventing and mitigating orbital debris. Beyond guidelines of the UN Committee on the Peaceful Uses of Outer Space (COPUOS) and NASA, Europe is catching up through the upcoming EU Space Law, the Zero Debris Charter, and the updated French Space Law, which increasingly promote standards for space safety and sustainability (i.e., ESA 2023). However, the mandate and enforceability of these initiatives often remain unclarified.

Global governance in general faces significant implementation issues, and space governance is no exception. International law holds nations theoretically accountable, with launching states liable for developing and enforcing their laws on space companies (cf. UNOOSA 1967; UNOOSA 1972). While national law is a viable option for enforcement, the lack of aligned regulation in climate change, biodiversity conservation, and other sustainability matters indicates that it is inappropriate to wait for every individual jurisdiction to enforce space safety and sustainability sufficiently.

Hoever, what is not enforced can be encouraged through incentives. Many regulatory instruments are still untapped. Penalties and sanctions are not the only regulatory options; in fact, there is an entire toolkit available. Proactive economic solutions, like taxation, subsidies, license, and public contract requirements, that incentivize the adoption of safety and sustainability standards through economic rewards are essential means for implementation.

Economic Incentives — How can we ensure that the adoption of space safety and sustainability standards is beneficial for space actors?

This became my guiding question when developing curricula for governmental trainings and participating in the development workshops of the Zero Debris Charter, a forward-looking initiative led by the European Space Agency.

Coming from a social and political science background, I focus on the economic aspects of implementation. The result is the Space Debris DAO, a decentralized autonomous organization for satellite operators that fills the implementation gap by incentivizing compliance with space safety and sustainability standards.

The communal effort of space safety and sustainability leads to a reduction in collision risk and damage claims, cutting insurance costs and unlocking further rewards provided by our network of professionals and commercial partners. By linking responsible satellite operators with our corporate partners, the DAO provides discounts on essential products and services for missions, as well as free educational material. This partnership attracts more responsible customers to our partners, such as risk coverage providers, who in return offer reduced pricing to our members.

Technological Implementation

These incentives are enabled through decentralized technology, facilitating a globally accessible economic reward system.

Decentralized autonomous organizations (DAOs) are blockchain-based communities that enable collaborative decision making on shared goods, interests, and resources using blockchain's transparency, immutability, and verification benefits. Blockchain technology provides a technical framework that democratizes global governance and enables broader participation.

Blockchain provides an immutable and globally accessible registry that can be used for verified certification of space safety and sustainability compliance, transactions, and voting, allowing international stakeholders to make joint decisions on

Continued on next page

Continued

issues of common interest. Different tokens permit varying voting rights, enabling advisory board votes on strategic decisions while space industry actors engage in operational concerns. Therefore, DAOs enable participation in a global incentive network for the space economy, combining resources, knowledge, and opportunities from various actors worldwide.

Recommendations

1. Build upon existing legal and governance frameworks, e.g., including space safety and sustainability in the Sustainable Development Goals and developing new legislation based on lessons learned from other jurisdictions (e.g., France).

2. Investigate economic incentives for non-binding charters and guidelines that enable the implementation of cross-organizational knowledge (like the Zero Debris Charter).

3. Leverage existing technologies to advance global collaboration as communal effort is a critical aspect of solving global issues (e.g., the Space Debris DAO).

Sources

• European Space Agency (ESA), 2023. Zero Debris Charter. Available at: https://esoc.esa.int/sites/default/files/Zero_Debris_Charter_EN.pdf

• Organisation for Economic Co-operation and Development (OECD), 2020. Space Sustainability: The Economics of Space Debris in Perspective. Available at: https://read.oecd-ilibrary.org/science-and-technology/space-sustainability_a339de43-en

• McKinsey & Company, 2024. Space: The $1.8 trillion opportunity for global economic growth. Available at: https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/space-the-1-point-8-trillion-dollar-opportunity-for-global-economic-growth

• Morgan Stanley, 2024. Global Space Economy. Available at: https://www.morganstanley.com/Themes/global-space-economy

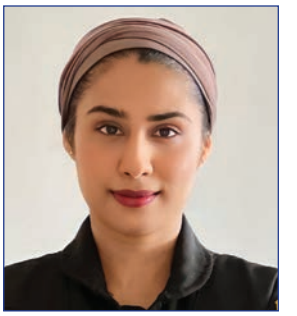
• United Nations Office for Outer Space Affairs (UNOOSA), 1967. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies. Available at: https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html

