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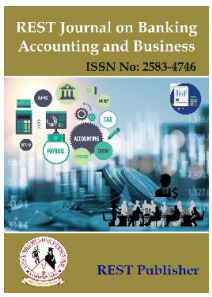

A Descriptive Study on- Scope of Space Research for Start-up With Reference to Indian Space Research Opportunities

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Abstract: *The space research scene in India is on the rise, and this study takes a closer look at what's happening. We explore how big the space research market is, what's making it grow, and who the key players are. In India, space research is booming thanks to cool projects and better technology. We check out the main players, from new start-ups to the big research centres, and see how they're making their mark in this busy space. The city is home to lots of space research spots, each doing different things like making satellites and exploring outer space. We look at the city's tech strengths and skilled pros, predicting that India is all set for more growth and cool stuff in space research. This study gives you a peek into what's happening now and what's in store for India as it becomes a major player in India's space exploration dreams.*
Key Words: *Space Research, Start-Ups, Innovations, Entrepreneurship, Collaborations.*

1. INTRODUCTION

The cosmos, with its boundless mysteries and unexplored frontiers, has long captivated the imagination of humanity. In recent decades, the realm of space exploration has witnessed a transformation, with a shift from the exclusive domain of major space agencies to a more inclusive arena welcoming the participation of start-ups. This shift is not merely a change in the cast of characters; it signifies a fundamental reimagining of how we approach and conduct space research. In the midst of this paradigm shift, India, with its rich history in space exploration, emerges as a focal point for burgeoning start-ups seeking to make their mark in the cosmic narrative. The title, "Scope of Space Research for Start-ups With Reference to Indian Space Research Opportunities," encapsulates a multifaceted exploration into the dynamic and evolving landscape of space research. This comprehensive inquiry will unfold across the following sections: The journey into the cosmos has undergone significant evolution over the years. From the early space race to the collaborative ventures of the International Space Station (ISS), we have witnessed a transition from competition to cooperation. This section will delve into the historical context of space exploration, highlighting key milestones, paradigm shifts, and the emergence of a new era marked by collaboration and inclusivity. As space exploration moved beyond the confines of government agencies, a new breed of space pioneers emerged—start-ups. This section will explore the factors that contributed to the rise of start-ups in space research. It will delve into the entrepreneurial spirit that seeks to challenge traditional norms, the infusion of private capital into space ventures, and the democratization of access to space.

India's space program, spearheaded by the Indian Space Research Organisation (ISRO), has carved a niche for itself on the global stage. This section will provide an in-depth analysis of India's contributions to space exploration, ranging from the successful Mars Orbiter Mission (Mangalyaan) to advancements in satellite technology. Understanding the existing landscape is crucial for envisaging the opportunities and challenges for start-ups in the Indian space sector. The heart of our exploration lies in understanding the vast opportunities that

await start-ups in the Indian space research sector. From satellite technology to interplanetary missions, this section will dissect the various avenues where start-ups can contribute meaningfully. It will also shed light on government initiatives, collaborative programs, and funding opportunities that act as catalysts for start-up engagement. In the pursuit of cosmic aspirations, challenges are inevitable. This section will provide a nuanced examination of the hurdles and considerations that start-ups might encounter in the Indian space research landscape. Regulatory frameworks, technological barriers, and market dynamics will be scrutinized to offer a comprehensive understanding of the road ahead. Learning from real-world examples is a cornerstone of informed decision-making. This section will present case studies of successful start-ups in the Indian space research ecosystem. These case studies will illuminate the diverse trajectories that start-ups can take, showcasing innovation, resilience, and adaptability. Space, by its very nature, transcends borders. This section will explore the potential for Indian start-ups to engage in collaborative ventures and international partnerships. It will analyze existing collaborations, such as those with NASA and other global space agencies, and delineate how such partnerships can propel Indian start-ups onto the global stage.

The future of space research is inherently tied to innovation and forward-looking endeavors. This section will cast a gaze into the future, envisioning the trajectories that the Indian space research sector might take. It will explore emerging technologies, novel mission concepts, and the role that start-ups can play in shaping the narrative of space exploration. As we navigate the expansive realms of the cosmos, this exploration into the scope of space research for start-ups within the context of Indian space research opportunities is not just a theoretical exercise; it is a roadmap for aspiring space entrepreneurs. It is an invitation to partake in the cosmic dance, contributing unique notes to the symphony of human exploration. The convergence of history, technology, and entrepreneurial spirit creates a canvas upon which start-ups can paint their visions of the cosmic future. This comprehensive analysis aims to equip potential space pioneers with the insights, knowledge, and inspiration needed to embark on a journey that extends far beyond our earthly confines. Welcome to the cosmic frontier, where the possibilities are as infinite as the universe itself. Now, let's dive a bit deeper into what this title really means. Imagine you're embarking on a grand adventure, but this adventure isn't on Earth—it's in space. The title, "Scope of Space Research for Start-ups with Reference to Indian Space Research Opportunities," is like an open invitation for small and new businesses to join in the excitement of exploring space. Think of it as an opportunity for start-ups to bring their fresh and smart ideas to the world of space exploration. It's not just about big organizations; it's a chance for start-ups to add their unique touch to the wonders of space. India, with its impressive space contributions, becomes a vibrant stage for start-ups to shine in the cosmic show. This exploration isn't just about learning facts; it's about inspiring a whole new generation of space pioneers to dream big and reach for the stars. So, get ready for an adventure where the possibilities are as vast as the universe itself, and start-ups are invited to write their own stories in the cosmic saga. Welcome to a journey where space and business come together, creating endless opportunities in the cosmic unknown.

2. METHODOLOGY

It is a descriptive study. Descriptive study often involves combining existing knowledge, reviewing literature, and developing theoretical frameworks instead of collecting new data through observation or experimentation. By studying various research papers from different countries like India, Pakistan, Germany, USA, Poland, UAE, China, and more, this study aims to bring together ideas from all around the world. It's like building a big picture using puzzle pieces from different places. The research wants to add about the Scope of Space Research for Start-up with Reference to Indian Space Research Opportunities.

Objectives:

- To study the advancement in the space research by various countries.
- To find out opportunities for startup with regard to space research.
- To conduct SWOT analysis for private entrance in space sector.
- To examine existing and potential collaborations between Indian space research startups and international space agencies.
- To analyze the market demand for space-related products and services in India.

3. HISTORICAL BACKGROUND

India's venture into space research started with the Indian National Committee for Space Research (INCOSPAR) in 1962, laying the groundwork for what later became the Indian Space Research Organisation (ISRO) in 1969. India's first satellite, Aryabhata, was launched by the Soviet Union in 1975. This marked India's entry into space research.Dr. Vikram Sarabhai, a key figure, played a crucial role in this early phase. The 1980s saw India launching its own satellites, like Rohini Satellite, using the Satellite Launch Vehicle (SLV) and introducing the Polar Satellite Launch Vehicle (PSLV) in the 1990s. These advancements allowed India to enter the global space arena.

In the early 2010s, India's missions to the moon (Chandrayaan) and Mars (Mangalyaan) gained international acclaim for their efficiency and cost-effectiveness. The development of the Geosynchronous Satellite Launch Vehicle (GSLV) and GSLV Mark III expanded India's capability to launch heavier payloads into geostationary orbits. Furthermore, the 1990s marked a shift, opening India's space sector to private industry, paving the way for space research start-ups to play a significant role in the nation's space exploration journey. Antrix, the commercial arm of ISRO, successfully facilitated satellite launches for international clients, establishing India's presence in the global satellite launch market.

Opportunities for Start ups in Indian Space Research:

1. **Launch Services:** Startups can explore opportunities in providing launch services, such as developing small satellite launch vehicles or offering payload space on existing launch vehicles like PSLV or GSLV.
2. **Satellite Development:** There is a growing demand for small and microsatellites for various applications like Earth observation, communication, and scientific research. Startups can design and build satellites to cater to these needs.
3. **Ground Stations and Communication:** Establishing ground stations for satellite communication and data reception is another potential area. This includes tracking, telemetry, and control (TT&C) systems.
4. **Data Analytics and Remote Sensing:** Utilizing satellite data for applications in agriculture, forestry, disaster management, and urban planning can be lucrative. Startups can develop data analytics tools and platforms.
5. **Space Technology and Components:** Innovations in space technology components, such as propulsion systems, materials, and sensors, are essential for the space sector's growth.
6. **Space Tourism and Exploration:** While in its nascent stages, space tourism and asteroid mining are emerging opportunities that startups can explore.
7. **Space Policy and Regulation:** Given the complexities of the space domain, startups can provide services related to space policy, regulation, and space debris management.
8. **Education and Outreach:** Promoting space education and awareness through online courses, workshops, and outreach programs can be a niche yet impactful field.
9. **Venture Capital and Funding:**There's a growing interest from venture capitalists and investors in space-related startups. Entrepreneurs can explore opportunities for raising funds and supporting innovative space ventures.
10. **International Collaborations:** Partnering with international space agencies and organizations can open up new avenues for startups in research, development, and technology exchange.

