Vol-08 Issue 06, June -2024 ISSN: 2456-9348
Impact Factor: 7.936

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

# SPACE INSURANCE FOR COMMERCIAL SPACE ACTIVITIES: NAVIGATING THE NEW FRONTIER

**Surya Narayan Saha**

## ABSTRACT
The expansion of commercial space activities has made space insurance crucial for managing the high risks associated with space missions. This article explores the evolving landscape of space insurance, focusing on the trends in commercial space activities, such as the rise of small satellites, commercial human spaceflight, and space tourism. It outlines best practices in space insurance, including comprehensive risk assessments, collaboration with industry experts, and the use of data analytics. The paper details the types of insurance required, such as pre-launch, launch, in-orbit, and third-party liability insurance, and examines the capital needs and coverage considerations. Through case studies of SpaceX, OneWeb, and Blue Origin, the article highlights the importance of insurance in mitigating financial risks and supporting the sustainability of commercial space ventures. The conclusion calls for continued innovation and adaptation in space insurance to keep pace with the rapidly evolving space industry.

**Keywords:**
Space insurance, Commercial space activities, Satellite insurance, Launch insurance, Third-party liability, Risk management, Space market trends

## INTRODUCTION
The dawn of the commercial space age has ushered in an era where private enterprises and government agencies collaborate to explore and utilize outer space. As activities in this high-risk domain increase, so does the need for comprehensive insurance solutions to mitigate financial risks. Space insurance, once a niche market, has now become essential for the sustainability and growth of commercial space endeavors. This journal article explores the intricacies of space insurance, examining its trends, best practices, and future prospects in supporting commercial space activities.
To look back at history, in 2019, the global space economy was valued at around $423.8 billion and includes various activities related to space research, exploration, and utilization. This broad industry can be categorized for easier analysis, notably in terms of space communications and scientific or commercial research and exploration of space.
In 2018, communications activities, especially consumer television, comprised about 26% of the total space economy. This share is expected to exceed 50% by 2040 as satellite and other space-based technologies become increasingly vital to internet infrastructure. The growth of this segment highlights the essential role of space-based communications in modern life, driving the need for robust insurance solutions to manage the associated risks.
The satellite segment, which overlaps with communications, has diverse applications. Satellites not only meet commercial communication needs but are also crucial for military operations, scientific research, and other non-commercial uses. In 2019, global satellite revenue was $271 billion, with 95 new satellites launched that year. Although the number of satellite launches has decreased since the peak years of the mid-1960s to late 1970s, the total number of operational satellites has continued to rise. By the end of 2019, there were 2,514 satellites in orbit, with 1,327 owned by the United States.
Another perspective for analyzing the space industry is by comparing private and government spending. In 2019, government expenditures made up about 20% of the global space economy, was around $85 billion. The U.S. government is the largest spender, with NASA's budget exceeding $22 billion in 2020. Other major government contributors include the European Space Agency and China's space program, which together spent just over half of NASA’s budget in 2017.
The evolution of the space insurance market parallels these developments. The inherent risks of space missions, such as launch failures, satellite malfunctions, and in-orbit collisions, necessitated specialized insurance. Initially,