• United Nations Office for Outer Space Affairs (UNOOSA), 1972. Convention on International Liability for Damage Caused by Space Objects. Available at: https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/liability-convention.html

• U.S. Chamber of Commerce, 2023. Economic Opportunity in Space. Available at: https://www.uschamber.com/space/economic-opportunity-in-space

• World Economic Forum, 2024. Space Economy Technology: Invest in Rocket Opportunity. Available at: https://www.weforum.org/agenda/2024/04/space-economy-technology-invest-rocket-opportunity

Sumbal Mushtaq // PAKISTAN
Astralbeam Organization



The Pursuit of Strategic Dominance in Space: A Threat to Global Peace and Progress

There is breaking news in 2045, reporting a surge in military tensions that occurred following the identification of an advanced space weaponry deployment by the United States and Russia through satellite imagery. China has aligned with Russia, and India is supporting the United States' stance. Meanwhile, most European states have abstained from commenting, further complicating the global geopolitical landscape. The United Nations expressed deep sorrow over the escalating conflict and urgently called for measures to de-escalate the situation and prevent further militarization of space.

This hypothetical yet plausible scenario highlights the pressing need for immediate action to regulate space territory. The current trajectory of space technology, marked by the pursuit of strategic dominance, could severely hinder developing nations' ability to find their place in this new frontier, ultimately jeopardizing our globally shared goals of peace, advancement, and sustainability.

The Strategic Pursuit in Space Technology

The competition for supremacy in space is not new. The narrative was interrupted following the easing of geopolitical tensions between the United States and the Soviet Union, ushering in a period of growth in the space sector, the outcomes of which we are experiencing today. However, recent advancements have heightened the competition once again. Major spacefaring nations are investing heavily in counterspace capabilities, including anti-satellite (ASAT) weapons, electronic warfare, and directed energy weapons. These advancements are not solely for scientific progress but are often aimed at gaining strategic military advantages, as evidenced by the formation of space forces by Russia, the United States, and China. The extensive utilization of these technologies could have significant global impacts that extend far beyond the military sphere, as large segments of the global economy and society depend more and more on space-based activities.

Space capabilities often serve dual purposes, allowing them to thrive in various ways. Russia, China, and the United States have been testing technologies for rendezvous and proximity operations in both low Earth orbit (LEO) and geostationary orbit (GEO), potentially leading to a co-orbital anti-satellite (ASAT) capability. In 2021, Russia demonstrated a direct-ascent (DA)-ASAT capability. It has sophisticated space situational awareness (SSA), which is currently used for surveillance or inspecting foreign satellites. Similarly, according to reports China has a mature DA-ASAT capability, started in 2007, with possibly a dedicated military space program underway that could provide counterspace capabilities. In 2016, China restructured its space forces as part of a broader military reorganization that also has control over electronic warfare and cyber. The United States continued testing intercept technologies in LEO and GEO and currently has operational mid-course missile defense interceptors; it has previously developed nuclear DA-ASAT capability but declared a moratorium on destructive DA-ASAT missile testing in 2022. The United States does not have a publicly acknowledged program for developing co-orbital capabilities; however, it possesses the technological proficiency required to pursue such initiatives. It also has the most advanced SSA capabilities, electronic warfare tech, satellite laser ranging (SLR) sites, and low-power laser systems capable of blinding Earth observation (EO) imaging satellites, possibly, but has no indication of any operational usage as of yet. India demonstrated ASAT capability by destroying its own satellite in 2019 and has long-range ballistic missile programs that could lead to DA-ASAT capabilities [1].

These considerable investments in developing counterspace capabilities suggest they see space as a domain for future conflicts, whether or not that is officially stated. It reflects a broader strategy to achieve superiority in space, a goal that is also evident in military doctrines and organizational frameworks for warfare.

Impact on Emerging Nations

The pursuit of authority in space can create significant barriers for developing nations, as major powers have the resources to invest in advanced space technologies and counterspace capabilities. This creates a disparity as emerging nations often lack the financial and technical means to compete on the same level. The militarization of space diverts attention and resources away from peaceful and cooperative uses of space technology, leaving developing countries at a disadvantage. This hinders their ability to fully participate or benefit from advancements in space exploration and utilization. Furthermore, the emphasis on strategic preeminence and military leverage undermines global efforts to address common challenges like climate change, debris mitigation, disaster management, and much more.

