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Is there enough space for Africa in outer space?

Significance:

Access to outer space is crucial for African nations, for enhancing agricultural efficiency, disaster management, bridging the digital divide, strengthening national security, promoting scientific research, innovation, and fostering international collaboration. Furthermore, gaining access to outer space would empower African nations to actively participate in and benefit from the global space economy. However, the challenge of space debris from spacefaring nations threatens this progress, potentially leading to conflicts. To safeguard their interests, African nations must increase involvement in space activities, promote collaborations, adhere to sustainability principles, and advocate fair debris responsibility. These steps are vital for the future of space exploration.

Introduction

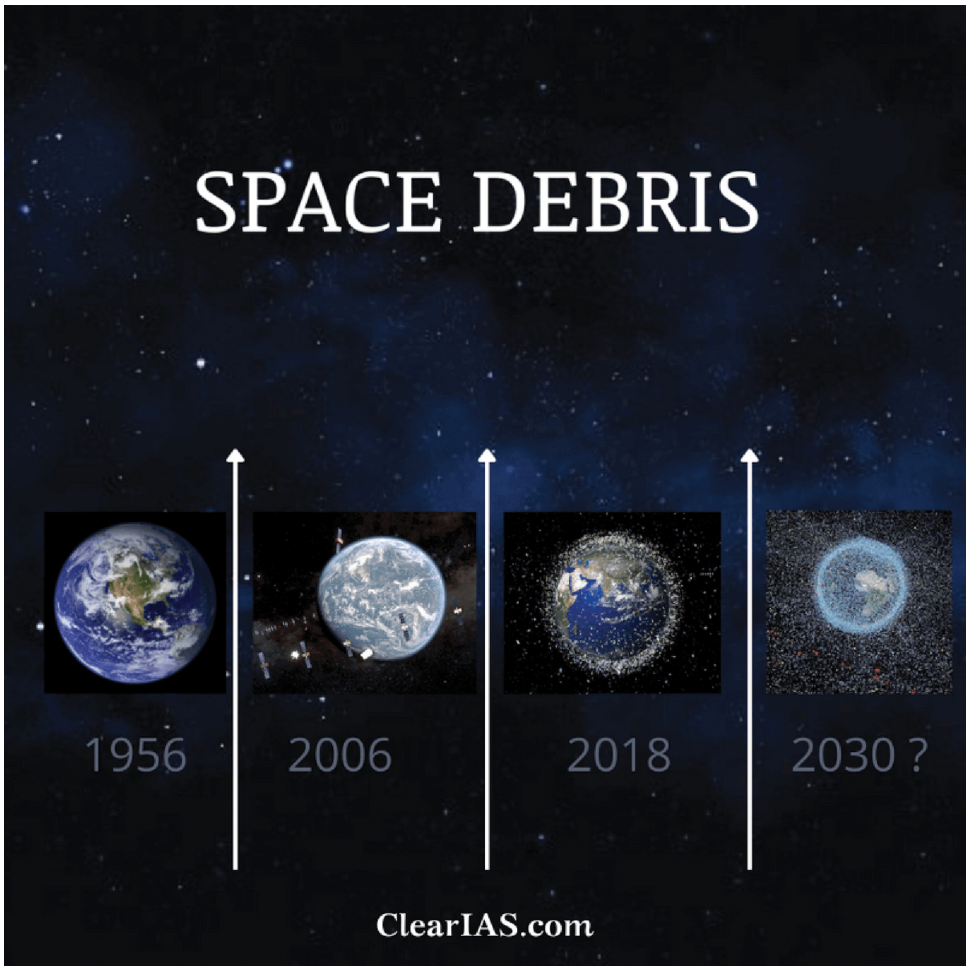
Earth observation satellites (EOS) have significantly improved environmental monitoring and communication accessibility, thus contributing to addressing various challenges faced by humanity. Investing in EOS activities yields numerous long-term benefits, including providing reliable data for informed decision-making in urban planning, agriculture, and biodiversity conservation, to mention only a few. This also entails ensuring consistent communication services, even in regions with challenging terrain or infrastructure limitations. Space-based projects are essential for promoting sustainable development on a global scale. Their varied technologies and wide-ranging applications enable them to effectively address all 17 Sustainable Development Goals (SDGs) and numerous Targets outlined in the 2030 Agenda.[1] However, although some SDGs benefit more from space-based projects than others, this Commentary does not aim to differentiate between these varying levels of support. Despite Africa's limited involvement in EOS and space exploration, recent literature indicates a growing interest and participation in this field.[2,3] However, inconsistent funding is a significant barrier to African space technology development.[4,5]