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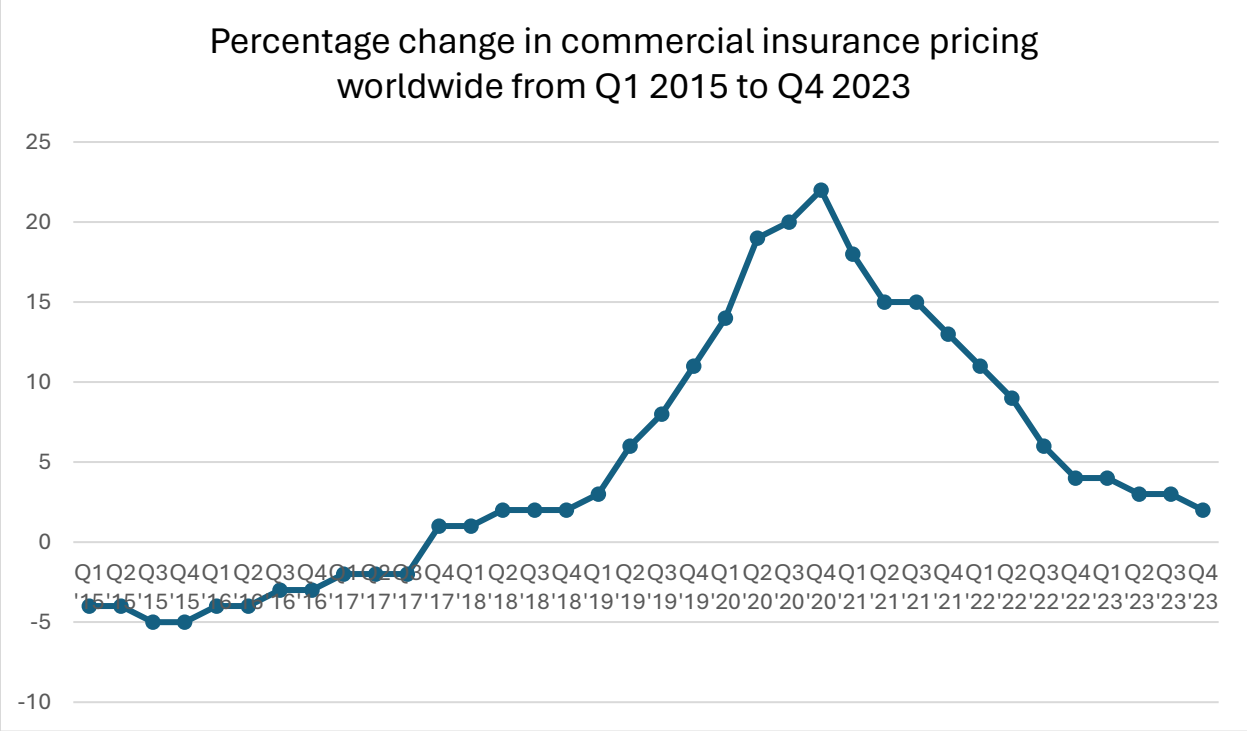
government agencies like NASA faced significant risks with limited financial protection. As commercial entities entered the space sector, the demand for comprehensive insurance solutions grew, leading insurers to develop products tailored to the unique challenges of space activities.

The space insurance industry has since become sophisticated, capable of underwriting large and complex risks. Policies typically cover various scenarios, from pre-launch and launch phases to in-orbit operations and third-party liabilities. The sum insured under a launch policy often includes the cost of procuring a replacement satellite in the event of a total loss, which can encompass the satellite's value, launch service costs, and sometimes the insurance premium itself. Besides, insuring space risks requires specialized expertise, and many insurers and brokers employ individuals with direct space industry experience to manage these risks effectively. The large insured values often involve multiple insurers to distribute potential catastrophic losses, demonstrating the collaborative nature of the global space insurance market.

Despite its growth, the space insurance market remains highly sensitive to industry events. Significant losses can affect premium rates and market capacity, as seen during high-loss periods in the late 1990s and early 2000s. However, the market has shown resilience, adapting to new challenges and evolving alongside space technology advancements.

The COVID-19 pandemic has also impacted the space insurance industry, causing delays in satellite launches and manufacturing, which affected insurance premium income and underscored the need for insurers to reduce volatility and ensure profitability. Despite these challenges, the space insurance market continues to grow, driven by the increasing complexity and volume of space activities and the ongoing expansion of the global space economy.

***Figure 1: Price change in commercial insurance worldwide 2015-2023***




Source: Statista, 2024

**Trends in Commercial Space Activities**

Commercial space activities have grown exponentially over the past decade, driven by advancements in technology, reduced launch costs, and increased private sector investment. One significant trend is the proliferation of small satellites, known as CubeSats, which has surged, enabling affordable access to space for companies and research institutions. These small satellites often operate in constellations, providing enhanced coverage and redundancy for

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various applications such as Earth observation, communication, and scientific research. The cost-effectiveness and versatility of CubeSats have democratized access to space, allowing even small companies and academic institutions to participate in space missions.

Another major trend is the emergence of commercial human spaceflight. Companies like SpaceX and Blue Origin are pioneering this frontier, aiming to make space travel accessible to civilians. This includes missions to the International Space Station (ISS) and beyond, raising the stakes for safety and insurance requirements due to the presence of human life. The successful launches of crewed missions by SpaceX, such as the Crew Dragon missions to the ISS, mark significant milestones in commercial human spaceflight, highlighting the critical need for robust insurance policies to cover potential risks.

Space tourism is also becoming a reality, with suborbital flights and orbital stays being marketed to affluent individuals. This trend introduces new insurance needs for passenger safety, liability, and mission success, as companies like Virgin Galactic and Blue Origin plan to offer regular space tourism flights. These missions require comprehensive insurance coverage to protect against potential accidents, ensuring the safety and satisfaction of tourists while safeguarding the financial interests of the companies involved.