Political, Economic, Social, Technological, Environmental and Legal Aspects (PESTEL):

Political aspects–In recent years, the Indian government has taken significant steps to support space research start-ups. The establishment of "NewSpace India Limited" (NSIL) in 2019 serves as a crucial initiative under the Department of Space, focusing on commercializing space products and technologies developed by ISRO. The forthcoming "Space Activities Bill" aims to provide a regulatory framework for private sector involvement in space exploration, ensuring clarity and legal support for space start-ups. Additionally, initiatives like the "International Cooperation Program" emphasize the government's commitment to fostering global collaboration, offering opportunities for knowledge exchange and joint ventures for Indian space research start-ups.

Economical aspects- India's space research offers startup opportunities with a growing market, affordable technology, and collaboration prospects with ISRO. Global demand for satellite services and data analytics from space presents practical applications. Startup-friendly regulations, a skilled workforce, and available

infrastructure make India's space industry accessible. Investment avenues and growing green initiatives enhance the startup environment. This aligns with global sustainability trends, allowing ventures to address environmental challenges. International collaborations position India as a key player in the global space industry, fostering economic growth and innovation.

Social aspects- Space startups in India bring social benefits by inspiring youth, fostering national pride, and creating specialized jobs, enhancing the economy. Their collaboration with other nations and data-sharing aid disaster response, gaining public support. The acquired knowledge holds cultural significance. Inclusivity and community involvement are crucial. Successful startups contribute not only to national pride but also generate skilled employment, stimulating economic growth. Their global collaboration and social responsibility extend beyond technology, addressing significant global challenges. These startups serve as a force for positive change, showcasing the dual role of advanced technology and social impact.

Technological aspects-Indian space startups emphasize technological advancements, focusing on smaller, efficient satellites and smart data tools. Improving communication, navigation, safety, and security is a priority. Startups also prioritize eco-friendly solutions, aligning with global standards for sustainable space exploration. By integrating new technologies and maintaining environmental consciousness, these startups contribute not only to technological progress but also to responsible and sustainable space practices, emphasizing a balance between innovation and environmental stewardship.

Environmental aspects-Environmental responsibility is crucial for Indian space startups. They focus on reducing space debris and adopting eco-friendly propulsion systems and solar power. Energy-efficient spacecraft made with green materials are prioritized. These startups actively monitor Earth's environment, study climate change, and explore space resources responsibly. Following global sustainability standards ensures ethical space research practices. Additionally, their role extends to Earth observation, weather monitoring, and resource exploration, contributing to a more sustainable and responsible approach in space exploration.

Legal aspects-Legal considerations are crucial for space research startups in India. They must adhere to national regulations and ISRO's licensing requirements while complying with international treaties. Liability insurance is necessary for potential damages, and safeguarding intellectual property is vital. Startups need awareness of export controls and data privacy laws. Environmental regulations and national security can impact operations, emphasizing the need for clear contracts and effective risk management. Additionally, startups must navigate rules regarding information sharing and environmental responsibility, ensuring compliance for safety and ethical conduct.

4. LITERATURE REVIEW

The study conducted by Hussain *et. al.*(2023) emanates from affiliations with "NUST Business School (NBS), National University of Sciences and Technology (NUST), Islamabad, Pakistan" and "National Defence University, Islamabad, Pakistan," strongly indicating its Pakistani origins. This research was conducted in Pakistan, focusing on India's advancements in space technology, especially Anti-Satellite (ASAT) capabilities. The findings offer crucial insights for startups looking at collaboration or competition in the South Asian space environment. Understanding India's role in space exploration is essential for startups considering space-related ventures, providing valuable insights into opportunities and challenges. The study explores variables like Space Exploration, Anti-Satellite Tests, Strategic Balance, India's Hegemony Quest, Military Space Assets, Space Governance, and Commercialization of Space. It also delves into historical events shaping India's space aspirations and adopts a comprehensive methodology, analyzing various aspects of global outer space exploration, India's progression, historical perspectives, and its impact regionally and globally.

Fogtman,A., *et. al.*(2023). (2023). In a comprehensive study conducted across esteemed institutions in Europe, including the European Space Agency in Cologne, Germany, and others, authors Fogtman, A., Baatout, S., Baselet, B., Berger, T., Hellweg, C. E., Jiggens, P., and Durante, M. (2023), shed light on the growing significance of space radiation exposure as human space exploration ventures into deep space, including lunar and Martian missions. The research finds the complex and risky nature of deep space radiation, driven by Galactic Cosmic Rays (GCR) and Solar Particle Events (SPEs), posing substantial health risks to astronauts and electronics. The objective is to tackle these challenges, a comprehensive strategy about space weather assessment, radiation shielding, dosimetry, radiobiology, risk assessment, and space medicine is essential. Startups are assured to play a pivotal role by innovating in areas like monitoring technology, space weather

prediction, shielding solutions, and radiation-resistant electronics, thus advancing human space exploration and capitalizing on emerging commercial opportunities.

This study was Conducted across European Space Agency (ESA) facilities in Italy, Germany, and France, this study, led by Pagnini,F *et. al.*(2023)., The study focuses on psychological challenges for astronauts on deep space missions, presenting a strategic entry point for Indian space startups. This offers innovation opportunities, especially in psychological support systems utilizing virtual reality and artificial intelligence for astronaut well-being during extended missions. Aligned with Indian space startup objectives, the study explores addressing psychological and social challenges during Moon and Mars missions. Startups can contribute through advanced mental health support, stress management tech, and virtual reality interventions, enhancing astronaut well-being. By aligning with these objectives, Indian startups not only contribute to space missions but also find applications in healthcare, remote work support, and high-stress industries, with collaborations amplifying global impact.

Klimburg-Witjes, N. (2023) finding Europe's pursuit of space autonomy through initiatives like the collaborative Ariane rocket program, involving countries such as France, Germany, the UK, and French Guiana. It examines differing opinions on whether to maintain broad cooperation or form narrower partnerships. The study underscores the growing importance of space for Europe's security and global role, transcending mere exploration. However, it highlights the challenge of decision-making due to varying national interests. Additionally, striving for space autonomy prompts Europe to foster innovation and technology. This focus holds significant implications for Europe's future actions in space. The study's objective, addressing psychological and social challenges faced by astronauts during deep space missions, also offers insights for Indian space startups seeking to develop solutions that enhance astronaut well-being and performance, with potential terrestrial applications in healthcare and high-stress industries.

This study, conducted by Rathnasabapathy,M.; *et. al.*(2023) is possibly in collaboration with the World Economic Forum (WEF), the study introduces the Space Sustainability Rating (SSR) to evaluate sustainable practices in space activities, addressing concerns about their long-term sustainability. It emphasizes the need for sustainable practices due to substantial growth in space activities. The study aims to guide space activities for a long time, especially considering the significant growth in India. It advocates for environmentally friendly practices in space. Indian space startups can learn from this study, adopting practices that ensure long-term benefits. The SSR tool is highlighted as a way to check if space activities align with good practices and environmental considerations. Indian startups can use this tool and adopt responsible and sustainable approaches, showcasing their commitment to ethical space research. The study outlines the design and development methodology of SSR, emphasizing the integration of regulatory norms and best practices, providing a framework for space actors to demonstrate their commitment to sustainability.

This study was conducted by Kawakatsu,Y *et. al.*(2023). This study involves collaboration among space agencies from various countries, including JAXA (Japan Aerospace Exploration Agency), NASA (National Aeronautics and Space Administration), CNES (Centre National d'Études Spatiales), ESA (European Space Agency), and DLR (German Aerospace Centre). The study focuses on the Martian Moons exploration (MMX) mission, launching in 2024, with key objectives. MMX aims to uncover the origins of Mars' moons, Phobos and Deimos, akin to Indian space research startups exploring planetary formation and the solar system's evolution. Indian startups analyse space materials and study changes over time in space and on celestial bodies, contributing to future space missions and technology advancement. MMX tests innovative concepts and explores Phobos as a potential base. Both MMX and Indian startups share a common mission: unravelling space's mysteries, understanding the solar system's history, and advancing space exploration collaboratively.

