DEFENSE, EMERGING TECHNOLOGY, AND STRATEGY PROGRAM

Space Technology Advances

Catalysts for Conflict or Pathways for Human Progress?

Abnesh Raina

HARVARD Kennedy School
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50 YEARS
OF RESEARCH, POLICY, AND LEADERSHIP

STUDENT PAPER
JUNE 2024

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Executive Summary

The profound impact that emerging space technologies are starting to have on global geopolitical dynamics and economic environments raises a crucial question: Are we forging a better future for humanity, or merely creating new catalysts for wars and conflicts that have marred humanity throughout history? As space technology continues to evolve, it is not only enhancing capabilities across various domains but also significantly reducing the cost of space access, thereby democratizing it and broadening participation from an array of state and non-state actors.

The economic potential of space, forecasted to evolve into a multi-trillion-dollar industry, funded by investments from both government and private sectors is driving innovations in space tourism, lunar & asteroid mining, and other space-related industries poised to create new markets and job opportunities. The advent of technologies such as hyperspectral imaging, advanced satellite systems, and artificial intelligence is reshaping capabilities in surveillance and reconnaissance of celestial bodies potentially creating conflicts over valuable extraterrestrial assets and national security concerns.

The disparities in technological and financial capabilities among nations will

also exacerbate global dependencies and foster geopolitical tensions. The existing international space law frameworks, such as the Outer Space Treaty of 1967, struggle to address the contemporary realities of space activities. These legal inadequacies complicate the commercial exploitation of space resources and the governance of militarization in space, leading to potential conflicts and ambiguities in international relations. To maintain orderly and responsible space activities there is an urgent need for updated legal frameworks to accommodate new activities such as space tourism, mining, and private space stations.

Additionally, fostering international cooperation to establish frameworks that ensure the peaceful, fair, and sustainable use of outer space resources is crucial.

In sum, **ensuring that space remains a domain for peaceful exploration and mutual benefit rather than a new frontier for conflict will significantly depend on the global community's ability to navigate the complex interplay of technological advancements, regulatory frameworks, economic opportunities, and geopolitical challenges.**

1. Introduction

Although space exploration is full of scientific promise,[1,2] it is not immune to the terrestrial geopolitical conflicts that have characterized human history. As countries compete for territorial claims, resource distribution, and strategic superiority, new tensions are starting to arise as their interests spread into space. For example, as technologies like hyperspectral imaging[3] reveal valuable resources on celestial bodies, competition over these resources will intensify, potentially leading to conflicts. Space technology is expected to be a major economic driver in not-too-distant future, fostering new industries and opportunities,[4,5] from space tourism to lunar and asteroid mining with the global space economy poised to become a multi-trillion-dollar industry, fueled by both governmental and private investments.[6,7]

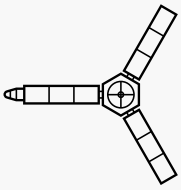
There is also the question of disparities in technological and financial capabilities between spacefaring nation's leading to new dependencies between nations and thus imbalances in global power dynamics. For example, if a certain country controls the technology for asteroid mining, how does this influence global economic power dynamics? This technological gap will exacerbate global inequalities and trigger geopolitical tensions. In addition, the existing frameworks of international space law, including the Outer Space Treaty[8] face challenges in addressing the contemporary realities of space exploration. Issues such as the commercial exploitation of space resources, the liability for space debris collisions, and the militarization of space require updated legal definitions and regulations.[9] The lack of consensus on these updates can lead to legal ambiguities and geopolitical rifts among nations.

So, will these opportunities and challenges spur more collaboration and innovation, advancing space exploration, or will they result in hostile conflicts that impede progress for humanity as a whole?

2. Key Emerging Technologies in Space Exploration

Emerging space technologies have significant geopolitical ramifications and are directly linked to the possibility for conflict and collaboration underscoring the importance of the international community's approach to space governance and regulation of these technologies. Here are a few considerations:

01



Advanced Propulsion Systems like ion thrusters, nuclear propulsion, and solar sails are being developed to enable faster space travel.