Furthermore, there are ambitious plans for resource extraction and space mining, presenting new opportunities and risks. These activities involve high-value assets and substantial financial investments, necessitating comprehensive insurance coverage for equipment, personnel, and mission success. Companies like Planetary Resources and Deep Space Industries are at the forefront of this emerging industry, exploring the potential of mining asteroids for valuable minerals and resources. Insurance for these missions must cover a wide range of risks, including technical failures, environmental hazards, and legal liabilities.

Finally, the expansion of satellite constellations is a noteworthy trend. Mega-constellations of satellites, such as SpaceX's Starlink, aim to provide global internet coverage, increasing the volume and complexity of space traffic. The high number of satellites increases the risk of collisions and requires robust insurance policies to cover potential damage and operational failures. These constellations, consisting of hundreds or even thousands of satellites, are transforming global communications and connectivity, but they also pose significant challenges in terms of risk management and insurance.

**Trends and Best Practices for Commercial Space Insurance**

The insurance industry has responded to these trends by developing specialized products tailored to the unique risks of space activities. A best practice in space insurance is conducting comprehensive risk assessments. Detailed analysis of potential risks associated with launch, in-orbit operations, and re-entry is essential. Insurers conduct thorough assessments to understand the technical and environmental challenges, ensuring that all possible risks are identified and mitigated. This process involves evaluating the reliability of the launch vehicle, the robustness of the satellite design, and the mission's overall feasibility.

Collaboration with industry experts is another critical best practice. Insurers work closely with aerospace engineers, space agencies, and other industry experts to understand technical aspects and mitigate risks. This collaboration helps in designing insurance products that are realistic and adequately priced, reflecting the true nature of space missions. By leveraging the expertise of scientists, engineers, and regulatory bodies, insurers can develop more accurate risk models and offer better coverage options to their clients.

Customized coverage plans are crucial in the space insurance sector. Tailored insurance packages that address specific needs, such as pre-launch, launch, and in-orbit phases, are necessary. Each space mission has unique requirements, and insurance policies must be flexible to accommodate these variations, covering everything from hardware malfunctions to mission delays. Customization ensures that all potential risks are addressed, providing comprehensive protection for the insured parties.

Continuous monitoring and adjustments are essential for effective space insurance. Ongoing evaluation of risks and insurance policies to adapt to evolving technologies and regulatory landscapes is necessary. The space industry is dynamic, with frequent technological advancements and regulatory changes, requiring insurers to regularly update their risk models and coverage options. This adaptability ensures that insurance policies remain relevant and effective in mitigating the latest risks.

Leveraging data and analytics is becoming a standard practice in space insurance. Utilizing big data and predictive analytics to assess risks more accurately and price policies competitively is essential. Advanced data analysis helps

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insurers understand patterns and predict potential issues, leading to more effective risk management and pricing strategies. By analyzing historical data, satellite telemetry, and other relevant information, insurers can develop more accurate risk assessments and offer competitive premiums.

**Capital and Insurance Coverage**

The capital required for space missions is substantial, often involving investments of millions to billions of dollars. Insurance coverage must reflect this high financial stake. One key aspect is policy limits. Insurance policies must have high limits to cover the significant costs associated with space missions. These limits need to be sufficient to cover the entire value of the spacecraft, payload, and associated launch services, ensuring that financial losses are minimized in case of an incident. High policy limits are necessary to protect against catastrophic losses that could jeopardize the financial stability of the insured parties.

Premium costs for space insurance can be high, reflecting the inherent risks, but vary based on mission specifics, risk mitigation strategies, and historical data. Factors influencing premium costs include the type of spacecraft, launch vehicle, mission duration, and the experience of the launch service provider. Insurers consider these factors when pricing policies, balancing the need for comprehensive coverage with the financial constraints of their clients. Premium costs are also influenced by the risk appetite of insurers and the competitive landscape of the space insurance market.

Reinsurance plays a critical role in managing risk exposure for primary insurers. To manage their risk exposure, primary insurers often rely on reinsurance, spreading risk among multiple parties to ensure stability in the event of large claims. Reinsurance allows primary insurers to offer higher coverage limits while protecting themselves from catastrophic losses. By distributing the risk across several reinsurers, primary insurers can maintain their financial health and continue to provide coverage for high-value space missions.