Jeopardizing Global Peace and Sustainability

The escalating militarization of space poses significant threats to global peace and sustainability. It increases the risk of conflicts extending to a domain that should ideally be shared and peaceful. It diverts resources from collaborative efforts to address critical global challenges. The historical context of weaponization complicates efforts to establish responsible norms in space activities. Precedents set by past militarization, coupled with trust deficits among nations and challenges of arms control, emphasize the need for robust diplomatic efforts aimed at shifting the narrative toward cooperation over competition.

Continued on next page

Continued

The question "Who possesses the moon?" is now more than just rhetoric. Instead, it strikes at the core of a lack of effective governance that could lead to conflicts beyond our planet. The exploration of the moon has led to global division. The Artemis Accords, signed by 43 countries, have been perceived as a unilateral effort by NASA and have not been supported by China and Russia. In response, there is a planned International Lunar Research Station, which 13 countries have agreed to support, leading to a fragmented approach to space exploration. Recently, Russia vetoed the U.S.-Japan-led UN Security Council resolution [2] to reaffirm the Outer Space Treaty's ban on weapons of mass destruction (WMD) in space, tautening tensions between the two countries over military space activities.

The potential implications of a new Cold War in space are profound, and may overshadow the potential for international cooperation in scientific research. The pursuit of dominance in space could lead to a fragmented and polarized world, hindering progress and innovation that arise from collaborative efforts.

A Vision Rooted in History

Since ancient times, humanity has yearned for peace but has never truly attained it. With the onset of a new space race, often referred to as "advancing humanity," there is an opportunity to emphasize global peace. Historically, notions like Albert Einstein's proposal for world governance to stop the disease of excessive nationalism or Immanuel Kant's vision of a federation of free states to ensure perpetual peace highlight efforts toward global harmony. These historical and philosophical parallels emphasize the importance of a renewed focus on peace in our current pursuit of space exploration, urging us to take measures to prevent the errors of the past.

The International Space Station stands as a beacon of global cooperation, uniting historical adversaries with the shared goal of advancing humanity. This spirit should extend to new frontiers, such as the moon. Without full participation by major space powers in a united agreement, the new space frontier risks becoming a battleground for geopolitical dominance rather than a platform for peaceful collaboration.

The incorporation of the wisdom and perspective of indigenous peoples, who have prioritized the well-being of the Earth and all life forms, can guide future space endeavors. The Six Nations of the Iroquois Confederacy [3] are considered by some to be the world's first people's republic and the first to make a national constitution — which the Iroquois call the "Gayanashagowa," or the Great Law of Peace. Written through belts of beads and passed down in oral tradition, it allowed for the peaceful coexistence of multiple indigenous peoples by codifying a number of inter- and intra-national matters. This approach may not work in the current earthly setting but can guide future interstellar governance to ensure that activities in space are conducted harmoniously and sustainably, promoting a future in space that prioritizes peace and shared progress for all of humanity

Charting a Course for the Future

Enhance International Agreements: Strengthen and broaden existing treaties like the Outer Space Treaty to manage modern challenges such as space debris and satellite blinding.

Prevent Space Weaponization: Define weapons of mass destruction comprehensively. Advocate for and enforce new agreements explicitly prohibiting space weaponization and destructive anti-satellite missile testing.

Promote Equitable Access: Establish international funding mechanisms and technical assistance programs to support the space initiatives of developing nations.

Encourage Transparency and Confidence: Major spacefaring nations should share information about their space capabilities to enhance transparency and reduce the risk of misunderstandings and conflicts.

Foster Collaborative Projects: Promote joint space missions among conflicting nations, scientific research, and technology development to demonstrate peaceful cooperation and shared benefits

Incorporate Indigenous Perspectives: Integrate indigenous peoples' respect for the planet and interconnectedness of life into space policies for a more harmonious and sustainable approach.

As we stand on the brink of a new era in space exploration, it is imperative to reflect on the path we are taking. By promoting policies that emphasize peaceful cooperation and equitable access, we can ensure that space truly remains a frontier for all humanity, fulfilling Yuri Gagarin's vision of a space that has room for everybody. The stakes are too high to ignore. We must act now to secure a future where space benefits all of humanity, not just the few who seek to dominate it. Let us work together to build a spacefaring civilization that reflects our highest ideals of peace, advancement, and sustainability.