This study was conducted by Balcerzak,T. (2023). In the past few decades, Poland has made significant strides in its space sector, with collaborative efforts at the core of its achievements The evolution in space research involves significant contributions from various sectors like aviation, defense, and information technology. Poland's key partnership with the European Space Agency (ESA), including agreements like the European Cooperating States (PECS), has played a pivotal role. Through PECS, Polish entities have collaborated on projects totaling around 11.5 million euros with ESA, enhancing their capabilities in space technologies. Full membership in ESA since 2012, marked by an annual premium payment of approximately 30 million euros, has further opened doors for Polish companies and research centers to engage in various ESA programs, spanning Earth observation, navigation, and telecommunications. In India, the thriving startup landscape in space

research, particularly in satellite technology, leverages substantial knowledge from sectors like aviation, defense, and information technology. Collaboration opportunities with entities such as the Indian Space Research Organisation (ISRO) and international space agencies provide them with avenues to contribute to space exploration and technology advancement.

This study was conducted by D. Rapagnani *et. al.*(2023), in a collaborative effort between European Recoil Separator for Nuclear Astrophysics ERNA and the Italian Aerospace Research Centre (CIRA), researchers embarked on a mission to develop a unique Supersonic Plasma Jet (SPJ) setup capable of using various gases. Their objective was twofold: investigate particle interactions under extreme conditions and test materials' resilience to hot, unconventional gases, crucial for space-related applications. Using advanced simulations and plasma generation experiments, they achieved remarkable results, transforming gases into electrically charged ions. Higher pressure helium required more heating. Meticulously designed nozzles ensured controlled gas release. Validating models with real-world data demonstrated practicality. This study enhances understanding of gases at high temperatures, crucial for space and nuclear astrophysics. India's space startups can learn—innovation through collaboration, intelligent tech use, and cost-effective solutions by leveraging resources. This mirrors the study's successful approach.

This study was conducted by Callsen,S. *et. al.*(2023). This study, conducted in Germany, could reveal some important insights. This study delves into how reusable rockets could revolutionize Earth travel, comparing SpaceLiner 7 and SpaceX's Starship for high-speed efficiency. Clever route optimization is proposed, addressing noise concerns and avoiding crowded areas. Technical challenges, like handling extreme heat and stress, prompt considerations for future rocket designs. The study also explores the transformative impact of rapid rocket trips on work and leisure travel. For Indian space startups, it signals opportunities for innovative space tech and emphasizes the need for cost-effective solutions. Partnerships for reusable rocket tech development and a focus on eco-friendly practices align with the study's objectives, offering avenues for Indian startups in space research.

This study was conducted by Choudhury,B. *et. al.*(2023) in various places like the University of Florida in the USA and Technological University of Panama, found some important stuff. This study ensured effective bacteria recovery from materials and highlighted the Atmospheric Pressure Plasma System (APS) as a quick, chemical-free solution for eliminating harmful bacteria on metal and fabric. Optimization efforts, such as adjusting machine components, demonstrated improved performance. The study emphasized energy efficiency, with the APS requiring about 13.2 Watts of power, making it relevant for sustainable space missions. It addressed concerns of heat and humidity in the machine, ensuring compatibility with fabric. The research emphasized the importance of preserving materials in space missions. For Indian space startups, this study offers insights into innovative technologies like APS for space cleaning, encourages eco-friendly practices, and prompts considerations for material durability in space missions, fostering ideas for exploration and sustainability.

D. Brain*et. al.*(2022). The study conducted in the United Arab Emirates (UAE) examines various aspects of spacecraft performance and maneuvers related to Mars exploration. These findings hold valuable lessons and opportunities for Indian startups in the space exploration sector. Firstly, the UAE's focus on training scientists and engineers can inspire India to nurture talent for innovative space-related endeavors. Secondly, emphasizing robust technological infrastructure, as seen in the UAE's efforts, can guide Indian startups in enhancing their competitiveness. Thirdly, the importance of international partnerships in the UAE's objectives can encourage Indian startups to collaborate globally. Strengthening academic programs, as highlighted, can ensure a skilled talent pool for Indian startups. Lastly, knowledge transfer and technology spin-offs can motivate Indian startups to explore commercialization avenues, fostering growth in the space sector. The study primarily explores interplanetary spacecraft, science instruments, launchpads, scientific probes, and space centers, offering insights applicable to Indian startups. The methodology involves a comprehensive overview of the Emirates Mars Mission, outlining its alignment with UAE government objectives and emphasizing its contributions to understanding Martian atmospheric dynamics and climate.

Batori,E.; et. al..(2021) The article, conducted at the Institut de Physique, Université de Neuchâtel in Switzerland, offers a comprehensive exploration of atomic frequency standards (AFS), with a specific focus on their applications in space, particularly within Global Navigation Satellite Systems (GNSS). It traces the historical evolution of AFS since their inception in 1955, highlighting their increased significance following the

redefinition of the SI second in 1967. The article categorizes AFS into primary frequency standards, including highly precise cesium-based standards, and alternative AFS technologies prioritizing long-term stability. It delves into key AFS like thermal cesium beam, hydrogen maser (H-maser), and rubidium atomic frequency standard (RAFS), discussing their roles in industrial and space-related advancements. The requirements for space AFS (SAFS) are outlined, emphasizing the need for compactness, lightweight design, radiation resilience, reliability, and GNSS-grade stability. Various SAFS technologies, such as RAFS, cesium beam frequency standard, hydrogen maser, and mercury trapped ions (199Hg+), are reviewed, highlighting their strengths and limitations. The article underscores the critical role of GNSS applications, driving the demand for stable and radiation-resistant clocks, and it explores ongoing trends in SAFS development, including efforts to reduce size, cost, and power consumption while enhancing clock performance for improved GNSS accuracy. The publication's core objective is to provide insights into the landscape of GNSS-grade or superior Space Atomic Frequency Standards (SAFS), making it a valuable resource for Indian startups aiming to align their efforts with the evolving demands of the space industry.

Blakey milner,B.; *et. al.*(2021) The article, a collaborative effort among researchers from various institutions worldwide, delves into the growing significance of metal additive manufacturing in the aerospace industry. Conducted across research groups in South Africa, the United States, Germany, Australia, and Norway, the study underscores the technology's potential for cost reduction, faster production, innovative materials, lightweight designs, and efficient component consolidation. It surveys the current state of metal additive manufacturing by drawing insights from diverse sources, emphasizing its commercial and technical advantages in critical aerospace applications like rocket engines, satellite components, and heat exchangers. Furthermore, it recognizes the challenges while pinpointing opportunities for further development in each specific scenario. For Indian startups, this article offers valuable insights into cost-effective manufacturing, accelerated production, lightweight engineering, and practical aerospace market entry points. It serves as a comprehensive guide for leveraging metal additive manufacturing's potential in the aerospace industry, encouraging proactive engagement with industry-specific challenges and opportunities.

Wang,L.; *et. al.*(2021) This article, authored by Wang, Feng, Pong Wong, and Zhang, presents findings that focus on the factors influencing tourists' intentions toward space-launch tourism activities at China's Wenchang spacecraft launch site. The study identifies a positive relationship between tourists' attitudes and their intention to participate, highlighting that a favorable outlook on space-launch tourism increases the likelihood of expressing the intention to participate. Moreover, the influence of subjective norms, driven by significant others, positively impacts both attitudes and intentions, enhancing tourists' overall positive views and their willingness to participate. Additionally, perceived behavioral control, reflecting the ease or difficulty of participation, positively influences intention. Furthermore, hedonic motivation, rooted in the desire for enjoyment and pleasure, plays a vital role in shaping tourists' intentions to engage in space-launch tourism. The article underscores the growing interest in space tourism in Asian countries, especially China, positioning China as a leader in the region's space exploration endeavors. It also emphasizes the scarcity of prior research on space tourism, highlighting the need for a better understanding of tourists' perceptions and intentions in this emerging field. The research objectives of the article offer valuable insights for Indian startups seeking to explore innovative tourism opportunities, align their offerings with influential factors, and leverage predictive models to cater to the evolving space tourism trend in Asia. The methodology of the study involves the use of a web-based survey questionnaire to collect data from individuals interested in space tourism. The study analyzes various variables, including attitude, subjective norm, perceived behavioral control, hedonic motivation, and intention, employing statistical techniques like SPSS and Structural Equation Modeling (SEM) to test hypotheses exploring the relationships between these constructs. The article concludes with a discussion of the theoretical and practical implications of the findings, along with acknowledging the study's limitations and suggesting potential avenues for future research.

Pareek,A.; *et. al.*(2021) The article, conducted jointly by researchers from Takshashila Institution in Bengaluru and Far Eastern Federal University in Vladivostok, examines India's space collaborations in a geopolitical context. It emphasizes India's pursuit of self-reliance in space endeavors while recognizing the importance of international partnerships. The study highlights India's extensive cooperation agreements, particularly with Russia and the United States, noting its pragmatic technology choices based on capabilities and interests. It discusses India's growing partnership with the United States in the Indo-Pacific, providing access to advanced technology and data while cautioning about potential sanctions. The enduring significance of Russia as a strategic ally for India in areas like submarines, missile development, and space cooperation is emphasized.