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These technologies can shorten travel times and reduce the costs of space missions, increasing the viability of cooperative international trips to celestial bodies.

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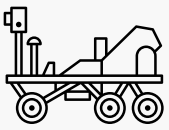
The same technology might be thought to be facilitating quicker military reaction times or space deployment capacities, which could lead to an increase in arms races.

02

Artificial Intelligence and Robotics are critical in navigating and operating in harsh space environments. Autonomous robots can perform high-risk and complex tasks such as drilling, repairs, and geological surveys without direct human intervention redefining geopolitical strategies



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AI and robotics can be applied to cooperative missions for construction, maintenance, and exploration in hostile space settings, and fostering scientific scientific research.

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The use of autonomous systems for military defense and surveillance in space raises the possibility of rivalry and conflict escalation

03

Human Spaceflight and Habitat Technologies are being developed to support long-duration human spaceflights, including life support systems and space habitats. These are crucial for future missions to the Moon and Mars.

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International outposts on the Moon or Mars can be established fostering cooperative science and shared human settlement.

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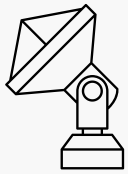
The establishment of exclusive bases by individual nations could lead to territorial claims and conflicts over extraterrestrial land.

04

Hyperspectral Imaging involves capturing and processing images across a wide spectrum of wavelengths and can detect mineral compositions, track atmospheric gasses, and identify military assets and facilities.[3]



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This technology can support international planetary research endeavors and aid in the planning of cooperative extraction projects.

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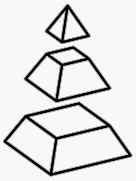
To locate key assets from space, hyperspectral imaging can potentially be utilized for military reconnaissance, which could increase security concerns.

05



Infrastructure Technologies for building infrastructure on the Moon and Mars, such as 3D printing using local materials, are critical for establishing human colonies. These technologies could enable the construction of space habitats and other structures.

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Using local materials to facilitate the building of structures for collaborative bases or research stations on extraterrestrial surfaces.

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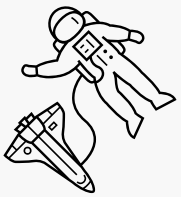
The race to deploy and establish infrastructures could lead to competition over landing sites and resources, especially if not regulated by international agreements.

06



On-orbit Servicing and Manufacturing technologies that enable satellite refueling, repairs, and manufacturing directly in space are becoming viable, potentially extending satellite lifespans, and reducing debris.

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By working together, nations can increase the lifespan of their satellites and other space assets thanks to on-orbit servicing technologies, advancing space sustainability.

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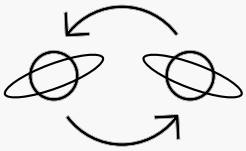
Geopolitical conflicts could arise from the employment of these technologies to interfere with or destroy the satellites of other countries.

07



Quantum Communication technology promises secure communication channels based on the principles of quantum mechanics which would ensure tamper-proof communication, essential for both military and commercial space operations.

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Quantum cryptography-based secure communication can shield data from espionage, guaranteeing secure and safe cooperative space operations.

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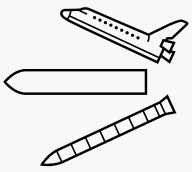
This would also lead to a race in developing communication security technologies and certain countries would use strategies like IP theft, Cybersecurity breaches, etc.

08



Reusable Rocket Technology spearheaded by entities like SpaceX with its Falcon series, is revolutionizing space access by reducing the cost of sending payloads into orbit.

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The reduced cost of access to space makes space more accessible for various nations and organizations, potentially enhancing international collaboration on space projects.

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Lower costs also mean that more nations can participate in space militarization or deploy more assets quickly, which could contribute to orbital congestion and strategic competition.