References

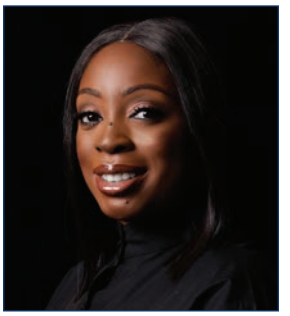
[1] Global Counterspace Capabilities, An open source assessment by Secure World Foundation https://swfound.org/media/207826/swf_global_counterspace_capabilities_2024.pdf

[2] Russia vetoes Security Council draft resolution on a weapon-free outer space https://news.un.org/en/story/2024/04/1148951

[3] Indigenous Pathways to Peace https://www.usip.org/publications/2024/04/indigenous-pathways-peace

Alma Okpalefe // NIGERIA

World Space Week Association



Embracing the Slow Movement and New Space Methodologies in Africa

"Fast and Slow do more than just describe a rate of change. They are shorthand for ways of being, or philosophies of life." — Carl Honoré [1]

When I first stepped foot in Maputo, Mozambique, even as a child, I knew instantly that something was different. The hustle and bustle of Lagos, Nigeria, was distinctively missing; things were slower. I loved it, but I kept it to myself. "Slow" often gets the short end of the stick – connotations are drawn with a lack of seriousness or poor coordination. On the other hand, "fast" is coveted, associated with leadership, innovation, and dynamism. The importance of speed is particularly apparent in space, where initiatives are often driven by the speed of innovation and pride of being celebrated as the first. The African space industry is growing, and New Space offers a viable means of further developing this burgeoning ecosystem; however, this should be pursued with intent, slowly – adjusting long-standing business ideas, and considering new methodologies that may reframe the expectations of what success in space should look like.

New Space promotes the accessibility of space to new players and a broader audience through innovative space products and services enabled by new business models. These form the building blocks for the new space economy, an ecosystem of companies whose new space products and services drive accessibility. Innovative business models drive New Space, one of which is the product-to-service model, which focuses on selling the service that a product provides rather than selling the product itself. This method, utilized for ground station services in the United States by Amazon Web Services Ground Station, stands out because participation is not contingent upon ownership of the performing assets, and perhaps shifting focus from ownership to leveraging may be central to unlocking the growth of the African ecosystem.

A movement that can be related to any field or sector, the slow movement has been defined as a cultural shift in the priorities of a given project – by shifting focus from immediate market needs to long-term requirements that are not only good, clean, and fair for all, but also secure meaningful connections with people, culture, and everything else. In the context of space, the slow movement would require the application of sustainability, mindful pacing, and minimalism.

Sustainability refers to making an informed distinction between what is available or possible and what is necessary. The Africa Space Industry Annual Report states that 125 new satellites have been lined up for development in 23 African countries by 2025. With the concerns over the environmental impacts of the megaconstellations in low Earth orbit, launching a satellite at a national level should be carefully considered. In the area of satellite communications, there are several satellites indigenous to Africa with available multiband capacity for lease, several of which have continental footprints – RASCOM, NIGCOMSAT, ANGOSAT. Sustainability can also be achieved by repurposing and thereby maximizing existing resources. Intelsat recently announced the extension of life of healthy in-orbit satellites with mission extension vehicles [2]. This serves the dual purpose of providing reliability of service to existing customers and demonstrates leadership in sustainable space operations.

Fast or slow, neither is inherently negative, rather the intentionality of pace is what matters for the slow movement. The African Space Strategy lists various action areas, and it may be tempting to feel that everything is urgent – infrastructure, international partnerships, human capital [3]. When viewed through a mindful lens, the criteria for urgency become more human focused, and as such skills development in the sector should be most urgent. Africa has the youngest population in the world, with the majority of the Sub-Saharan population being under the age of 30; this is a vast pool to develop the requisite human resources for the space sector.

Minimalism is achieved when you reduce the resources required to support your activities whilst still meeting your business objectives. Minimalism also drives cooperation and breaks down silos and duplication of efforts that often plague continental, regional, and even national space programs. Nigeria recently signed an agreement with Space Exploration and Research Agency (SERA) to facilitate Nigeria's first human spaceflight [4]. This is a step toward the fulfillment of a long-standing objective of the Nigerian Space program [5]. The initial objective was to train a Nigerian astronaut by 2015 and achieve a space mission by 2030. By reconsidering methods and leveraging partnerships, this astronaut program has leapfrogged, and this can be replicated across the continent.

One of my favorite African folktales is the story of the Tortoise and Hare, not because the slow tortoise won the race against all odds, but because of how he won – by being resolutely himself. There are several impediments to African nations replicating the success of more established spacefaring nations, but there are fewer impediments to African nations redefining what success in space is and how it is achieved.

