Committee: Committee on the Peaceful Uses of Outer Space

Issue: Ensuring long-term sustainability in space research and manufacturing

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Introduction

Space research has revolutionised our understanding of the universe and provided invaluable insights into technological advancement. The space industry is experiencing rapid innovation, unlike anything since the launch of Sputnik around 70 years ago. Human space exploration continues to be a subject of interest around the world.[1] To achieve ambitious goals such as a human base on the Moon, international cooperation is highly desirable to build common interest. Although international cooperation adds a layer of complexity, they provide resilience and optimal use of resources.

As human space activity continues to expand, the prioritisation of long-term sustainability is crucial to the continuation of our species. The challenges associated with sustainable space research and manufacturing range from satellite sustainability footprint to orbital capacity. An establishment of a resource management framework is essential now more than ever for the proper mitigation of harmful environmental impact. To ensure the invaluable domain of outer space for future generations, states must adopt an approach to ensure proper utilisation of space resources. The enactment of proactive measures through international cooperation should be accentuated to ensure a place where space activities not only propel scientific progress but uphold the core principles of sustainable development.

Definition of Key Terms

Space debris:

Space debris is defined as man-made objects such as retired satellites and used rocket stages that orbit the Earth. Space debris poses a serious risk to manned spacecraft due to its high velocity.

Geomagnetism:

Geomagnetism refers to the magnetic field of the Earth caused by the fluidity of the molten iron in its core. Understanding geomagnetism is important in the development of satellites and other aerospace applications.

ASAT (Anti-Satellite) Weapon Testing:

[1] [https://www.sciencedirect.com/science/article/abs/pii/S0265964609000976]

ASAT (Anti-Satellite) Weapon Testing is the testing of weapons designed to destroy satellites through ground or air systems.

Weapons of Mass Destruction (WMD):

Weapons of Mass Destruction or WMD are nuclear, chemical, biological, or other devices built to harm a large number of people. WMD testing in space should be avoided to ensure long-term international safety.

History

United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS)

Established in 1959, the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) coordinates space-related operations for the benefit of all of humanity. Sustainability on Earth has been addressed by the United Nations for the past four decades. However, the extension of the sustainability principles to outer space is a much more recent development. The acknowledgement stems from the fact that the Earth's orbital space environment is utilized by a growing number of actors: states, non-governmental organisations, and commercial entities.

Space for the Sustainable Development Goals (Space4SDGs)

The United Nations identified aspects in which space applications can be incorporated to further its 17 sustainable development goals or SDGs. For example, Arizona State University devised solutions for the growing problem of junk and debris in low Earth orbit that could potentially lead to economic growth and improvements in space innovation and infrastructure. (https://epics.engineering.asu.edu/2020/09/space4sdgs/)

Outer Space Treaty

In 1963, The UN General Assembly ratified two resolutions on outer space. The UN Resolution 1884 and UN Resolution 1963 established the two main principles for the Outer Space Treaty: ban of WMD stationing and open exploration and usage. The Outer Space Treaty, officially signed in 1967, agreed that the exploration and use of outer space shall be carried out for the benefit and in the interest of all countries and shall be the province of mankind. [1] The treaty established that nations are banned from placing nuclear weapons or military bases in space. 110 states, including the United States and the Soviet Union, have ratified the treaty, with an additional 89 countries in the ratification process.

As stated in Article IV, States committed to refrain from the following:

- Install nuclear weapons or WMD on satellites orbiting Earth or other celestial bodies
- Station WMD in outer space in any shape or form

- Establish military bases or installations, initiate weapon testing, or practice military exercises in outer space

In regards to ensuring open international space usage, the following provisions have been stated:

- Outer space should be open to all countries and investigated freely for scientific purposes
- Celestial bodies are not open to national claims of ownership
- Countries should avoid harming and contaminating space and its celestial bodies
- By the principles of cooperation and mutual assistance, astronauts should provide aid to one another if needed. (https://www.armscontrol.org/factsheets/outerspace)