Outer space availability

The high cost of launching EOS into space – in competition with other essential expenditures such as food, water, and infrastructure development – limits Africa's space exploration endeavours. However, the primary threat facing space exploration is the generation of space debris, which poses a significant risk to EOS and manned missions. Space debris, which consists of defunct satellites and fragments from previous missions, has increased substantially since the inception of space missions, leading to congestion in Earth's orbit.[6,7] Collisions at orbital velocity can cause catastrophic damage to operational satellites and pose risks to future space exploration missions. The Kessler Syndrome predicts that, as the number of debris objects increases, collisions will become more frequent, creating a self-perpetuating cycle of debris.[7] Despite the vastness of space, most EOS are concentrated in low Earth orbit, which is regarded to be particularly vulnerable to debris accumulation.[7] Accidental satellite collisions have occurred in previous instances, resulting in further debris generation. Computer simulations predict an increase in collisions in the coming decades, potentially rendering low Earth orbit inaccessible due to debris density.[7] Currently, out of the 34310 objects under observation in orbit, about 25% are operational satellites, with the rest being debris [6,7] (Figure 1). Furthermore, there are an estimated 130 million debris fragments, too small to be monitored, ranging from 1 mm to 1 cm in size.[7] Travelling at speeds exceeding 25 000 kilometres per hour, even these tiny fragments pose a substantial risk of inflicting damage to operational satellites.[8,9]

The vulnerability of space to interference and disruption has led the USA security space community to perceive space as a contested domain, acknowledging its potential for significant social, economic, and military advantages.[11] The advancement of microsatellite technology and the establishment of multiple satellite constellations have enhanced space exploration initiatives for both the private and government sectors. This has generated greater interest in Africa's activities in space exploration, with ambitious projects such as the 'Africa to the Moon' initiative.[12] Meanwhile, concerns about space debris and the availability of space resources persist, prompting international efforts to promote space sustainability through treaties like the Outer Space Treaty of 1967. This treaty encourages international cooperation in space exploration and utilisation, while prohibiting the deployment of nuclear weapons or any form of mass destruction weapon in space. It explicitly states that no state can assert sovereignty over or occupy outer space, the moon, or any other celestial body. Additionally, the treaty addresses liability and mandates states to inform the United Nations (UN) Secretary-General and the international scientific community about the nature, conduct, location, and outcomes of their activities in outer space. The 1972 Liability Convention establishes international liability for damage caused by space objects. The convention imposes an international and absolute liability on a launching state, or states, and on states that are members of inter-governmental organisations, for any damage caused by their objects. The state that launches or procures the launch of a space object, or from whose territory or facility the launch occurs, is defined as the launch state, regardless of the launch's success or failure. Damage encompasses the loss of life, personal injury, or any other health impairment, as well as damage to a state's property or the property of individuals, whether natural or juridical, or the property of international or intergovernmental organisations. This also applies to any damage caused by a space object on the surface of the Earth or to an aircraft flight.

Despite these treaties' existence, leading spacefaring nations have demonstrated non-compliance. Since the 1960s, both the USA and Russia have conducted numerous anti-satellite test missions in space, resulting in a significant portion of the orbital debris present today. China executed an anti-satellite mission on 11 January 2007, targeting its outdated FY-1C meteorological satellite positioned at an altitude of 855 km. The satellite was destroyed



Source: ClearIAS[10] (reproduced with permission)

Figure 1: The status and future prediction of outer space debris.

by a missile, resulting in the creation of more than 3000 pieces of debris larger than 10 cm.[13,14] The USA conducted a similar mission on 21 February 2008, destroying a military satellite at an altitude of about 250 km. Then-President George W. Bush dismissed concerns about the negative impact of such operations.[15] On 15 November 2021, Russia conducted an anti-satellite missile test that destroyed the defunct Soviet satellite Cosmos 1408. The resulting debris came extremely close to the International Space Station, forcing its crew to take shelter.[16] Australia's Defence Minister Peter Dutton and Foreign Minister Marise Payne condemned the test as provocative and dangerous, questioning Russia's commitment to the peaceful use of space. These events highlight the dominance of advanced spacefaring nations and raise concerns about potential bullying in space.

Navigating outer space accessibility

The intentional destruction of satellites[15,16] has exacerbated the hazardous space debris environment, significantly increasing the risk of collisions with operational satellites. Thus, the threat of satellite loss due to space debris is no longer a theoretical concern but a harsh reality that is likely to intensify in the future.[7,17] The deliberate generation of space debris could also ignite conflict between nations with a vested interest in space exploration, potentially escalating into war. Therefore, it is essential to maintain a stable outer space environment that is free of conflict, with minimum creation of new debris, and effectively manage the existing debris. This will ensure space remains accessible for all those who wish to explore and utilise it. Consequently, it is crucial for all states – whether established, emerging, or future space actors – to engage in multilateral dialogues aimed at developing cooperative international solutions to address and mitigate these shared challenges.[18,19]

With its growing endeavours in outer space, Africa must actively and constructively engage in these discussions. However, the continent's participation in space affairs has been hindered by the absence of formal governance frameworks for collaboration, resulting in countries operating independently. This is set to change with the establishment of the African Space Agency (AfSA), headquartered in Egypt. Supported by a comprehensive space strategy and policy, the agency aims to align with the African Union's Agenda 2063[9], which underscores the critical role of space in Africa's development. The African Union's space policy and strategy are recognised as one of 15 key programmes within this agenda, providing a framework for Africa's space priorities, programmes, and partnerships.[19] The African Space Strategy, grounded in the African Space Policy, outlines fundamental principles for the use of outer space. It emphasises key actions and objectives necessary to leverage space science and technology to address political, economic, social, and environmental challenges. The space policy and strategy were endorsed by African heads of state to foster continental growth by enhancing capabilities in Earth observation, navigation, positioning systems, satellite communication, and space exploration.[19] The African Union Agenda 2063 is also aligned with the UN Sustainable Development Goals (SDGs) 2030.