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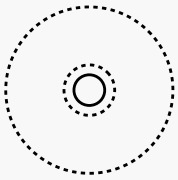

Satellite Constellations include deployment of thousands of small satellites by SpaceX's Starlink and Amazon's Project Kuiper.[15]

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Large constellations can provide global coverage for communications and Earth observation, benefiting international scientific and humanitarian initiatives.

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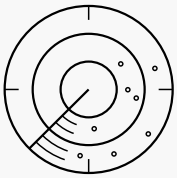
Overcrowding of orbits with large constellations will potentially lead to conflicts over orbital slots and increased risk of collisions.

10

Space Situational Awareness technologies are vital for tracking and managing the increasing number of satellites and space debris in Earth's orbit to prevent collisions and ensure the safety and sustainability of space operations.[14]



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Enhanced tracking and management of objects in space can prevent collisions and promote a sustainable orbital environment through shared situational awareness.

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These surveillance capabilities might also be used for military monitoring and strategic dominance, increasing distrust among space-faring nations.

3. Geopolitical Implications of Advanced Space Technologies

The geopolitical dynamics of space exploration are shaped significantly by the actions and agendas of leading spacefaring nations and entities such as the United States, China, Russia, the European Space Agency (ESA), and more recently India. A few private sector players have also been active in this field as of late.[16] As outlined in EXHIBIT A, different countries have distinct strategic approaches to space technology and defense, reflecting their broader geopolitical ambitions, technological capabilities, and diplomatic strategies. Private corporations also influence international policy and challenge the traditional power structures in space exploration.

As Earth's natural resources dwindle, space presents a virtually limitless reserve of valuable minerals and materials without causing pollution and climate impacts on Earth. Celestial bodies such as the Moon and asteroids are coveted for their rich deposits of rare minerals and Helium-3 ($4B/ton), a promising fuel for future nuclear fusion reactors. However, “Space mining is subject to relatively little existing policy or governance, despite potentially high stakes” with no agreement on how to establish or agree on ownership in space.[17] This competition for access and control over these resources will escalate geopolitical tensions, as nations will assert territorial claims or exclusive rights, challenging the notion of space as a "global commons" established by the Outer Space Treaty. Resources like water on the moon,[18] crucial for life support and fuel, heighten these stakes, mirroring the geopolitical conflicts over Earth-based resources.

Strategic Rivalry

Nations leading in space capabilities will influence international treaties, governance, and secure advantages in defense, surveillance, and economic gains. The strategic rivalry for dominance in space, essential for enhancing military, scientific, and economic power, involves a race for technological superiority, territorial claims on Mars, asteroids, and the

Moon, and control over key orbits and other celestial bodies. As countries and private entities vie for lucrative space resources, issues of sovereignty and resource rights will become forefront. The race to colonize celestial bodies and exploit asteroid resources will heighten tensions without a cooperative international framework. Additionally, many space technologies, with dual civilian and military uses, raise security concerns, particularly as advancements in satellite technology enhance surveillance capabilities.[19]

Weaponization of Space

In the domain of space, these dangers include the potential weaponization of space[20] including ASAT weapons, which can disable or destroy satellites, is particularly contentious, with testing by countries like China, Russia, US, and India stoking fears of a space arms race. Satellites are essential for military operations, providing capabilities for communication, navigation, and surveillance and efforts are being made for protection of these satellites.[21] Disabling a nation's military satellites could severely impair its precision targeting, reconnaissance, and battlefield coordination. Advanced communication and surveillance technologies in space confer strategic advantages, akin to controlling the 'high ground' in military strategy, potentially shifting global power balances, and necessitating new international norms and treaties. These developments not only threaten the safety of space assets but also raise geopolitical and security challenges,[22] escalating tensions and potentially sparking conflicts that transcend Earth's borders. The dual-use nature of many space technologies, serving both civilian and military purposes, further complicates international space governance and exacerbates geopolitical disputes.