Moon Agreement

The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, also known as the Moon Treaty, provides a "framework law" to ensure adequate consensus on the sustainable development of outer space. Established in 1979, several considerations guided the drafting of the agreement. (The Moon Agreement: Its effectiveness in the 21st century) The main principle is that the moon and other celestial bodies were to be used exclusively for peaceful purposes. The Moon Agreement sought to redefine the ambiguous phrase that space resources should be "province of all mankind", as in the Outer Space Treaty, to a "common heritage of mankind". This includes the concept of "beneficial domain", which has been excluded from the Outer Space Treaty. The last major consideration is the freedom of exploration and the use of space, and the subsequent promotion of scientific investigation. (The Moon Agreement: Its effectiveness in the 21st century: https://www.files.ethz.ch/isn/124689/espi_%20perspectives_14.pdf)

Space Sustainability Rating (SSR)

With the collaboration of the European Space Agency, MIT Media Lab, and others, the World's Economics Forum launched a rating system for space missions. With the increasing reliance on space infrastructure from internet access to GPS, a method to increase transparency to space debris mitigation without disclosing sensitive information was deemed essential. A "Tier Score" with rating levels among Bronze, Silver, Gold or Platinum. After achieving a certain combined score between 0 and 1 based on the evaluation of each individual module, a second score is aggregated where credit is given towards a bonus "Step" indicator. This gives the possibility to earn credit towards a bonus "Step" indicator, which shows that a mission can go far beyond the baseline sustainability rating. (https://spacesustainabilityrating.org/the-rating/)

Key Issues

Resource utilisation

Space-based research and manufacturing is dependent on the utilization of energy, water, and raw materials. In the future Artemis mission, ice on the Moon or asteroids has the potential to enable long-term manned missions. However, the limited availability of these resources necessitates careful planning and management to ensure long-term sustainability. NASA's Lunar Surface Innovation Initiative is currently developing in-situ resource utilisation (ISRU) methods, such as advancing solar arrays.

In-Situ resource utilisation

The construction of sustainable infrastructure will enhance the exploration and study of the Moon. NASA's Lunar Surface Innovation Initiative is currently developing technologies to harness the water, fuel, and other supplies on the lunar surface.

Additive manufacturing

Mike Curtis-Rouse of Satellite Applications Catapult states that although ten years ago there were only 12 launch companies, today there are more than 320. Space agencies and companies internationally are turning to additive manufacturing for thrusters and engines. Used in conjunction with 3D printing, it allows for "building in reduced spaces and in compact fashion". NASA's Artemis mission includes the construction of infrastructure such as launch pads and roads. Due to the costly nature of the transportation of raw materials to space, these technologies will be key to prolonging space missions and further exploration.

Waste management

Space activities generate various forms of waste, including debris, spent rocket stages, and discarded equipment. Effective waste management systems are essential to minimise the accumulation of space debris and reduce the environmental impact of space-based operations. Responsible disposal methods should be implemented to mitigate the risks associated with space debris and promote long-term sustainability. Also, military space surveillance of all Earth-orbiting objects – a "space object catalogue" – is needed to detect, track and identify objects for possible collisions. Currently, no treaties on minimising space debris exist. In 2007, the United Committee on the Peaceful Use of Outer Space (COPUOS) established voluntary guidelines on such matters, and in 2008, the committee devised methods to prevent collisions between satellites.

Waste Sites

The spacecraft cemetery, officially known as the South Pacific Ocean (ic) Uninhabited Area, is where spacecraft that have reached their "retirement" date are crashed. Repeated dumping of space waste in areas such as these give rise to environmental concerns.

Space Debris

Space debris refers to the retired satellites, used rocket stages, and various other spacecraft parts that orbit the Earth. It can pose a significant challenge to space operations, potentially deterring the safety and efforts of astronauts.