Additionally, the study touches on China's emergence as a space player and introduces Russia's Zeus TEM, a nuclear-powered space platform, highlighting its potential benefits for India. The article's objective is to inform Indian startups about evolving geopolitics in space exploration, offering insights into collaboration opportunities and challenges. It also introduces the Zeus TEM as a technology of interest. The methodology involves a comprehensive literature review, data collection from various sources, expert opinions, historical analysis, and an assessment of geopolitical dynamics to provide insights into India-Russia space cooperation.

M. holsclaw,G.; *et. al.*2021) The article discusses the Emirates Mars Ultraviolet Spectrometer (EMUS) and its role in the Emirates Mars Mission (EMM). EMUS, an imaging ultraviolet spectrograph, investigates the Martian upper atmosphere, specifically the thermosphere (100–200 km altitude) and exosphere (above 200 km altitude). It aims to characterize composition, spatial structure, and atmospheric dynamics. EMUS offers extensive spatial and spectral coverage, addressing measurement requirements. The study highlights international collaboration in planetary research, indirectly suggesting opportunities for Indian space research startups in aerospace innovation, data processing, AI, and ground station operations, aligning with space education and outreach efforts. The methodology outlines EMUS's technical aspects, scientific objectives, and observational strategies, emphasizing its unique capabilities in Martian atmospheric studies.

Pandey,S.; *et. al.*(2022) The study, conducted across institutions like Amity University Mumbai, Blue Marble Space Institute of Science in the USA, Mars Society Australia, and the Open University in the UK, highlights the crucial role of astrobiology in inspiring both students and the general public to engage with space exploration. It emphasizes how astrobiology, as an interdisciplinary field, fosters collaboration among scientists from diverse backgrounds in India, effectively breaking down existing silos within the scientific community. Furthermore, the article underlines the significance of astrobiology in shaping space exploration programs, particularly within the Indian Space Research Organization (ISRO). It also explores the relevance of the Indian National Space Promotion and Authorization Centre (IN-SPACe) and the emerging New Space ecosystem in India, suggesting that these developments present unique opportunities to overcome traditional challenges related to cost, time, and program management for astrobiology missions. In terms of objectives, the article indirectly connects astrobiology's collaborative nature and the evolving Indian space landscape to the potential scope for startups in Indian space research. It highlights opportunities for startups to engage with experts from various space-related fields, leverage IN-SPACe and the New Space ecosystem for innovative solutions, and contribute to astrobiology missions, especially in advanced instrumentation, technology, and data analysis domains. Overall, this article underscores the expanding opportunities for startups within the Indian space research arena, emphasizing collaboration, innovation, and active participation in the evolving space ecosystem, with key variables encompassing Mars exploration, asteroid mining, commercial space life, microgravity science, and space science.

Dr k. Sivan (2021), is based in the Indian Space Research Organization, Bangalore, provides valuable insights for Indian space tech startups. It emphasizes the importance of persistence, collaboration, and innovation. The historical trajectory of India's space program demonstrates the value of long-term vision and dedication, inspiring startups to remain committed despite challenges. Collaboration, both nationally and internationally, is underscored as vital for enhancing research capabilities and expanding market reach. The achievements in satellite technology and rocket development highlight the need for innovation. Government support, private sector involvement, and academic collaborations play crucial roles. Startups are encouraged to explore these opportunities, leverage market potential, and consider incubators and accelerators for support. While the article's specific methodology isn't detailed, it likely draws from historical records and expert knowledge to provide this informative narrative.

Wedler,A.*et. al.*(2021) The article, conducted at various institutes including DLR (German Aerospace Center) in Germany and ESA/ESTEC in the Netherlands, discusses DLR's efforts in developing autonomous robotic technology for lunar and planetary exploration. It emphasizes the need for increased autonomy in unmanned lunar missions and highlights DLR's contributions, such as the Mobile Asteroid Scout (MASCOT) mission and lessons from the Robotic Exploration of Extreme Environments (ROBEX) project. The article's objectives, centered on DLR's initiatives, are relevant to India's space research startup scene, offering insights and collaboration opportunities for Indian space startups seeking to enhance planetary exploration capabilities. DLR's technological advancements can expedite Indian startups' research and development efforts, bolstering their competitiveness globally. DLR's achievements, like MASCOT and ROBEX, serve as inspirational case studies for Indian startups, helping them strategize missions and address common challenges. The methodology

integrates mission descriptions, lessons learned, technological advancements, and collaborative agreements, while emphasizing the importance of technological innovation in achieving scientific objectives.

Amati,L. *et. al*.(2021) The article discusses the THESEUS (Transient High-Energy Sky and Early Universe Surveyor) space mission concept, focusing on its goals and objectives. THESEUS aims to use Gamma-Ray Bursts (GRBs) to study the early Universe and advance multi-messenger astrophysics. It plans to explore the first billion years of the Universe, including topics like early low-mass galaxies, cosmic re-ionization, and star formation evolution. The mission also seeks to identify electromagnetic counterparts to gravitational wave and neutrino sources, collaborating with future observatories. THESEUS has versatile instruments and wide energy coverage, expanding the discovery space for high-energy events across cosmic history. It indirectly relates to Indian space research startups by highlighting the importance of innovation, collaboration, data analysis, commercialization, and education in the space sector. The methodology in the article is descriptive, presenting THESEUS's mission concept, objectives, and instrumental capabilities.

This study was conducted by Millan ,R *et. al.*(2019). The study conducted at Dartmouth College, USA, the International Space Science Institute in Switzerland, the Space Research Institute in Russia, the University of Trieste in Italy, and the Space Science Division in South Korea underscores the substantial impact of small satellites, including CubeSats, on diverse space science fields. It aims to create a clear roadmap under COSPAR's guidance to advance scientific frontiers globally through innovative collaboration using these satellites. Emphasizing the swift growth in the small satellite industry and the increased accessibility due to cost-effective launches, the article encourages the scientific community to propose inventive concepts, enabling more frequent scientific missions and data generation. The article further addresses evolving data management and processing methods, stressing international cooperation between scientists, universities, agencies, and the private sector to harness small satellites' potential. Policy-related factors, such as spectrum access and orbital debris management, are also discussed as critical for the success of small satellite science.

Denis ,G.; *et. al.*(2020). The article explores the transformative dynamics of commercial space activities, often referred to as "New Space," unveiling several key findings. It underscores the rapid rise of this sector, propelled by start-ups and space ventures reshaping the industry. These endeavors have attracted substantial investments, reaching approximately $21.8 billion between 2000 and 2018, signifying a growing momentum. Legacy players in the space industry are facing challenges from these new entrants, yet they demonstrate resilience and adaptability. It delves into the current space landscape, dissecting its actors, trends, and activities, while also speculating on possible future scenarios and emphasizing the importance of agility, vision, risk management, and collaboration over company size or age.

Kopacz ,J.; *et. al*.(2020). The small satellite industry has undergone remarkable transformations in recent years, poised for explosive growth with proposals for constellations exceeding 1000 satellites. This surge is driven by the flexibility, rapid development, resiliency, cost-effectiveness, and risk tolerance that small satellites offer to commercial customers, prompting governments to reevaluate their utility. These micro-spacecraft, made possible by advances in micro-electronics, maintain modern spacecraft performance in remarkably compact forms, making them affordable to build, test, and launch. Large constellations of small satellites are revolutionizing various sectors, from defense and agriculture to business intelligence and disaster recovery, by providing daily imagery and innovative solutions. These capabilities have the potential to connect the world in unimaginable ways, offering precision support during disasters and unveiling new perspectives on our planet.

This study was conducted by Cruce,P.; *et. al.*(2020). This article discusses the challenges and transformations in the field of space physics data analysis, particularly in the context of the Heliophysics/Geospace System Observatory (H/GSO). It highlights the emergence of the Space Physics Environment Data Analysis System (SPEDAS) as a valuable software platform officially supported by NASA Heliophysics. SPEDAS is designed to streamline data retrieval, analysis, and visualization for a multitude of space missions and ground observatories, offering both command-line and graphical user interface modes. The article also outlines SPEDAS' technical aspects, its integration with international standards like CDF and potential expansion to Python, emphasizing its role in enhancing the scientific return in the era of multi-mission space research and global magnetospheric studies.

This study was conducted by Robinson ,K.; *et. al.*(2019). This article delves into the evolving landscape of mission-oriented innovation policies, with a particular focus on the space sector, where agencies like NASA and ESA are adapting to the changing dynamics of the industry. The transformation is driven by various factors,

including the increasing emphasis on addressing societal grand challenges, the emergence of new space companies, and the global trend of interconnecting industries. The study explores the responses of NASA and ESA to these evolving pressures, shedding light on how they are reshaping their innovation policies to foster market creation. This analysis serves as a valuable case study for understanding the changing nature of mission-oriented policies in the context of grand challenges and provides insights for other public agencies grappling with similar challenges in different domains.