References

[1] Carl Honore, In Praise of Slow https://www.carlhonore.com/book/in-praise-of-slowness/

[2] Intelsat extends satellite life extension contracts. https://spacenews.com/intelsat-extends-satellite-life-extension-contracts/#:~:text=TAMPA%2C%20Fla.,four%20more%20years%20to%202030

[3] African Space Strategy https://au.int/sites/default/files/documents/37434-doc-au_space_strategy_isbn-electronic.pdf

[4] NASRDA Signs MoU with SERA to Launch Nigeria's First Astronaut to Space https://spaceinafrica.com/2024/06/20/nasrda-signs-mou-with-sera-to-launch-nigeria-first-astronaut-to-space/

[5] Harnessing New Space for sustainable growth of the Space Sector https://read.oecd-ilibrary.org/science-and-technology/harnessing-new-space-for-sustainable-growth-of-the-space-economy_a67b1a1c-en#page14

Carolyn Overmyer // UNITED STATES

Lockheed Martin Space

Orbital Debris Is Risking Human Exploration of Space

Orbital debris is risking human exploration of space. When I was a young child in the 1970s, my dad and I would sit out in the backyard at night and try to spot the satellites passing overhead. They were hard to find, and it was cool when you would spot one and track it until it went out of view. We lived in Nassau Bay, Texas, about a mile from the main entrance of NASA Johnson Space Center and my father was part of the astronaut program. He would talk about how he was going to be the pilot of a Space Shuttle mission one day and he was going to be orbiting in the same space with these satellites. I worried that he would run into one and he just laughed and said that space was so big that there was plenty of room up there for us. He did eventually pilot the fifth Shuttle mission in 1983, and was the commander of the 17th Shuttle mission in 1985, both very successful missions.

Now, the story is very different. It's not unusual to see a whole string of satellite constellations crossing high above the Earth. We have so much stuff in low Earth orbit, it is commonly referred to as "the soup" and a lot of the stuff is not functioning – including discarded rocket bodies and hardware from separation events to satellites with limited or no maneuverable capability. And that's only the stuff we can track. There are some things that are too small to track. Now going through low Earth orbit is like playing a game of Frogger and dodging space debris is not uncommon.

As Lockheed Martin's Chief Engineer of the Orion spacecraft program, which is going to take four astronauts to the moon on each Artemis mission, my job is to have a successful mission and to make sure the crew safely returns home. The Orion vehicle will have to cross through "the soup" six times during the mission, so we do everything we can to minimize the risk to the astronauts. This includes a lot of analysis to determine what our risk is for a debris hit to the spacecraft using the latest information available and we design the vehicle to withstand small debris strikes. We also use the U.S. Space Force to monitor for orbital debris during the mission and alert the Orion mission operations team any time there is debris that might get close to the spacecraft. Then the operators can decide if we need to do an avoidance maneuver.

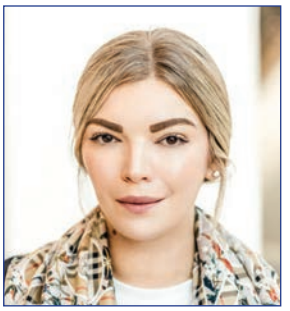
Every year, more and more debris collects in low Earth orbit and it is going to get harder and harder to keep the astronauts safe. Since the early 2000s, there has been an annual call to clean up "the soup" but it comes with a big price tag and the economic costs are seen to outweigh the benefits. NASA recently released a report on the cost and benefit of mitigating, tracking, and remediating orbital debris [1]. This report contains a list of actions to be considered to not only clean up existing debris but to also mitigate the creation of debris. It focuses on an economic approach using a cost-benefit ratio for debris reduction that shows that small steps can make big improvements. For example, reducing the time to deorbit a satellite once its mission is complete can significantly reduce the on-orbit debris and one less thing to track.

An effort to clean up space would help reduce the risk of an impact from orbital debris on the spacecraft. This could include technology improvements focused on spacecraft and rocket design to eliminate new debris, innovative approaches to mitigate existing debris and reduce collisions, improving debris tracking, implementing domestic and international policy changes, and of course finding a way to stop in-space anti-satellite weapons testing events. The time to do this is now, before we find our ability for human exploration of our universe is too risky to attempt and I will not be able to get our crews home safely.

[1] Cost and Benefit Analysis of Mitigating, Tracking, and Remediating Orbital Debris, NASA Office of Technology, Policy, and Strategy; Jericho Locke, Thomas J. Colvin, Laura Ratliff, Asaad Abdul-Hamid, Colin Samples Published May 2024 Report ID 20240003484

Olga Stelmakh-Drescher // GERMANY

Exolaunch



You Are "Space" Cool! But How Crucial Is It to Be Responsible? — Strategizing the Bridge Between Designed Solutions and Transformational Responsible Behaviors

The 21st century has shown that SPACE IS FOR (nearly) ALL with many novel space technology solutions, capabilities, and stemmed business models championing space activities these days. "The speed and complexity of developments have outpaced our systems for cooperating and coping" [1]. How positive is this trend?