Civilian Infrastructure & Financial Risks

Banking systems, power grids, and transportation networks, depend on satellite services. Because satellites are also used for surveillance and espionage, they could lead to geopolitical frictions. Disabling satellites would also lead to widespread civilian disruptions, from the loss of GPS navigation to failures in transaction systems. The economic repercussions of satellite disruptions could be severe, affecting sectors from telecommunications to emergency services. A prolonged outage could result in significant financial losses.[23]

Risk of Wars

As space operations increase, there is a genuine risk of wars over space resources.[24] These wars could be fought on earth or on the celestial bodies that are the cause of conflict. This potential is influenced by multiple factors:

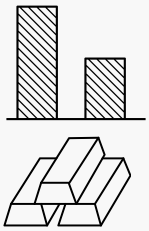
01

Limited High-value Locations: There are areas in space that have a high strategic or economic value, but few are accessible, such as some lunar regions or asteroids rich in precious minerals. In the absence of established international conventions or rules controlling their extraction and usage, competition for these resources will cause tensions and possibly conflicts.

02

Interests Related to National Security: Space capabilities are being incorporated into national security frameworks more and more. National defense goals are entwined with the capacity to access and use space resources, especially the strategic high ground of specific orbits and celestial bodies. This could result in war scenarios when nations believe their security interests are threatened.

03

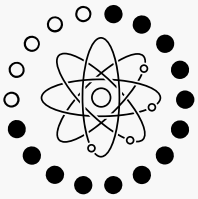


Economic Incentives: Governments and businesses will have substantial financial incentives to claim and protect space resources as commercial space projects become more viable and possibly profitable. Conflicts may result from this, particularly if there are perceived unfairness in the distribution of resources.

04

Legal and Policy Uncertainties: The Outer Space Treaty, which is the main piece of current international space law system, only offers rudimentary foundation for peaceful space utilization. It has vague provisions about the use of space resources, which could lead to misunderstandings and conflict.

05



Technology Proliferation: As a result of technological advancements, an increasing number of countries and commercial organizations can participate in space activities. As more organizations compete for the same resources, this proliferation may result in heightened rivalry and possible confrontations.

4. Strategic Recommendations

Since the Outer Space Treaty was signed in 1967, the international community has made limited progress at restricting the testing, deployment, and use of weapons in outer space. As space technologies transition from instruments of scientific exploration to pivotal platforms of geopolitical competition and economic opportunity, there is a growing risk that individual national interests will overshadow and stall collective advancements complicating the trajectory of humanity's future in space. To address these challenges and help unify global visions for space exploration, the following recommendations are proposed:

Strengthening Public-Private Partnerships

Public-private partnerships (PPPs) in space exploration can not only boost technological and economic development but also play a crucial role in maintaining global cooperation and peace in outer space activities.

i. Public-private partnerships can harness the innovative capabilities of the private sector[25] and often involve multi-national corporations that can act as bridges between different governmental space agencies helping **expand international cooperation.** This cooperation can help harmonize interests among countries, reduce the potential for conflict over orbital slots or lunar landing sites, and establish common goals for space exploration and utilization.

ii. Exploration of space is costly and risky. Through PPPs, public and private organizations can **share operational, technological, and financial risks.** This can draw greater support and stabilize relations between participating nations in joint ventures by making ambitious initiatives more viable and sustainable.

iii. PPPs can encourage more environmentally friendly methods of space exploration by enlisting the private sector. The need for profit in the private sector pushes for the development of technology that can **improve the sustainability of space activities,** including reusable spacecraft.

iv. Government-industry partnerships in space initiatives can stimulate new space-related sectors including satellite manufacturing, space tourism, and asteroid mining, as well as high-tech jobs. Due to its mutually beneficial nature, this **economic incentive can assist reduce geopolitical tensions** by discouraging conflict.

International Collaboration

In response to these challenges, global cooperation and dialogue are imperative. Nations with advanced space capabilities must champion and adhere to international treaties that promote the peaceful use of space and support sustainable practices, such as minimizing space debris and responsibly deorbiting satellites. The International Space Station (ISS) is a prime example of international cooperation in space. It brings together the scientific capabilities and resources of multiple countries, including the U.S., Russia, Japan, Canada, and ESA member states, to conduct research that no single country could economically or logistically support alone. Cooperation can accelerate scientific discovery, spread costs, and foster peaceful relations between participating nations. And while competition can drive innovation and reduce costs, excessive nationalistic rivalry in space can lead to duplication of efforts, increased debris risks,[25.1] and heightened tensions that might obstruct international agreements on space governance.