International cooperation and governance

Efforts among space agencies, industry stakeholders, and international organisations are important to share knowledge, coordinate activities, and establish common standards. For example, the International Organization for Standardization (ISO) has published space system-related standards, space debris mitigation, and the

Inter-Agency Space Debris Coordination Committee (IADC)

The Inter-Agency Space Debris Coordination Committee (IADC) is defined as "an international governmental forum for the coordination of activities related to the issues of man-made and natural debris in space". The IADC's objectives are to exchange information regarding space-based research to coordinate internationally. NASA, KARI (Korea Aerospace Research Institute), and ROSCOSMOS (State Space Corporation) are some of the member agencies.

Major Parties Involved and Their Views

Governments

United States of America

The United States has been actively involved in space research for decades – setting foot on the lunar surface during Apollo 17. Spending the most on space research annually, the United States has shown its dedication to the pursuit of understanding the inner workings of space through programs such as Artemis. The United States views investment in space activities as "a source of American innovation and opportunity" and that "new space goods and services create new industries and jobs, such as in clean energy technology and broadband access" (United States Space Priorities Framework, 2021). The Obama administration signed an act "to facilitate a pro-growth environment for the developing commercial space industry by encouraging private sector investment and creating more stable and predictable regulatory conditions and for other purposes." (Commercial Space Launch Competitiveness Act, 2015) The United States

China

Since 2016, China has heavily contributed to the development of its own space industry and has made rapid progress. China aims to facilitate the use of outer space for peaceful, research-oriented purposes and to protect its security. China has pledged and shown initiative in cultivating international space exchanges, having "signed 46 space cooperation agreements or memoranda of understanding with 19 countries and regions and four international organisations." (China's Space Program: A 2021 Perspective, 2022) China actively dealt with issues regarding the long-term sustainability of space activities and space manufacturing – advancing the Space2030 Agenda by the UN.

Japan

Japan shows an active interest in promoting sustainable space research practices. The Japan Aerospace Exploration Agency (JAXA) improved upon its Basic Plan on Space Policy by implementing SDGs in 2020. In 2021, Kyoto University and Sumitomo Forestry, a logging company in Japan, announced the "LignoStella Project". This project aims to build a wooden satellite that endures electromagnetic waves and geomagnetism without releasing harmful substances into Earth's atmosphere.

Russia

Due to Russia's Ukraine invasion, international space cooperation has become increasingly worrying. According to European Space Agency Director General Josef Aschbacher, organisations in Europe have imposed "very serious sanctions" against Russia. In November 2021, Russia initiated an ASAT weapon test that poses a threat to the future of responsible and safe use of space. Russia is also the greatest contributor to space debris. However, Russia has engaged with countries such as Brazil to support "regional space-related activities to support research and development, capacity building and data sharing". (Exploring space technologies for sustainable development, United Nations 2021)

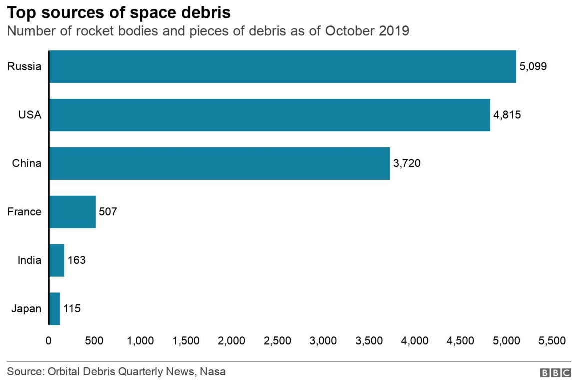

Figure I. Top sources of space debris

Space Agencies

The National Aeronautics and Space Administration (NASA), Roscosmos, and the European Space Agency (ESA) have similar goals in ensuring long-term sustainability in space research and manufacturing. Each of these agencies has devised potential solutions to reducing space debris and protecting bodies in space. For example, in March 2023, NASA conducted a cost-and-benefit analysis of orbital debris remediation. NASA has also "convened an Orbital Debris Review Team (ODRT) to identify priority challenges and solutions related to space sustainability". (Cost and Benefit Analysis of Orbital Debris Remediation, NASA 2023)

Private Companies

Companies such as SpaceX and Blue Origin have focused on ensuring sustainable space research as well as manufacturing. Both of these companies have developed reusable rocket technology to reduce both the monetary and environmental costs of launches. Falcon 9 and Falcon Heavy rockets have been tested to land and reuse their first stages numerous times. SpaceX has been developing ways to produce propellant in space. This makes long-term space travel more sustainable. Both companies collaborated with NASA to foster knowledge sharing and leverage resources. For example, the SpaceX Dragon spacecraft carrying solar arrays and cargo was launched from NASA's Kennedy Space Center in June 2023.