Space activities are unlocking a number of impactful opportunities and technology-enabled benefits [2], but equally require full accountability for what space actors undertake, unconditional consciousness, and reciprocal responsibility against the others, including toward the future generations. While the growth of the space economy is an absolutely vital indicator highlighting its indisputable value [3], it also shows the risks at stake when non-sustainably revolutionizing the way space actors are conducting activities in space.

What we undertake today has long-term consequences for the future, including for access to space and the quality of the operating environment. The more we demand of ourselves when conducting space activities, the more guarantees we have for space to remain operational in the long run and capable of being used for the benefit of all. Also, we need to examine whether the traditional and commonly perceived use of space instead of a responsible, accountable and conscious behavior when conducting space activities fosters a default consumer behavior? The patterns we have observed lately evidence a growing number of commercially aggressive space activities where space sustainability merely vests with certain non-binding statements and declarations often used for positioning purposes of concerned stakeholders.

We lack a clear roadmap for all that would streamline the efforts to be taken to ensure the safe, sustainable, and secure space activities. With an absolute minimum set of responsible behaviors to be identified, we should continue with distilling the scope of actions for desirable and therefore expected behavior, directing the actors to aim higher and commit more. We must outline the gap between the actions taken if pursuing the minimum pathway and the desired one to particularly highlight the deviation in consequences.

While all space actors must be equally accountable irrespective of their nature, size, level of maturity, heritage, and capabilities, we can't talk about identical requirements to be posed to them. The efficient legal regime requires a holistic approach covering all space actors while on implementation and execution levels foreseeing a differentiated treatment that considers the capabilities of diverse actors and efforts each stakeholder should invest into a responsible and sustainable evolutionary trajectory of the space environment.

Space sustainability can't tolerate any more delays; to find a consensus around the proportionality regime engaging and committing the global stakeholders, it is a high time for stakeholders to be proactive setting the benchmarks and shaping the best practices based on transformational ethical considerations and patterns of responsible behaviors. Space actors should bear in mind the consequences space activities will have on the future if not conducted responsibly.

The space sustainability discussions are relatively young and often exclude those whom the implementation policies might affect in the future. The space sustainability governing architecture is split in puzzles without being challenged to be transformed into an inclusive live commitment. And this is where we must face the problem. Here are some of the multiple dedicated efforts launched over the last years:

- Space Debris Mitigation Guidelines (IADC & UN COPUOS)
- UN COPUOS Guidelines for the Long-term Sustainability of Outer Space Activities
- Artemis Accords
- ESA Green Agenda, Space Environmental Report, Statement for a Responsible Space Actor and Zero Debris Chapter
- EU (draft) Space Law and certain national or regional regulations touching on these issues directly or indirectly
- NASA's Space Sustainability Strategy (in progress)
- WEF Space Sustainability Rating & Space Sustainability Monitor
- AIAA Satellite Orbital Safety Best Practices
- Certain space-sustainability elements in domestic or regional strategies and some countries working on dedicated space sustainability strategies
- Multiple internal institutional policies, guidelines and instructions

All the above listed are united by a tacit acknowledgment that the way we conduct space activities these days endangers our common future. Technological advancements are going way faster than a legal architecture framing them and the development of enforced solutions to serve as an action plan, including the mandatory rules of reference, for preserving long-term sustainability.

They touch on a broad range of critical topics that all together constitute the realm of space sustainability. From space debris mitigation to space sustainability awareness to space traffic coordination (management) and beyond, leveraging different parts of the space environment.

Shall we do more or shall we do better?

Shall we go beyond or shall we go more in-depth?

Shall we wait for global mutually inclusive commitment or start acting now within the scope we envision is necessary?

There is no reason to wait for the mandatory rules or the worst scenario to start acting responsibly. We always have an "opportunity to put us in a better path" [4]. The backbone of responsible behaviors is in each one of the stakeholders.