This study was conducted by Bettina M,.;(2019) in Embry Riddle Aeronautical University. The article delves into the escalating challenge of orbital debris, particularly in Low Earth Orbit (LEO), where satellites are essential for various purposes like weather monitoring and global communication. While technology has made satellite launches easier, the harsh space environment often leads to satellites failing prematurely, contributing to a mounting orbital debris issue. The projected surge in satellite launches exacerbates this problem, creating an unsustainable accumulation of defunct satellites. The Kessler Effect, which describes a cascade of collisions leading to debris saturation, further compounds the challenge. The article explores an innovative solution: performing maintenance on satellites in orbit. It suggests that advancements in propulsion, navigation, and robotics could enable in-orbit servicing in LEO, potentially reducing collision risks and aiding other debris mitigation strategies. Through a modified causal loop diagram, the article illustrates how satellite maintenance could play a crucial role in minimizing the Kessler Effect and enhancing orbital debris management. These objectives hold great relevance to India's space research opportunities, given ISRO's expertise and growing satellite deployments. Collaborative efforts in this field could position India as a key player and open doors for research, development, and commercial ventures in satellite servicing on the global stage.

This study was conducted by Lisa C.S,.; *et. al.*(2019) in National Cancer Institute, UNITED STATES. The article talks about NASA's work on keeping astronauts safe during long journeys in deep space. They're concerned about the harmful radiation from space, especially galactic cosmic radiation (GCR), which can cause health problems like cancer, brain issues, tissue damage, and weak immune systems. To better understand these risks, NASA built a special "GCR Simulator" at their Space Radiation Laboratory. It acts like a space radiation machine, helping them study how this radiation affects living things. They hope to confirm what they've learned about health risks and radiation doses to make sure astronauts stay healthy on future missions to the Moon and Mars. India's space agency, ISRO, might also find this research helpful for their space goals. This work looks at different things like the types of radiation, how long it lasts, and how it affects living things. The scientists use the GCR Simulator to do experiments and check their findings about the health risks and doses of radiation. This way, they can make sure astronauts are safe when they go on long trips in space.

SPEDAS is a vital tool for startup ventures in Indian space research. It offers a user-friendly interface, data access, and plans for integration. This can empower Indian startups to analyze and visualize space data efficiently, fostering innovation in space-related technologies.

The study from the University of Luxembourg highlights the opportunities for Indian startups in the field of satellite communications (SatComs). It emphasizes the innovation drivers and applications of SatComs, which can be leveraged by startups to contribute to India's growing technological advancements in space and address critical sectors like agriculture and disaster management. Additionally, the integration of SatComs with 5G can offer startups opportunities to enhance digital services in remote areas, opening up new markets and applications. This study's comprehensive literature review can serve as a valuable resource for Indian startup researchers, helping them collaborate internationally and tackle future challenges in satellite communications.

This study was conducted by Joshua B.,*et. al.*(2020) in California Institute of Technology, Pasadena, CA, USA. The article discusses NASA's ECOSTRESS mission launched to the International Space Station in 2018, mainly focusing on studying evapotranspiration (ET). It generates Level-3 latent heat flux (LE) data from Level-2 land surface temperature and emissivity data, along with additional surface and atmospheric information. The article's primary aim is to validate the accuracy of ECOSTRESS's clear-sky ET product by comparing it to LE measurements from 82 global sites. The results show strong performance with an r2 value of 0.88, an 8% overall bias, and a 6% normalized root-mean-square error. ET uncertainty remains consistent across various factors, despite an overrepresentation of temperate sites.This article can serve as a valuable reference for Indian space researchers, offering insights into the utility of high-resolution remote sensing data and potential collaborative opportunities with NASA or other international partners for Earth observation missions.

This study was conducted by Sweeting, M. (2018) in Guildford, U.K. This article highlights the evolution of small satellites, emphasizing their cost-efficiency and reduced development time. These smaller satellites offer operational and commercially viable services. The paper explores the role of Indian space research startups in driving innovation, commercial opportunities, policy frameworks, international collaboration, technological progress, challenges, growth strategies, market opportunities, and funding avenues for small satellite projects.

This study was conducted by Karouia, F. *et. al.*(2017). Conducted at the University of California San Francisco, Department of Pharmaceutical Chemistry, San Francisco, USA, along with contributions from NASA Ames Research Center's Exobiology Branch and Flight Systems Implementation Branch in Moffett Field, USA, as well as Peyvan Systems Inc., Seattle, USA, the article "Space Biotechnology: Advancements in Omics Techniques for In Situ Research in Space" explores the potential of omics techniques like DNA amplification, sequencing, RNA analysis, protein measurement, and metabolite profiling in space research. It discusses adapting specialized instruments for space research, focusing on automation, miniaturization, and resilience to space conditions, offering insights for Indian space startups. It advocates for high throughput instruments in space exploration, mirroring opportunities for startups in biomedical studies, life support, resource utilization, planetary protection, and space biology research. The central message is the value of real-time, in situ research for startups to enhance space biology and technology understanding.

This study was conducted by Gao, Y.; *et. al.*(2017). This article highlights the importance of space robotics in space exploration, emphasizing their role in tasks like exploration, construction, and maintenance. It discusses the multidisciplinary nature of this field, offering a technical roadmap for Indian space startups to align with global challenges. The article encourages collaboration across STEM disciplines and motivates startups with the inspirational aspect of space robotics for future generations. Key topics covered include space exploration, space robotics, interdisciplinary collaboration, benefits of robotics, types of space robots, robotic missions, international collaboration, autonomy, and future trends. The article employs a comprehensive review approach, gathering data from various sources to provide a coherent overview of space robotics in space exploration.

This study was conducted by Jung Choi, E.; *et. al.*(2017). A study conducted in South Korea, including the Korea Astronomy and Space Science Institute, shows improved re-entry prediction accuracy due to tracking technology, computational power, and modeling advancements. It emphasizes international collaboration for space safety. Accurate predictions are crucial for risk assessment and managing fragmentation events. Machine learning and artificial intelligence show promise for refining predictions. Challenges include limited tracking data, atmospheric uncertainties, and space debris. Policy and regulations related to space debris mitigation and space traffic management are increasingly important. Indian space startups can align with these findings to offer satellite deployment services with responsible disposal practices, contributing to space debris mitigation and global space industry prominence.

This study was conducted by Gupta, B.; *et. al.*(2018). Conducted in Bhubaneswar and Kharagpur, India, this study highlights the significant advancements in global space research and India's emergence as a key player, particularly through Antrix, ISRO's commercial arm, which has successfully launched 209 foreign satellites and engaged in various commercial space activities. It underscores the need for aligning India's legal framework with international space law to address the expanding scope of commercial space activities. The article also explores the multifaceted objectives of Indian space startups, including contributions to innovation, policy evaluation, international collaboration, market opportunities, and support mechanisms, all aimed at fostering their growth in the dynamic space industry.

This study was conducted by Prasad, N. (2017). The study conducted at the Observer Research Foundation in New Delhi, India, emphasizes the crucial need for a thriving NewSpace ecosystem in India and proposes the development of a space startup incubator to foster this growth. This article highlights the role of incubators in supporting space startups, government backing, and challenges like funding and specialized infrastructure access. It promotes aerospace education and international collaboration, showcasing success stories from startups. The study looks ahead at India's NewSpace sector, outlining growth and innovation areas. Its objectives include supporting space startups, exploring incubation models, addressing funding challenges, promoting education and innovation, and integrating startups into the broader space ecosystem.

This study was conducted by Prasad, N. (2017). The article, conducted at the Observer Research Foundation in New Delhi, India, titled "Traditional Space and NewSpace Industry in India: Current Outlook and Perspectives for the Future," highlights India's remarkable growth in the space sector, expanding from scientific and societal

applications to commercial ventures, diplomacy, and security support. It underscores the potential for Indian enterprises, including startups, in the $300 billion global space industry. The article discusses traditional space models, the private sector's evolving role, and the need for capacity building in the Indian space sector, offering valuable insights for startups. The variables covered include Indian Space Program growth, diversification of objectives, enterprise opportunities, traditional space models, private sector involvement, SWOT analysis, and capacity building. While the specific methodology isn't detailed, it may involve a literature review, interviews, data analysis, case studies, and various research methods to present these insights.