**Types of Insurance Needed**

Commercial space missions require various types of insurance, each addressing specific risks. Pre-launch insurance covers risks during the assembly, integration, and testing phases before launch. This insurance protects against damage to the spacecraft or payload during the manufacturing and preparation stages, including accidents, natural disasters, and technical failures. Pre-launch insurance ensures that any issues arising during these critical phases do not result in financial losses for the mission stakeholders.

Launch insurance protects against failures during the launch phase, including damage to the rocket and payload. This coverage typically extends from the ignition of the rocket until a few days post-launch, ensuring that the payload is successfully deployed and operational. Given the high-risk nature of rocket launches, launch insurance is essential for mitigating financial risks associated with launch failures. This type of insurance provides coverage for various scenarios, such as rocket explosions, engine failures, and other technical issues that could lead to mission loss.

In-orbit insurance covers the operational life of satellites, protecting against malfunctions, collisions, and space debris. This insurance ensures that satellite operators are financially protected against unexpected technical issues or external factors that could disrupt their operations. In-orbit insurance is crucial for maintaining the financial stability of satellite operators, as it covers the costs associated with repairing or replacing malfunctioning satellites, as well as revenue losses due to operational disruptions.

Third-party liability insurance addresses potential damage caused to third parties, both in space and on Earth, by space activities. This coverage is essential for meeting regulatory requirements and protecting against claims for damages or injuries caused by space debris or malfunctioning spacecraft. Third-party liability insurance ensures that space operators are financially protected against legal liabilities arising from their activities, promoting responsible behavior in space operations.

Space tourism insurance is an emerging product designed for human spaceflight, covering health, safety, and mission success. As space tourism becomes more prevalent, specialized insurance policies are being developed to address the unique risks associated with carrying passengers into space. These policies cover a wide range of risks, including passenger injuries, vehicle malfunctions, and mission cancellations. Space tourism insurance provides financial protection for both space tourism companies and their customers, ensuring that potential risks are adequately managed.

**Pre-Launch and Launch Insurance**

Pre-launch and launch phases are critical, with high stakes and numerous risks. Insurance coverage during these stages includes protection for the assembly and testing phases. Pre-launch insurance covers risks during satellite assembly,

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integration with the launch vehicle, and ground testing. This insurance ensures that any damage or delays during the preparation stages do not result in financial losses for the mission stakeholders. By covering risks such as manufacturing defects, handling accidents, and environmental hazards, pre-launch insurance provides comprehensive protection for the spacecraft and payload before launch.

Launch insurance covers the period from ignition to payload deployment. It addresses potential failures that could result in mission loss, with typical coverage periods extending a few days post-launch to ensure successful deployment and initial operations. This type of insurance is crucial given the high-risk nature of rocket launches. Launch insurance provides coverage for various scenarios, such as rocket explosions, engine failures, and other technical issues that could lead to mission loss. By mitigating the financial risks associated with launch failures, launch insurance ensures that space missions can proceed with confidence.

**Third-Party Launch Liability Insurance**

Third-party launch liability insurance is crucial for protecting against claims arising from damage caused to other parties by space activities. Many countries mandate third-party liability insurance for launches conducted within their jurisdiction. These regulations ensure that launch operators have sufficient coverage to compensate for any damage or injuries caused by their activities, promoting responsible behavior in space operations. Compliance with regulatory requirements is essential for obtaining launch licenses and maintaining the legal and financial integrity of space missions.

Policies often have high coverage limits, sometimes reaching hundreds of millions of dollars, to address potential catastrophic events. These limits are set based on the potential severity of incidents, such as a failed launch causing widespread damage or debris impacting inhabited areas. High coverage limits ensure that launch operators can meet their financial obligations in the event of a major incident, protecting their assets and reputation.

Compliance with international treaties, such as the Outer Space Treaty and the Liability Convention, is also a key consideration for third-party launch liability insurance. These agreements govern liability for space activities, establishing the legal framework for handling claims and disputes arising from space activities. Ensuring compliance with these treaties promotes international cooperation and accountability, fostering a safer and more responsible space environment.

**Satellite Risk and Coverage**

Satellites, once in orbit, face various risks that require specialized insurance. In-orbit failure coverage protects against technical malfunctions or failures that prevent the satellite from fulfilling its mission. This insurance ensures that satellite operators can recover from financial losses due to operational disruptions, providing coverage for repair or replacement costs, as well as revenue losses.

Insurance against collisions with space debris is becoming increasingly important as the number of objects in orbit increases. The growing congestion of space traffic raises the risk of collisions, threatening the operational integrity of satellites. In-orbit insurance covers potential damages caused by collisions with space debris, ensuring that satellite operators are financially protected against these risks.