Regulatory Overhaul

The existing international legal frameworks,[26] such as the Outer Space Treaty, are increasingly challenged to address the contemporary realities of space exploration, such as commercial space ventures and resource extraction. As we stand on the brink of significant technological advancements in space, we confront immediate challenges in space traffic

management, space debris mitigation, militarization, and frequency spectrum allocation. Without a consensus on updating these laws which are inadequate, ambiguities may persist and lead to conflicts. These challenges fuel regulatory and geopolitical debates that call for proactive diplomacy and updated legal frameworks to accommodate new realities such as space mining, planetary defense, and autonomous robotic systems. Modernizing legal frameworks to accommodate new activities such as space tourism, mining, and private space stations is essential to maintain orderly and responsible space activities. Strengthening or establishing new international frameworks can help guarantee the fair and peaceful use of these resources. Below are a few regulatory changes to think about:

i. To prevent collisions and effectively manage the increasing number of satellites in orbit, an **international convention on space traffic management** should be established. This convention should outline protocols for satellite routes, plans for minimizing debris, and national collaboration. To do this, international conferences comprising of nations that have space exploration capabilities, commercial space companies, and scientific communities may be convened to negotiate agreements and establish a framework for global information sharing and monitoring.

ii. To prevent the overexploitation of celestial bodies, the **Outer Space Treaty should be updated** to include rules for resource extraction, a description of resource sharing, and environmental guidelines. To guarantee sustainable practices and fair access for all countries, legislative framework that governs the extraction and use of space resources, such as minerals from asteroids or water from the moon should be created.

iii. Establish an **international code of conduct** for the development, testing, and use of ASAT technology to prevent space militarization and ensure the long-term sustainability of space activities. Establish a treaty that would include no-first-use agreements on ASAT technologies, transparency measures for testing ASAT weapons, and sanctions for offenders. The can be carried out through the United Nations Office for Outer Space Affairs (UNOOSA).

IV. Encourage and support **international collaboration on joint projects to eliminate and reduce space trash,** including funding for creative approaches to safely deorbit abandoned spacecraft and debris. Create a global fund to support organizations and countries developing technologies for debris removal, supported by businesses and spacefaring states; encourage the sharing of ideas and best practices.

V. Implement worldwide guidelines for the design, operation, and decommissioning of satellites with focus to decrease space trash and improve the safety of space activities. **Establish regulations requiring deorbit systems** or other end-of-life plans for all new satellites. These regulations should be enforced by national and international space organizations.

Establish an **international code of conduct** for the development, testing, and use of ASAT technology to prevent space militarization and ensure the long-term sustainability of space activities. Establish a treaty that would include no-first-use agreements on ASAT technologies, transparency measures for testing ASAT weapons, and sanctions for offenders. The can be carried out through the United Nations Office for Outer Space Affairs (UNOOSA).

R&D Investments Targeted to Address these Challenges

Addressing the growing density of space operations is vital for maintaining safe and sustainable orbital environments. This includes implementing advanced tracking systems to manage the increasing number of satellites and prevent collisions, particularly with the rise of satellite mega-constellations. Further research is needed into the effectiveness of Space Surveillance and Tracking systems. Investments and government incentives including grants can be targeted to address the issue of space junk for example. Governments should boost funding for public research institutions and incentivize private innovation through grants and partnerships.

Education

Education is equally important; investing in STEM education[27] at all levels will develop a skilled workforce capable of not just advancing but also better understanding space technology implications.