This study was conducted by Ashok G.V. *et. al.*(2017) at the Observer Research Foundation in New Delhi, India. The article on "SATCOM Policy: Bridging the Present and the Future" discusses how SATCOM policy fosters innovation through regulatory frameworks and incentives. It emphasizes efficient spectrum allocation, LEO satellites, HTS, international collaboration, regulatory challenges, and private sector involvement. For Indian space startups, it aims to highlight policy relevance, encourage innovation, raise awareness of existing policies, promote sustainability, and stress adaptability. Variables covered include SATCOM Policies, Indian Space Startups, Innovation, Regulatory Awareness, Entrepreneurship, International Collaboration, Sustainability, Socioeconomic Impact, Adaptability, and Competitiveness.

The study, conducted by Abhijeet, K. (2017) at the Observer Research Foundation in New Delhi, India, presents significant findings in the article titled "Privatisation of Space in India and the Need for A Law." The article emphasizes the private sector's increasing role in India's space industry, focusing on satellite launches, services, and space exploration. It highlights regulatory gaps and ambiguities in current space laws and calls for new legislation to address these challenges. The article stresses the need for clear legal frameworks covering risk mitigation, liability, and insurance in private space activities. It suggests that these legal reforms can attract domestic and foreign investments, boosting innovation and commercialization in the space sector. Additionally, the article discusses international comparative analyses, space traffic management, public-private partnerships, national security concerns, environmental responsibility, and India's global competitiveness in the space industry.

The study, conducted by Handberg, R. (2017) at the Department of Political Science, University of Central Florida, Orlando, USA, presents findings from the article titled "Canada's Space Program: Challenges and Future Directions Amid Changing Dynamics." The article explores Canada's history of collaboration with the United States in space endeavors, including its involvement with the European Space Agency since 1979. It highlights Canada's strategic role in space technology sectors, generating economic returns and addressing challenges related to NASA's restructuring and economic downturns. The article underscores the importance of maintaining an independent space program for economic benefits and international prestige, considering associated costs. It places Canada's program in the context of global space powers and discusses the role of space technology in economic development and global competitiveness. Objectives for Indian space research startups within this context could include assessing international space cooperation, identifying collaborative opportunities, analyzing economic implications, examining regulatory frameworks, exploring innovation avenues, and offering policy recommendations for the Indian space research startup ecosystem.

This study was conducted by Nagendra,N,P.(2016). In Nagendra's study from 2016, which was conducted in Thumba, a coastal area in Thiruvananthapuram, India, the focus was on understanding how India's space program has evolved over the past ten years. This program started with basic rockets in the 1960s and has since grown impressively. India aimed to provide cost-effective space services, like Earth imaging and improved communication. They built the necessary infrastructure and launched numerous satellites. The study also analyzed ISRO's funding allocation for science and defence. India collaborated internationally and engaged private companies. These actions influenced India's foreign relations and security. The study examined space training's impact on the industry and job creation. They outlined future space aspirations based on meticulous data collection, expert consultations, and rigorous research, culminating in actionable suggestions.

This study was conducted by Prasad Nagendra,N.; *et. al.*(2016). The study was conducted in India, focusing on the country's space program and its development. India rapidly embraced space tech with government support, driving growth in various sectors. Assets like IRS, INSAT, PSLV, and GSLV were developed. Challenges include a lack of prominent private space firms, limited industry engagement, unclear policies, and SME growth. Recommendations entail a think tank and structural changes for competitiveness. The study covers budget allocation, ISRO performance, diversification, diplomatic impacts, private sector, national security,

HRD, and industry growth. The methodology included a literature review, data collection, expert input, ethical considerations, peer review, and visual presentation.

The study is conducted by Bergouignan,A *et. al.*(2016). The provided article delves into the realm of space nutrition, with a primary focus on its pivotal role in supporting astronauts' health and metabolic needs during space missions. The article highlights the adverse effects of inadequate nutrition on various physiological systems during space travel, including radiation exposure, immune system deficits, and oxidative stress, and muscle and bone loss. It recognizes the presence of bioactive micronutrients in the diet, offering potential long-term health benefits. The study emphasizes the importance of ensuring proper astronaut nutrition during missions and addresses deficiencies. Six key issues in space nutrition are identified: in-flight energy balance, altered feeding behaviour, metabolic stress, micronutrient deficiency, gut microflora changes, and fluid/electrolyte balance alterations. The article promotes further research in space nutrition to enhance astronaut well-being during space exploration.

The study was conducted by Aubert,A *et. al.*(2016). The information in the passage is derived from the THESEUS project initiated by the European Commission, which aimed to plan Europe's human exploration of space. This project focused on understanding the impact of space travel on astronaut health, as it's clear that space accelerates aging processes, affecting various physiological systems. Countermeasures, notably exercise, have been explored, but with plans for longer missions, addressing health challenges is vital. The THESEUS project prepared for these challenges, with potential benefits for space and Earth health. In the context of Indian space research, these principles remain relevant, particularly if India embarks on longer crewed missions. Objectives involve understanding space's health impact, emphasizing countermeasures, and integrating these into mission planning. Key variables considered include weightlessness duration, intrathoracic pressure, fluid redistribution, tissue thickness, countermeasure effectiveness, and radiation exposure. The methodology describes and explains the THESEUS project's objectives and the broader context of space research, offering a high-level overview without specific research methods, providing insights into human space exploration and its applications on Earth.

The study was conducted by Metzger,P.;(2016). The concept of establishing a Self-sufficient Replicating Space Industry (SRSI), as discussed in the article conducted at the Florida Space Institute, holds relevance for Indian space research and exploration endeavors. India, via ISRO, has excelled in space technology. Embracing SRSI could bring benefits by participating in international collaborations for technological advancement (Stage 1). India could also explore lunar and asteroid resources for a self-sustaining space supply chain (Stage 2). Chandrayaan missions provide valuable data for this. SRSI participation offers economic, environmental, and scientific gains, enhancing India's space industry and addressing global challenges. Indian policymakers and researchers can advocate for this through diplomatic efforts, partnerships with other space agencies, and aligned national space policies. This adoption could elevate India's role in the global space community and unlock new opportunities for progress.

This study was conducted by Crucian,B. *et. al.*(2016). This study was carried out in NASA Johnson Space Centre, Houston, TX, USA, as well as in Departments of Medicine and Psychology at the University of Basel, Switzerland, and the Department of Biomedicine, Pharmacology, Aarhus University, Aarhus, Denmark. Experts designed a questionnaire to investigate the effects of space missions on the immune system, stress factors, virus reactivation, and countermeasures for long missions. Indian startups can engage in space research by developing technologies for astronaut health, radiation, and life support, collaborating with international space agencies. This aligns with India's space research goals, offering exciting opportunities. The methodology entails using a questionnaire to gather global expert insights on space travel's impact on the immune system and related challenges.

This study was conducted by Timiebi Aganaba-Jeanty(2016). This study conducted at McGill University in Montreal, Canada, delves into the challenge of achieving sustainable development in the realm of space, primarily due to the prevalent focus on national interests. Emphasizing national interests in space can lead to inequalities and barriers. The article proposes addressing these issues while focusing on global space sustainability. This aligns with "Governance for Global Security," benefiting existing space actors. To balance national interests and cooperation, it suggests using "Cosmopolitan Approaches to International Law." India, through ISRO, contributes to sustainable development by launching satellites for agriculture and disaster management. Collaborations with international space agencies promote capacity building and technology

sharing. As India's space capabilities grow, it must address market protectionism. Embracing cosmopolitan approaches, India can play a pivotal role in promoting fair and inclusive space governance, reinforcing its significance in space exploration.

This study was conducted by Rao,M. et. al.,(2016). The study, carried out at the National Institute of Advanced Studies (NIAS) in India, is dedicated to the formulation of a comprehensive "Indian Space Policy. This policy aims to align India's space endeavors with industrialization and development goals, emphasizing collaboration between the government and private space entities. It focuses on advanced space technologies, operational services, and job opportunities, driven by a growing user base for space services. It considers deregulation, increased investment, privatization, and cooperation within India's evolving policy landscape. The study underscores the importance of long-term commitments to ambitious space missions, including human spaceflight and planetary exploration, reflecting India's aspirations beyond Earth. The policy's development involves consultations with experts, policymakers, and stakeholders, reinforcing India's role in the global space community, fostering progress, economic efficiency, and international collaboration in space exploration and utilization.

The Study was conducted by Gupta, B; *et. al.*(2016). A study at IIT Kharagpur focuses on India's achievements in space science and technology, particularly through ISRO, spanning education, telemedicine, communication, agriculture, and meteorology. India's sharing of space technologies with other nations, like offering satellite access to SAARC countries, demonstrates its commitment to regional development and geopolitical collaboration. The article explores the potential benefits of these collaborations, especially in South Asia's underdeveloped context, aligning them with India's security interests. Key variables include space advancements, socio-economic development, education, telecommunications, and international cooperation, enhancing India's prominence in the global space arena. The methodology likely involves data analysis, historical context, and policy assessments to convey these findings and proposals.