Protection against damage caused by solar storms and other space weather phenomena is also critical. These natural events can disrupt satellite operations and even cause permanent damage. In-orbit insurance provides coverage for damages caused by solar storms, radiation, and other space weather events, ensuring that satellite operators can mitigate the financial impact of these occurrences.

Coverage for the safe deorbiting or disposal of satellites is essential for mitigating space debris issues. Ensuring that satellites are responsibly decommissioned and removed from orbit is critical for maintaining the long-term sustainability of space activities. In-orbit insurance includes coverage for end-of-life disposal, ensuring that satellite operators can meet their obligations to minimize space debris and promote a safer space environment.

**Current and Future Market for Space Insurance**

The space insurance market is undergoing significant and rapid evolution, marked by notable advancements and promising future opportunities. The sector is experiencing considerable growth, propelled by the rising number of commercial space missions. This expansion is driven by the entrance of new participants in the space industry, technological advancements, and an increasing demand for satellite-based services. The growth of the space insurance market underscores its vital role in ensuring the sustainability and success of commercial space endeavors.

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Insurers are creating innovative products to address the unique risks associated with emerging activities such as space tourism and asteroid mining. These specialized insurance products are designed to meet the distinct challenges of new space ventures, offering comprehensive coverage for novel risks. By developing tailored insurance solutions, insurers enable space companies to manage the risks inherent in pioneering activities, thus fostering innovation and growth in the space sector.

The entry of more insurers into the market is increasing competition and reducing premium costs. This competitive environment benefits space companies by making insurance more accessible and affordable, which in turn encourages further investment in space activities. As a result, the space insurance market's competitive landscape ensures that companies can obtain the necessary coverage at reasonable costs, promoting the financial stability of the space industry.

Regulatory changes are also influencing the space insurance market, with international cooperation playing a crucial role in standardizing insurance requirements. Regulatory bodies are striving to create a consistent framework that ensures adequate insurance coverage for all space activities, thereby promoting safety and accountability. The development of standardized regulations ensures that space insurance policies comply with necessary legal and safety standards, supporting a responsible and sustainable space industry.

Market dynamics indicate that insured losses from space missions are predominantly concentrated during the launch phase and the initial months in orbit. Data since 2000 shows that over 40% of insured losses occur during the launch vehicle flight phase, approximately 41% within the first two months in orbit, and about 12-13% from the third through the twelfth months. These statistics highlight the high-risk nature of the early stages of a satellite's operational life, necessitating comprehensive insurance coverage during these critical periods.

The insured value under a launch policy typically includes the cost of procuring a replacement satellite in the event of a total loss, encompassing the satellite's total value, the cost of launch services, and sometimes the insurance premium itself. These values are influenced by the insured's risk appetite and budget considerations. Policyholders can save on premiums by insuring a lower agreed value and retaining a portion of the risk. On average, launch risk policies cover values between $200 to $250 million, though they can exceed $500 million.

Insuring space risks is a complex task requiring specialized knowledge of space technology and processes. Many insurers and brokers employ experts with experience in launch services or satellite manufacturing to better assess and manage these risks. Given the substantial values involved, often as high as $500 million, space insurance policies typically involve multiple insurers to distribute potential catastrophic losses.

The space insurance market is global, with key players located in the UK, France, United States, Germany, and Switzerland. The total market capacity, or the maximum amount of coverage insurers are willing to underwrite, is currently about $1 billion for any single risk. Despite the high values insured, premium rates for satellite risks are at historic lows, driven by competitive market conditions and advancements in risk assessment methodologies.

The market's sensitivity to events is evident from historical trends. Periods of high losses, such as those in 1998 and 2001 due to generic failures, can significantly impact premium rates and market capacity. For instance, a series of losses during these years compressed premium rates and reduced available capacity from a peak of more than $1.2 billion.

The satellite launch and space insurance market were valued around $620 million in 2022 and is projected to exceed $700 million by 2028, with a compound annual growth rate (CAGR) of 3.93%. This market includes various insurance forms needed to protect satellites from factory launch through their operational life in orbit. The insurance landscape has evolved from simple launch policies to a sophisticated discipline involving risk assessment, contract analysis, and claims negotiation.