Conclusion

While the challenges are significant, strategic management of space resources and technologies can foster a future where space technology advances human progress. The strategic implications of space technologies profoundly influence global power dynamics, and the interplay of emerging technologies with geopolitical competition necessitates a balanced approach that embraces technological innovation, strategic foresight, and international cooperation. This will ensure space remains a competitive yet cooperative arena for all humanity. Through integrated efforts in collaboration, regulation, innovation, and education, we can ensure robust leadership and sustainability in the space sector.

To ensure that space stays a place of cooperation rather than confrontation, there is work to be done, lots of it, and then some....

EXHIBIT A: SPACE AGENDAS - A COMPARATIVE STUDY [14,28,29,30]

UNITED STATES $53.9B (2024)

APPROACH

Alliance building, manned missions, deep space exploration, partnerships with the private sector. Innovation in both military and civilian space technologies.

KEY ACCOMPLISHMENTS

First Moon landing, Space Shuttle, Mars Rovers.

FUTURE AGENDAS

Artemis program[12] to put humans back on the moon by 2025 & long-term presence by the end of the decade. Gateway space station in lunar orbit supporting long-term human habitation on the moon and acting as a staging area for deep space exploration.[31] Mars missions.

CHINA $10-13B (2022)

APPROACH

Historically operated more independently in space, beginning to seek international partnerships. Development of both autonomous and manned capabilities, space station development.

KEY ACCOMPLISHMENTS

Chang'e Moon landings, brought lunar samples to Earth, Beidou Navigation System, Tiangong space station

FUTURE AGENDAS

With Tianwen-1 orbiter and rover mission to Mars build capacity to run missions beyond Earth orbit. Manned Moon landing, expand satellite launches, research the Martian soil and environment.

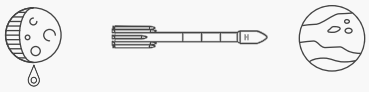
INDIA $1.91B (2022)

APPROACH

Developed several indigenous launch vehicles. Cost-effective, innovative missions with high success rates.

KEY ACCOMPLISHMENTS

Chandrayaan-3 became 1st probe to land near lunar south pole in Aug 2023, Mars Orbiter Mission, reliable satellite launch services.



FUTURE AGENDAS

More advanced missions, aimed at further lunar exploration, and a mission to study the Sun. Manned spaceflight (Gaganyaan), increase commercial launches.

RUSSIA $3-3.5B (2022)

APPROACH

Wants to preserve its historical reputation as a pioneer in space exploration. Manned spaceflight, and international satellite launch market.

KEY ACCOMPLISHMENTS

Historical first human and satellite in space, significant player in commercial launches and ISS contributions. Recent setbacks with Luna 5 lunar mission.

FUTURE AGENDAS

Investigating Moon and Venus for possible resource extraction. Despite financial limitations wants to showcase the dependability and development of Russian space technology.

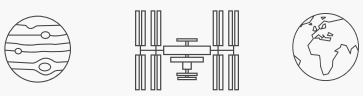
EUROPEAN UNION €16B (total 2021-2027)

APPROACH

Collaborative projects focusing on scientific research, satellite navigation, and earth observation. Partnership with Artemis.

KEY ACCOMPLISHMENTS

Leadership in Copernicus and Galileo programs, major contributions to ISS, pioneering earth observation missions.



FUTURE AGENDAS

Participating in the Lunar Gateway, partnered with Roscosmos to look for indications of life on Mars. Key contributor to the Gateway, including habitat modules and the service module for the Orion spacecraft. sustainability in space activities, expansion of satellite navigation systems