Timeline of Relevant Resolutions, Treaties and Events

Date	Description of event
January 27, 1967	Outer Space Treaty signed

December 18, 1979	Moon Treaty signed
September 25, 2015	United Nations Sustainable Development Goals (SDGs) published
June 2017	United Nations Guidelines for the Long-Term Sustainability of Outer Space Activities
May 15, 2019	Artemis Accords announced
September 22, 2020	Space Sustainability Rating launched by the World Economic Forum (WEF)
June 2021	Long-Term Sustainability Guidelines adopted by COPUOS

Evaluation of Previous Attempts to Resolve the Issue

Although previous attempts to resolve the issue of ensuring long-term sustainability in space research have resulted in some advancements, the lack of sufficient formal resolutions leads to future uncertainties. Space debris mitigation measures and guidelines by organisations such as NASA and the European Space Agency have been established, but adequate enforcement has to be attained through international treaties. Eco-friendly additive manufacturing has shown promise in reducing reliance on Earth-based supply chains.

Possible Solutions

The development of in-situ resource utilisation technologies, advancement of additive manufacturing in space, and active debris removal are potential technological solutions to ensure sustainable space research. Furthermore, strengthening international cooperation and governance is crucial for ensuring the agenda.

Bibliography

1. *China's Space Program: A 2021 Perspective* - 国家航天局, www.cnsa.gov.cn/english/n6465645/n6465648/c6813088/content.html. Accessed 8 July 2023.
2. Dodson, Gerelle. "US, Japan Sign Space Collaboration Agreement at NASA Headquarters." *NASA*, 2023, www.nasa.gov/press-release/us-japan-sign-space-collaboration-agreement-at-nasa-headquarters/.
3. Donaldson, Abbey. "NASA, SpaceX Launch Solar Arrays, Cargo to Space Station." *NASA*, 5 June 2023, www.nasa.gov/press-release/nasa-spacex-launch-solar-arrays-cargo-to-space-station.
4. Garcia, Mark. "Space Debris and Human Spacecraft." *NASA*, 14 Apr. 2015, www.nasa.gov/mission_pages/station/news/orbital_debris.html.
5. Hall, Loura. "Overview: In-Situ Resource Utilization." *NASA*, 1 Apr. 2020, www.nasa.gov/isru/overview/.

6. “Inter-Agency Space Debris Coordination Committee.” *IADC*, www.iadc-home.org/what_iadc. Accessed 8 July 2023.
7. Jdelriov. “United NationsOffice for Outer Space Affairs.” *Space4SDGs: How Space Can Be Used in Support of the 2030 Agenda for Sustainable Development*, www.unoosa.org/oosa/en/ourwork/space4sdgs/index.html. Accessed 8 July 2023.
8. McGillis, Charlie. “Space Sustainability in the Wake of Russia’s Latest Asat Test.” *Slingshot Aerospace Blog*, blog.slingshotaerospace.com/space-sustainability-wake-of-russia-asat. Accessed 8 July 2023.
9. Ryan, Sarah. “Space for Concern: Trump’s Executive Order on Space Resources.” *OUPblog*, 26 Apr. 2020, .oup.com/2020/04/space-for-concern-trumps-executive-order-on-space-resources/.
10. “Space Debris and Space Traffic Management: The Aerospace Corporation.” *Aerospace Corporation*, 14 Nov. 2018, www.aerospace.org/space-debris.
11. “What Is Space Junk and Why Is It a Problem?” *Natural History Museum*, www.nhm.ac.uk/discover/what-is-space-junk-and-why-is-it-a-problem.html. Accessed 8 July 2023.