The study was conducted by Artigas,J.; et. al.(2016). This paper from the Institute of Robotics and Mechatronics at the German Aerospace Center (DLR) in Wessling, Germany, introduces a groundbreaking robot controller designed specifically for space telerobotics missions, with a strong focus on meeting the unique demands of the collaborative KONTUR-2 mission between Germany and Russia. The paper focuses on space telerobotics achievements, challenges, and the development of a space-ready joystick for the KONTUR-2 mission aboard the ISS, enabling astronauts to control Earth-based robots. It addresses control requirements, introduces a novel bilateral control architecture, and recognizes the control-communication interplay's impact on performance. In summary, the paper emphasizes interdisciplinary collaboration between control and communication experts for mission success, with objectives centered around advancing space robot technology and enhancing future missions. Key variables include requirements, controller design, human proprioception, performance, and mission objectives. The methodology involves joystick development, ISS experiments with Cosmonaut Oleg Kononenko, data collection, analysis, and addressing the control-communication relationship.

5. FINDINGS

- India's ASAT capabilities guide startups for potential collaborations.
- Space radiation exposure study emphasizes health risks for astronauts and electronics.
- Space psychology challenges present opportunities for startups to develop innovative solutions.
- Europe's pursuit of space autonomy through initiatives like the Ariane rocket program.
- The Space Sustainability Rating (SSR) highlights the importance of sustainable practices.
- The MMX mission launching in 2024 presents collaborative opportunities for startups.
- ESA collaboration and a growing space sector demonstrate significant potential.
- SPJ study enhances understanding of high-temperature gases for space.
- Metal additive manufacturing transforms aerospace, impacting rocket engines and satellites.
- China's space tourism influence and India's strategic decisions in collaborations.
- Astrobiology inspires students, shaping India's space programs.
- Small satellites promise breakthroughs; SPEDAS facilitates space data analysis.
- Transformation in space agencies provides insights for responding to evolving innovation policies.
- Article on satellite servicing suggests collaboration for India in debris management.
- NASA's GCR Simulator study is crucial for ensuring astronaut health.

- Assessment of NASA's ECOSTRESS mission offers collaborative opportunities for Indian space researchers.
- Space biotechnology in situ research advances life understanding beyond Earth in real-time.
- Space robotics, vital for exploration and maintenance, requires interdisciplinary collaboration.
- Advances in re-entry predictions show increased accuracy, aided by improved tracking.
- India's Antrix excels globally in satellite launches, showcasing diverse space activities.

6. RECOMMENDATIONS

1. Collaborate with ISRO: Partnering with ISRO can offer startups access to invaluable resources, mentorship, and cutting-edge technology. Such collaborations can significantly accelerate your research and development efforts while benefiting from ISRO's expertise and infrastructure.

2. Focus on satellite technology: Satellites have a wide range of applications in areas such as communication, navigation, Earth observation, and scientific research. Developing innovative satellite-based solutions for specific needs, like agriculture, disaster management, or climate monitoring, can open up lucrative market opportunities.

3. Leverage data analytics: The data generated from space research is immense. Startups specializing in data analytics and artificial intelligence can harness this data to create actionable insights for various sectors, including agriculture, urban planning, and environmental monitoring. This can lead to data-driven decision-making and informed policymaking.

4. Space tourism and services: With the growing interest in space tourism, startups can explore opportunities to offer experiences, accommodations, or technology solutions to support this emerging industry. Creative offerings can position your startup at the forefront of this exciting field.

5. Space debris management: Space debris poses a real threat to future space activities. Startups can develop novel solutions for tracking, removing, or repurposing space debris, contributing to the long-term sustainability of space operations.

6. International partnerships: Collaborating with international space agencies and private companies can extend your reach and diversify your opportunities. It allows startups to access global markets, share knowledge, and potentially secure funding from international sources.

7. Support for research and development: Government initiatives and grants, like "New Space India Limited," offer financial support for space-related projects. By actively participating in these programs, startups can secure funding for research and development, reducing financial constraints.

8. Skilled workforce: Building a highly skilled team is essential. Invest in training and attract talent in aerospace engineering, space science, and related fields. A knowledgeable and skilled team is critical for the success of your space research endeavors.

9. Stay updated on regulations: The space industry is heavily regulated for safety and security reasons. Staying informed about the latest legal and regulatory changes is crucial to ensure compliance and avoid potential setbacks or legal issues.

10. Sustainable space practices: The space industry is increasingly emphasizing sustainability. Implementing environmentally responsible practices in your research and operations can enhance your reputation and appeal to environmentally conscious customers and partners.

11. Public-private partnerships: Collaborating with government agencies and private enterprises in joint ventures can be mutually beneficial. It allows startups to share resources, reduce costs, and access government-backed infrastructure, while also contributing to public space missions and national development.

12. Market diversification: Diversifying your offerings to cater to both space and non-space markets can provide a more stable revenue stream. Leveraging space technology for terrestrial applications can broaden your business prospects and reduce dependence on the volatile space sector.

In summary, the Indian space research sector offers exciting opportunities for startups, but success requires a combination of innovation, collaboration, compliance, and long-term vision. By following these recommendations and staying agile and adaptive, startups can thrive in this competitive and dynamic industry.

7. CONCLUSION

In wrapping up our exploration of "Opportunities for Space Research Startups in India," we find an exciting tale of innovation and growth. We've seen that startups in India can be real game-changers in space exploration. They're not just on the sidelines; they're at the forefront of introducing new ideas and technologies, which is pretty cool. Our deep dive into this topic shows that startups can do even more by teaming up with existing space organizations. This collaboration can offer them valuable support, guidance, and access to resources. Internationally, joining hands with other countries in space projects allows Indian startups to tap into global knowledge and markets.

Our research suggests that startups should think outside the box and use groundbreaking technologies. There are so many untapped opportunities, from creating small satellites to inventing new ways to propel spacecraft. And, importantly, we've found that there's a growing need for eco-friendly practices in space exploration. Startups can be part of this global movement toward responsible and sustainable space activities. Looking ahead, it seems like Indian startups have a bright future in space research. Their combination of big ideas, tech skills, and willingness to work together not only aims for the stars but also envisions them shining brightly in the vast cosmic expanse. The upcoming chapters hold the promise of Indian startups leaving a lasting impact on scientific progress, economic prosperity, and our collective human journey into the great unknown. To sum it up, the story of Indian startups in space research is more than reaching new heights; it's a narrative of creativity, collaboration, and the endless possibilities that lie beyond our home planet.

The scope of space research for startups in India is vast and promising, with numerous opportunities awaiting exploration. The Indian space industry has grown significantly in recent years, thanks to the Indian Space Research Organization (ISRO) and the government's supportive policies. In conclusion, the space research landscape in India offers a fertile ground for startups to innovate and prosper. With supportive government policies, an established space agency, and a rising demand for space-related services, the Indian space industry presents a world of possibilities. As startups take bold strides into this domain, they not only contribute to technological advancement but also unlock new economic avenues, propelling India's presence in the global space research arena. The stars, quite literally, are the limit for Indian space startups.

REFERENCE

[1]. Hussain, S., & Shahzad, K. (2023). India's quest for ‘global space and influence’through the ‘outer space’domain. Journal of Space Safety Engineering.
[2]. Fogtman, A., Baatout, S., Baselet, B., Berger, T., Hellweg, C. E., Jiggens, P., ... & Durante, M. (2023). Towards sustainable human space exploration—priorities for radiation research to quantify and mitigate radiation risks. npj Microgravity, 9(1), 8.
[3]. Pagnini, F., Manzey, D., Rosnet, E., Ferravante, D., White, O., & Smith, N. (2023). Human behavior and performance in deep space exploration: next challenges and research gaps. npj Microgravity, 9(1), 27.
[4]. Klimburg-Witjes, N. (2023). A rocket to protect? Sociotechnical imaginaries of strategic autonomy in controversies about the European rocket program. Geopolitics, 1-28.
[5]. Rathnasabapathy, M., & David, E. (2023). Space Sustainability Rating in Support of the Development and Adoption of Regulatory Guidelines Related to Long-Term Sustainability. Air and Space Law, 48(Special).
[6]. Kawakatsu, Y., Kuramoto, K., Usui, T., Sugahara, H., Ootake, H., Yasumitsu, R., ... & Tokaji, A. (2023). Preliminary design of Martian Moons eXploration (MMX). Acta Astronautica, 202, 715-728.
[7]. Balcerzak, T. (2023). Polish Space Activities in Europe. In National Space Law in Poland (pp. 127-164). Brill Nijhoff.
[8]. Rapagnani, D., Cutrone, L., Ranuzzi, G., Fumo, M. D. S., Savino, L., De Cesare, M., ... & Gialanella, L. (2023). Feasibility study of a compact and multi-gas supersonic plasma jet for nuclear astrophysics and space research. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 1056, 168536.
[9]. Callsen, S., Wilken, J., Stappert, S., & Sippel, M. (2023). Feasible options for point-to-point passenger transport with rocket propelled reusable launch vehicles. Acta Astronautica, 212, 100-110.