The COVID-19 pandemic has impacted the space insurance industry, causing delays in satellite launches and manufacturing. The pandemic's disruption to the aerospace supply chain and manufacturing delays have affected insurance premium income and increased the focus on reducing volatility and ensuring profitability. Despite these challenges, the space insurance market remains resilient, with North America leading in growth rate and companies like Munich Re and AXA XL playing significant roles.

In conclusion, the space insurance market is rapidly expanding, driven by the increasing complexity and volume of space activities. The market's capacity to adapt and innovate in response to emerging risks and regulatory changes will be crucial in supporting the continued growth and sustainability of commercial space ventures.

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**Use Cases**

Several high-profile cases highlight the importance and application of space insurance. SpaceX's Falcon 9 launches are typically insured for both launch and in-orbit phases, covering potential failures and third-party liabilities. This comprehensive coverage ensures that SpaceX can recover from any financial losses resulting from mission failures or accidents. The insurance policies provide financial protection for SpaceX, enabling the company to continue its ambitious space missions with confidence.

OneWeb's satellite constellation has extensive insurance coverage to protect against deployment failures and in-orbit collisions. This coverage is crucial for maintaining the operational integrity of OneWeb's global communication network and ensuring uninterrupted service. The insurance policies provide comprehensive protection for OneWeb's satellite constellation, ensuring that the company can manage the risks associated with deploying and operating a large number of satellites.

Blue Origin's suborbital flights include insurance for passenger safety, vehicle integrity, and third-party liabilities. This insurance is essential for protecting Blue Origin from financial risks associated with human spaceflight and ensuring the safety and satisfaction of their customers. The comprehensive insurance coverage ensures that Blue Origin can mitigate the risks associated with space tourism, providing financial protection for both the company and its customers.

**Conclusion and Considerations for Insurers**

As commercial space activities continue to expand, the role of space insurance becomes increasingly vital. By providing comprehensive coverage for the myriad risks associated with space missions, insurance supports the growth and sustainability of the space industry. The future of space insurance will likely see further innovation and adaptation, ensuring that this crucial sector can keep pace with the rapidly evolving landscape of commercial space exploration and utilization. With robust insurance solutions in place, the space industry can confidently navigate the challenges of the final frontier, unlocking new opportunities for exploration, innovation, and economic growth.

Moreover, the increasing reliance on satellite technology for communications, internet infrastructure, and various commercial applications underscores the critical role of space-based assets. As private companies and government entities invest more heavily in space exploration and satellite deployment, the demand for comprehensive insurance solutions is expected to rise. The rise in satellite deployments, particularly with mega-constellations like SpaceX's Starlink and Amazon's Project Kuiper, will drive higher demand for launch and in-orbit insurance coverage. Additionally, the growing involvement of private companies in space tourism, asteroid mining, and lunar missions will introduce new risks and insurance needs, necessitating insurers to adapt to these novel commercial activities. Technological advancements such as reusable launch vehicles and more resilient satellite designs could reduce some risks but introduce new ones, requiring insurers to stay abreast of these developments to accurately assess and price risks. Evolving international regulations and space policies will impact the risk landscape, so insurers must monitor these changes to ensure compliance and anticipate their effects on the industry. Furthermore, the increase in space debris and the effects of climate change on space operations pose significant risks, highlighting the need for innovative insurance products and collaborative efforts with space agencies and operators.

To capitalize on the growth opportunities and manage the evolving risks in the space industry, insurers should invest in expertise and technology, building teams with specialized knowledge in space technology and operations. Leveraging advanced analytics, satellite data, and artificial intelligence can improve risk assessment and underwriting accuracy. Engaging with space agencies, commercial operators, and industry associations will provide valuable insights into emerging risks and technological trends, enabling collaborative efforts to develop standardized risk management practices. Insurers should create tailored insurance products to address the unique challenges of new space activities, such as space tourism and lunar missions, offering flexible coverage options and comprehensive risk management solutions. Implementing robust risk management frameworks, including thorough pre-launch assessments, continuous in-orbit monitoring, and contingency planning, will help mitigate potential losses and improve claims handling. Staying informed about international space regulations and policies is crucial for compliance and anticipating market shifts. Insurers should also focus on sustainability by addressing space debris concerns, supporting initiatives for debris mitigation, and partnering with organizations working on space debris removal technologies. Finally, insurers must remain agile, adjusting premium rates and coverage terms in response to significant losses or technological breakthroughs, maintaining a balance between profitability and competitive pricing

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for long-term success. By adopting these strategies, insurers can effectively navigate the dynamic space industry, ensuring they are well-positioned to support the growth of the global space economy while managing the complex risks associated with space activities.

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