[1] UN Summit of the Future https://www.un.org/en/summit-of-the-future

[2] WEF Six ways space technologies benefit life on Earth, www3.weforum.org/docs/WEF_GFC_Six_ways_space_technologies_2020.pdf

[3] WEF Space Economy, www.weforum.org/agenda/2024/04/space-economy-technology-invest-rocket-opportunity/

[4] UN Summit of the Future https://www.un.org/en/summit-of-the-future

Salman Ali Thepdawala // PAKISTAN

University of Bundeswehr - Munich

The Dual-Use Dilemma: Leveraging Existing Multilateral Treaties for a Way Forward in Space Governance

As Carl Sagan said, "We are like butterflies who flutter for a day and think it is forever." This poignant metaphor captures the essence of our shortsighted actions in space exploration. Despite remarkable technological advancements, the uncoordinated expansion in low Earth orbit is leading us toward a future fraught with risks – congestion, collisions, and political conflicts. The rapid and competitive deployment of satellite constellations by entities like Starlink, OneWeb, Kuiper, and Telesat, alongside initiatives from the European Union, China, Russia, and Japan, underscores the urgent need for globally coordinated efforts to ensure the sustainable and equitable use of space. This unregulated expansion raises concerns over the dual-use capabilities of modern satellites, posing significant threats to both space security and global stability. Without effective governance, we risk turning space into a conflict zone where private entities exploit resources and profit at the expense of safety, mirroring the exploitation seen in terrestrial conflicts. In this context, we must examine the political and military challenges, learn from historical precedents, and seek cooperative solutions to prevent a similar fate for space.

Political and Military Challenges

While numerous recommendations for policy and regulatory frameworks have been proposed at the UN Committee on the Peaceful Uses of Outer Space and other international platforms, none has been agreed upon unanimously. The primary barrier, to date, to achieving space sustainability lies within the realm of politics, where geopolitical tensions and competing interests among nations hinder efforts toward collective action. Although there have been instances of collaboration, such as the Apollo-Soyuz Test Project (ASTP) and the International Space Station, these successes are far outnumbered compared to disrupted events due to geopolitical tensions or conflicting strategic goals (e.g., the cancellation of the ExoMars Rover partnership, ASTP follow-ups, U.S.-China cooperation, and complications surrounding Iranian satellite launches).

While the intersection of space technology with military capabilities has always driven innovation, it also threatens peace in space. Though space-based weapons are more noticeable and likely to provoke international response, the use of space for intelligence and surveillance has been a longstanding practice, providing both military and civilian services. However, with the advent of private megaconstellations, many states increasingly fear their potential use in global conflicts. For instance, during the Russia-Ukraine conflict, the Pentagon has contracted SpaceX to provide internet services in Ukraine, exemplifying the role private companies can play in shaping global tensions. These companies, many of which also engage in defense projects, can act under the guise of commercial activities while potentially supporting military operations, further blurring the lines and subsequently triggering similar responses from other states.

This dual-use nature of space technology extends beyond intelligence and surveillance, highlighting a broader issue. Technologies developed for clearing space debris, such as active debris removal, can be repurposed for hostile actions against satellites. The dual-use nature of these technologies, along with the surge in satellite launches and adaptable payloads, has made space an increasingly hostile and contested domain. Moreover, the integration of modern weapons with space-based technology highlights the potential for terrestrial conflicts to easily convert into kinetic and non-kinetic actions in outer space, posing grave implications for global stability and the sustainability of space activities. For example, all leading space nations have conducted anti-satellite tests, signaling military might and causing significant threats to peaceful space activities. Although many believe we have moved past the "guy with the red button" dilemma, we still underestimate the drastic actions people can take in desperate times, as evidenced by the Cuban Missile Crisis, the Able Archer 83 scare, the Suez Crisis, and the Kargil Conflict, where the world came dangerously close to a supposed apocalypse. These events underscore how a single misstep or misinterpretation can quickly lead to heightened hostilities and global repercussions.

Table 1. Treaties Prioritizing Peaceful Use and Scientific Cooperation

Treaty	Summary	Key Aspects	Parallels with the Space Industry
Antarctic Treaty	Prioritized scientific research and environmental protection in Antarctica.	Signed by Cold War adversaries; prohibits military activity; international cooperation for peaceful purposes.	A model of governance that prioritizes scientific collaboration and environmental protection can be adapted for space, keeping it free from military conflict and extensive commercial exploitation.
Outer Space Treaty (OST)	Established the framework for international space law.	Prohibits placing nuclear weapons in space; encourages peaceful exploration and use.	Building on the OST to develop more specific regulations and enforcement mechanisms for modern challenges.