Currently, 17 African countries have collectively launched 61 satellites, with Egypt and South Africa leading the way through the launches of EgyptSat-1 in 2007 and SUNSAT-1 in 1999, respectively.[20] Senegal recently joined this initiative with the launch of GAINDESAT-1A on 16 August 2024.[18] Despite being latecomers to space activities, African leaders are urged to act to safeguard outer space and promote development and prosperity. Smith et al.[21] argue that addressing the challenge of space debris will enable the African continent to enhance its

national and regional legal frameworks, aligning them with international standards. This engagement will also allow Africa to play a proactive role in the global initiative for the long-term sustainability of outer space.[21] Additionally, African nations must actively participate in establishing international best practices for responsible behaviour, which includes engaging in discussions regarding the draft International Code of Conduct for Outer Space Activities.[22] Active participation in these consultations is crucial for African states to ensure that any resulting agreements reflect their specific interests, particularly those of emerging space actors.

International guidelines have been created to promote responsible space activities, but compliance varies among nations and is not enforced by any global authority.[21] Gaps in international law and national policies contribute to uncertainty in addressing outer space issues.[23] Atkins et al.[23] argue that the current political and legal frameworks for space security are inadequate for the needs of today's spacefaring and space-dependent communities. They also highlight the absence of a clear global regulatory framework to address key issues such as ownership rights in space, liability for collisions, dispute resolution, licensing, or the registration of security interests. In this regulatory vacuum, individual nations have developed their own space legislation and policies, leading to inconsistent and potentially conflicting regulations across countries. This lack of coordination risks disputes and creates an unpredictable environment for space investments and activities.[17] Furthermore, progress on legally binding agreements in traditional forums has been limited, despite the growing urgency to address space stability and sustainability.[17,23] Therefore, it is crucial for African nations to engage in the creation of legislation that balances national interests with the collective goals of space agencies.

Collaborative efforts among different nations to implement a space debris remediation programme are limited. Therefore, to ensure the long-term sustainability of space operations, coordinated efforts are essential to mitigate the risks of operating in a debris-congested environment.[23] This involves both preventing the creation of new space debris and effectively managing existing debris. Support from external organisations, such as the US National Aeronautics and Space Administration (NASA), the European Space Agency (ESA), and the China National Space Administration (CNSA), would be invaluable to the emerging African Space Agency (ASA).

The UN Committee on the Peaceful Uses of Outer Space (COPUOS) Scientific and Technical Subcommittee adopted non-binding space debris mitigation guidelines based on the Inter-Agency Space Debris Coordination Committee (IADC) standards, which were endorsed by the UN General Assembly in 2007. These space debris mitigation guidelines provide seven key principles to guide the mission planning, design, manufacture, and operations of spacecraft and launch vehicles. The principles are: limiting debris release during normal operations, minimising the risk of break-ups, reducing the probability of accidental collisions, avoiding intentional destruction, minimising post-mission break-ups, restricting the long-term presence of objects in outer space, and promoting international compliance with space debris mitigation measures.[22] Through its African Union policy, Africa is committed to supporting the space regulatory principles to ensure that outer space remains accessible to all. Additionally, the continent seeks to promote the long-term sustainability of outer space by adopting responsible practices in its continental space programmes.[18]

Conclusion

Protection against space debris as well as space debris mitigation impose significant costs on space actors, including potential loss of satellites during collisions with space debris. Mitigation efforts involve measures such as impact avoidance (e.g. shielding and debris avoidance manoeuvres), orbit clearance, and venting residual fuel, all of which can affect spacecraft design. Additionally, there are considerable expenses associated with debris surveillance, tracking, and reporting, with little known about the impact of non-tracked debris objects.[24]

It is believed that the current costs associated with space debris are minimal compared to what lies ahead. In a worst-case scenario, certain orbits could become unusable due to the ongoing and self-perpetuating generation of space debris.[7,25] This situation would significantly hinder the delivery of vital government services and likely impede economic growth, particularly for developing continents like Africa.

Africa should expand its space situational awareness to include tracking space debris and assessing collision risks. African members of the COPUOS should advocate for historical space powers to bear financial responsibility for debris removal, with costs proportional to their cumulative payloads. Additionally, Africa should conduct technological research and develop methods for space debris removal. Promoting international collaborations, adhering to principles of space sustainability, and advocating for equitable responsibility in debris removal are crucial for the future of space exploration.[26] Recent developments, such as the 2023 collaboration between South Africa and the Russian government to establish a space debris monitoring facility in South Africa, should be encouraged. Moreover, the African Space Agency's efforts to advance outer space research should encompass studies on space debris, acknowledging that the benefits of space exploration go beyond mere discovery. By addressing the threats posed by space debris and promoting the sustainable use of outer space, Africa can help ensure the long-term availability and accessibility of space for future generations.

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