REFERENCES

1. Economic Impact of Space Technologies Euroconsult (2023)
   https://www.euroconsult-ec.com/press-release/value-of-space-economy-reaches-424-billion-in-2022-despite-new-unforeseen-investment-concerns-2
2. Future of Space Tech and its Benefits to Humanity
   https://global.upenn.edu/sites/default/files/perry-world-house/space-ben-itzhakthoughtpiece.pdf
3. Hyperspectral Imaging Satellites
   https://ieeexplore.ieee.org/document/9463743
4. 3 Ways the Private Sector is Changing the Space Industry
   https://www.uschamber.com/on-demand/space/3-ways-the-private-sector-is-changing-the-space-industry
5. Who owns the moon owns the future
   https://www.wbur.org/onpoint/2023/09/25/moon-planets-space-travel-united-states-race
6. Things Are Looking Up for Asteroid Mining
   https://www.wired.com/story/things-are-looking-up-for-asteroid-mining
7. DARPA is exploring ways to build big things in space
   https://www.space.com/darpa-us-military-space-manufacturing
8. Outer Space Treaty
   https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html
9. Space Law is Inadequate
   https://www.economist.com/international/2019/07/18/space-law-is-inadequate-for-the-boom-in-human- activity-there
10. Autonomous Systems Help NASA's Perseverance Do More Science on Mars
    https://www.nasa.gov/missions/mars-2020-perseverance/perseverance-rover/autonomous-systems-help-nasas-perseverance-do-more-science-on-mars-2
11. China And Russia Test Quantum Communication Link
    https://thequantuminsider.com/2024/01/02/report-china-and-russia-test-quantum-communication-link
12. Artemis
    https://www.nasa.gov/feature/artemis
13. The World Factbook – Space Programs
    https://www.cia.gov/the-world-factbook/references/space-programs
14. The Space Briefing Book
    https://www.spacefoundation.org/wp-content/uploads/2019/10/SpaceFoundation_Space101.pdf
15. https://www.newscientist.com/article/2395991-amazon-is-launching-its-first-internet-satellites-to- rival-starlink
16. The Role of Private Companies in Advancing Space Exploration Initiatives
    https://spacevoyageventures.com/space-exploration-initiatives

17. Governance in Space: Mining the Moon and Beyond
https://www.rand.org/pubs/commentary/2022/11/governance-in-space-mining-the-moon-and- beyond.html

18. Chandrayan -1 Moon Impact Probe
https://science.nasa.gov/mission/chandrayaan-1

19. The dual-use nature of satellites and their impact on international relations are analyzed in the book “Space Warfare and Defense” by Bert Chapman, which discusses how satellite technologies influence global security dynamics (Chapman, Bert. “Space Warfare and Defense.” ABC-CLIO).

20. Space Weapons
https://aerospace.csis.org/wp-content/uploads/2020/05/Harrison_IntlPerspectivesSpaceWeapons-compressed.pdf

21. US Strategy on Protection of Satellites
https://media.defense.gov/2023/Sep/14/2003301146/-1/-1/0/COMPREHENSIVE-REPORT-FOR- RELEASE.PDF

22. National Security and Space Technologies:
https://www.csis.org/analysis/space-threat-assessment-2024

23. Riding the exponential growth in space
https://www2.deloitte.com/us/en/insights/industry/aerospace-defense/future-of-space-economy.html

24. Space as Warfighting Domain: Issues for Congress (treaties aimed at preventing conflict)
https://crsreports.congress.gov/product/pdf/IF/IF11895

25. Space Foundation Report
https://www.spacefoundation.org/2023/10/23/the-space-report-2023-q3

25.1. Space Debris
https://www.washingtonpost.com/opinions/interactive/2023/space-junk-debris- removal/?itid=hp_opinions_p003_f001

26. A Strategic Framework for Space Diplomacy
https://www.state.gov/wp-content/uploads/2023/05/Space-Framework-Clean-2-May-2023-Final- Updated-Accessible-5.25.2023.pdf

27. The National Science Foundation outlines strategies and programs to strengthen STEM education
https://ncses.nsf.gov/interest-areas/stem

28. China's Chang'e 5 mission returns Moon samples
https://www.bbc.com/news/science-environment-55160768

29. Russia plans to launch own space station after quitting ISS
https://www.reuters.com/lifestyle/science/russia-plans-launch-own-space-station-after-quitting-iss-2021- 04-21

30. European Space Agency: ExoMars and Lunar Missions
https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/ExoMars

31. https://www.nasa.gov/mission/gateway
https://science.nasa.gov/mission/chandrayaan-1

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