Table 2. Treaties Emphasizing Collective Environmental Benefits

Treaty	Summary	Key Aspects	Parallels with the Space Industry
Montreal Protocol	Phased out the production of substances that deplete the ozone layer.	Collective global benefit of protecting the ozone; scientific consensus and clear environmental benefits drove cooperation.	Emphasizing collective benefits of preserving the space environment can motivate nations to cooperate on space sustainability.
Kyoto Protocol	Committed state parties to reduce greenhouse gas emissions.	Binding targets for developed countries; mechanisms for monitoring and enforcement.	Binding targets and monitoring mechanisms could be applied to managing space debris and reducing emissions from space activities.

A Way Forward – Leveraging Historical Analogies and Lessons

The challenges posed by the militarization and dual-use nature of space technologies highlight the urgency of establishing robust international governance to ensure the peaceful and sustainable use of space. Historically, humanity has faced similar challenges on Earth, where geopolitical tensions and technological advancements have necessitated international cooperation and the creation of treaties. By examining these historical precedents, we can identify strategies that might be adapted to the context of space governance.

Historical evidence suggests that crisis often precedes cooperation. For example, the devastation of European wars led to the formation of the European Union, and the Industrial Revolution's environmental toll resulted in agreements like the Kyoto Protocol and the Paris Agreement. Similarly, the unchecked exploitation of space may lead to significant challenges before driving us toward meaningful collaboration. However, unlike past crises, the degradation of space may not give us another chance for rebuilding. Space assets are integral to sustainability efforts on Earth, and their loss could undermine global efforts to address climate change, disaster response, and technological advancement. We must learn from these historical lessons and proactively seek cooperation to avoid repeating past mistakes in space.

Table 3. Treaties Involving Verification Mechanisms and Transparency

Treaty	Summary	Key Aspects	Parallels with the Space Industry
Strategic Arms Reduction Treaty (START)	Reduced the number of strategic nuclear weapons held by the U.S. and USSR/Russia.	Achieved during Cold War tensions; mutual benefits of reduced arms race; involved verification mechanisms and transparency.	Verification mechanisms and transparency can ensure compliance and build trust in space treaties. Mutual benefits of preventing weaponization of space.
Intermediate-Range Nuclear Forces Treaty (INF)	Eliminated intermediate-range and shorter-range missiles.	Reached despite significant geopolitical tensions; verification mechanisms were crucial.	Similar transparency and verification could prevent the deployment of dual-use or offensive technologies in space.
Nuclear Non-Proliferation Treaty (NPT)	Prevented the spread of nuclear weapons and promoted peaceful use of nuclear energy.	Prevented the spread of nuclear weapons and promoted peaceful use of nuclear energy.	Similar framework could balance preventing weaponization, promoting disarmament, and encouraging peaceful use of space.

The 2024 cohort of the Diverse Dozen are influential thinkers and emerging leaders from around the globe. These individuals represent an exclusive ASCEND community built over the past five years of exceptionally minded and passionate activists devoted to realizing a sustainable future beyond Earth. These authors are the featured speakers in a series of rapid-fire lightning talks highlighting their vision for a sustainable space ecosystem. What needs to happen for space to be more transparent, more predictable? How can we use a globally accessible pool of evidence to help us make decisions and hold people accountable for their behaviors in this shared domain?

Find out by attending their ASCEND session.

Read the archive of Diverse Dozen OpEds at

www.ascend.events

Nifemi Awe // CANADA
PwC Canada

Priyanka Dhopade // NEW ZEALAND
University of Auckland

Martina Dimoska // NORTH MACEDONIA
International Space Alliance

Jose Figueroa // PUERTO RICO / USA
Aqua/Sky Launch Innovations (ASLI)

Amir Gohardani // UNITED STATES
Springs of Dreams Corporation

Kim Macharia // UNITED STATES
Space Prize Foundation

Isabelle Mierau // GERMANY
Space Debris DAO

Sumbal Mushtaq // PAKISTAN
Astralbeam Organization

Alma Okpalefe // NIGERIA
World Space Week Association

Carolyn Overmyer // UNITED STATES
Lockheed Martin Space

Olga Stelmakh-Drescher // GERMANY
Exolaunch

Salman Ali Thepdawala // PAKISTAN
University of Bundeswehr - Munich

Moriba Jah is the Chief Scientist and a co-founder of Privateer, a data and intelligence platform empowering the future of space sustainability. He is a renowned space environmentalist and astrodynamicist, as well as an associate professor of Aerospace Engineering and Engineering Mechanics at the University of Texas at Austin where he is the holder of the Mrs. Pearlie Dashiell Henderson Centennial Fellowship in Engineering. At the University of Texas at Austin, he has worked with a team to develop ASTRIAGraph, an award-winning near real-time map of where objects are predicted to be located in space.