[10]. Choudhury, B., Revazishvili, T., Lozada, M., Roy, S., Mastro, E. N., Portugal, S., & Roy, S. (2023). Distributed compact plasma reactor decontamination for planetary protection in space missions. Scientific Reports, 13(1), 1928.
[11]. Amiri, H. E. S., Brain, D., Sharaf, O., Withnell, P., McGrath, M., Alloghani, M., ... & Yousuf, M. (2022). The emirates Mars mission. Space Science Reviews, 218(1), 4.
[12]. Batori, E., Almat, N., Affolderbach, C., & Mileti, G. (2021). GNSS-grade space atomic frequency standards: Current status and ongoing developments. Advances in Space Research, 68(12), 4723-4733.
[13]. Blakey-Milner, B., Gradl, P., Snedden, G., Brooks, M., Pitot, J., Lopez, E., ... & Du Plessis, A. (2021). Metal additive manufacturing in aerospace: A review. Materials & Design, 209, 110008.
[14]. Wang, L., Fu, C. F., Wong, P. P., & Zhang, Q. (2022). The impact of tourists' perceptions of space-launch tourism: An extension of the theory of planned behavior approach. Journal of China Tourism Research, 18(3), 549-568.
[15]. Pareek, A., & Gubin, A. (2021). India-Russia Space Cooperation: A Way Forward. Takshashila Discussion Document.
[16]. Holsclaw, G. M., Deighan, J., Almatroushi, H., Chaffin, M., Correira, J., Evans, J. S.,& Tyagi, K. (2021). The emirates Mars ultraviolet spectrometer (EMUS) for the EMM mission. Space Science Reviews, 217, 1-49.
[17]. Pandey, S., Macey, M. C., Das, D., Mohanty, A., Tiwari, S., Jose, J. V., & Sharma, S. (2022). Astrobiology as a Driver to Connect India's Public, Scientists, and Space Missions. New Space, 10(1), 51-67.
[18]. Sivan, K. (2021). From Sounding Rocket to Launch Vehicles—Achievements of Department of Space.
[19]. Wedler, A., Schuster, M. J., Müller, M. G., Vodermayer, B., Meyer, L., Giubilato, R.,& Reill, J. (2021). German Aerospace Center's advanced robotic technology for future lunar scientific missions. Philosophical Transactions of the Royal Society A, 379(2188), 20190574.
[20]. Amati, L., O'Brien, P. T., Götz, D., Bozzo, E., Santangelo, A., Tanvir, N., ... & Theseus Consortium. (2021). The THESEUS space mission: science goals, requirements and mission concept. Experimental Astronomy, 1-36.
[21]. Millan, R. M., von Steiger, R., Ariel, M., Bartalev, S., Borgeaud, M., Campagnola, S., ... & Wu, J. (2019). Small satellites for space science: A COSPAR scientific roadmap. Advances in space research, 64(8), 1466-1517.
[22]. Denis, G., Alary, D., Pasco, X., Pisot, N., Texier, D., & Toulza, S. (2020). From new space to big space: How commercial space dream is becoming a reality. Acta Astronautica, 166, 431-443.
[23]. Kopacz, J. R., Herschitz, R., & Roney, J. (2020). Small satellites an overview and assessment. Acta Astronautica, 170, 93-105.
[24]. Angelopoulos, V., Cruce, P., Drozdov, A., Grimes, E. W., Hatzigeorgiu, N., King, D. A., ... & Schroeder, P. (2019). The space physics environment data analysis system (SPEDAS). Space science reviews, 215, 1-46.
[25]. Angelopoulos, V., Cruce, P., Drozdov, A., Grimes, E. W., Hatzigeorgiu, N., King, D. A., ... & Schroeder, P. (2019). The space physics environment data analysis system (SPEDAS). Space science reviews, 215, 1-46.
[26]. Chang, E. Y. W. (2020). From aviation tourism to suborbital space tourism: A study on passenger screening and business opportunities. Acta Astronautica, 177, 410-420.
[27]. Kodheli, O., Lagunas, E., Maturo, N., Sharma, S. K., Shankar, B., Montoya, J. F. M., ... & Goussetis, G. (2020). Satellite communications in the new space era: A survey and future challenges. IEEE Communications Surveys & Tutorials, 23(1), 70-109.
[28]. Mrusek, B. M. (2019). Satellite maintenance: an opportunity to minimize the Kessler effect. International Journal of Aviation, Aeronautics, and Aerospace, 6(2), 2.
[29]. Simonsen, L. C., Slaba, T. C., Guida, P., & Rusek, A. (2020). NASA's first ground-based Galactic Cosmic Ray Simulator: Enabling a new era in space radiobiology research. PLoS biology, 18(5), e3000669.
[30]. Fisher, J. B., Lee, B., Purdy, A. J., Halverson, G. H., Dohlen, M. B., Cawse-Nicholson, K., ... & Hook, S. (2020). ECOSTRESS: NASA's next generation mission to measure evapotranspiration from the international space station. Water Resources Research, 56(4), e2019WR026058.
[31]. Sweeting, M. N. (2018). Modern small satellites-changing the economics of space
[32]. Karouia, F., Peyvan, K., & Pohorille, A. (2017). Toward biotechnology in space: High-throughput instruments for in situ biological research beyond Earth. Biotechnology advances, 35(7), 905-932
[33]. Gao, Y., & Chien, S. (2017). Review on space robotics: Toward top-level science through space exploration. Science Robotics, 2(7), eaan5074
[34]. Choi, E. J., Cho, S., Lee, D. J., Kim, S., & Jo, J. H. (2017). A study on re-entry predictions of uncontrolled space objects for space situational awareness. Journal of Astronomy and Space Sciences, 34(4), 289-302
[35]. Gupta, B., & KD, R. (2018). Chartering Territories in Outer Space: Obligating the Need for a National Legal Framework in India. Astropolitics, 16(1), 59-74
[36]. Prasad, N. (2017). Developing a Space Start-up Incubator to Build a NewSpace Ecosystem in India. Space India 2.0, 71
[37]. Prasad, N. (2017). Traditional Space and NewSpace Industry in India: Current outlook and perspectives for the future. Space India 2.0, 11
[38]. Ashok, G. V., & D'Souza, R. (2017). SATCOM policy: Bridging the present and the future. Space India 2.0, 119
[39]. Abhijeet, K. (2017). Privatisation of Space in India and the Need for A Law. Space India 2.0, 103

[40]. Handberg, R. (2017). Dancing with the pygmy elephant: The Canadian space program, future directions amid challenges. Technology in Society, 51, 209-214
[41]. Nagendra, N. P. (2016). Diversification of the Indian space programme in the past decade: Perspectives on implications and challenges. Space Policy, 36, 38-45.
[42]. Nagendra, N. P., & Basu, P. (2016). Demystifying space business in India and issues for the development of a globally competitive private space industry. Space Policy, 36, 1-11.
[43]. Bergouignan, A., Stein, T. P., Habold, C., Coxam, V., O'gorman, D., & Blanc, S. (2016). Towards human exploration of space: The THESEUS review series on nutrition and metabolism research priorities. npj Microgravity, 2(1), 1-8.
[44]. Aubert, A., Larina, I., Momken, I. et al. Towards human exploration of space: the THESEUS review series on cardiovascular, respiratory, and renal research priorities. npj Microgravity 2, 16031 (2016)
[45]. Metzger, P. T. (2016). Space development and space science together, an historic opportunity. Space Policy, 37, 77-91.
[46]. Frippiat, J. P., Crucian, B. E., De Quervain, D. J., Grimm, D., Montano, N., Praun, S., ... & Choukèr, A. (2016). Towards human exploration of space: The THESEUS review series on immunology research priorities. NPJ microgravity, 2(1), 1-6.
Aganaba-Jeanty, T. (2016). Space sustainability and the freedom of outer space. Astropolitics, 14(1), 1-19.
[47]. Rao, M. K., Murthi, K. S., & Raj, B. (2016). Indian space: Toward a "National Ecosystem" for future space activities. New Space, 4(4), 228-236.
[48]. Gupta, B., & Raju, K. D. (2016). Space Exploration by India and Socio-economic Cooperation with SAARC Countries. India Quarterly, 72(3), 278-289.
[49]. Artigas, J., Balachandran, R., Riecke, C., Stelzer, M., Weber, B., Ryu, J. H., & Albu-Schaeffer, A. (2016, May). Kontur-2: force-feedback teleoperation from the international space station. In 2016 IEEE International Conference on Robotics and Automation (ICRA) (pp. 1166-1173). IEEE.

