

# ACCOUNTING FOR THE FINAL FRONTIER: LIFECYCLE VALUE, RISK, AND SUSTAINABILITY IN THE SPACE ECONOMY

## Abstract

This article introduces a conceptual framework that highlights risk-governed costing, sustainability integration and lifecycle value that explains the concept of management accounting in the commercial space economy. There is a discrepancy between space economy and traditional accounting methods which is brought into light in this article which brings a multi-dimensional approach which can enhance the commercial performance, effective decision-making and sustainably increase the value creation as this sector evolves into a capital-intensive industry.

## Introduction

Until now the outer space was government controlled and it is shifting to a commercially vital ecosystem which indicates that the world's economic order is going through a tectonic shift. Indian Space Research Organization and other private players like Blue Origin and SpaceX are redefining the value that needs to be created. The size of the global space economy was around \$630 billion and is projected to reach \$1.8 trillion by 2035 due to integration into terrestrial sectors and rapid commercialization. (World Economic Forum).

This change is basically financial in nature and not just technological. The traditional accounting system which is designed for the terrestrial industries day by day is becoming ineffective and anachronistic to address the complexities of space-based industries.

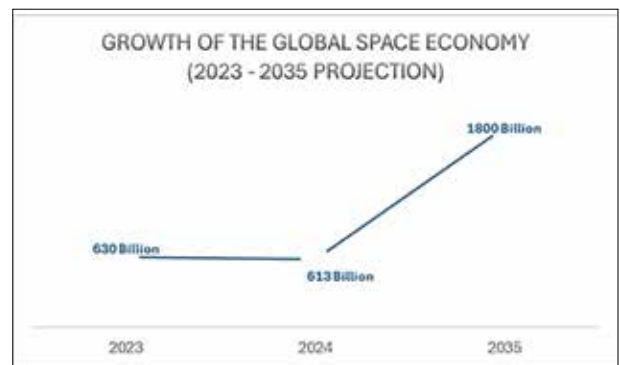


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The sector of Commercial space is more capital – intensive industry due to long asset lifestyles, new sustainability risks and uncertain top-line revenues along with complexities of debris accumulation and orbital congestion. These strategic changes led us to rethink the accounting systems from basic cost tracking to framing financial decision-making in terms of risk integration and modeling lifecycle value.



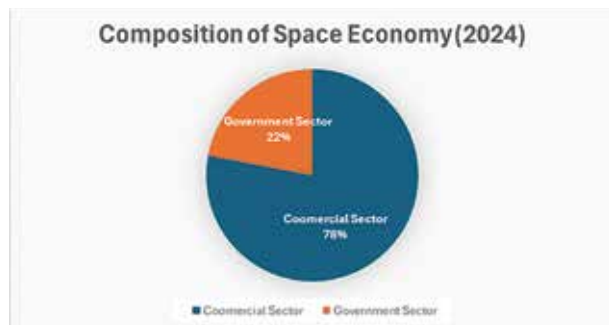
**Figure 1: Growth of the Global Space Economy (2023–2035 Projection) (Source: Author's compilation based on World Economic Forum (2024) and Space Foundation (2025)).**

### Structural Shifts in the Space Economy

Recent empirical trends highlight the need for a re-visioning of accounting regimes.

- ⊙ The global space economy was about \$630 billion in 2023 and in 2024 it was \$613 billion which is about 78% of the total value contribution by the commercial sector (Space Foundation)
- ⊙ Space economy has exploded from about 200 satellite launches per year in 2013 to more than 2,600 by 2023 (OECD, 2024).
- ⊙ It was estimated that more than 9,500 operational satellites are circulating in orbit alongside tens of thousands of debris objects as of early 2024 reports (OECD, 2024; ESA, 2024).

These trends testimonies the shift towards a more persistent, service design economic systems from the one – off missions.



**Figure 2: Composition of Space Economy (2024) (Source: Space Foundation (2025))**

### Literature Gap and Problem Statement

The present space economy literature focuses mainly on macroeconomic potential, advanced engineering technology and policy frameworks and the management accounting framework which are not fully developed needs an in-depth upgradation. Clear correlation between costs and revenues, relatively short lifecycle and predictable utilization of assets are all assumptions on which conventional accounting systems relies. When we turn our attention to space-based operations these assumptions do not hold true. Space assets have

high levels of uncertainty due to technological, regulatory and operational risks, multi – phased delayed realization of revenues and long gestation period. So, conventional accounting does not reflect the investment risk and actual economic value related to them in the space economy firms which can give a distorted results and wrong performance evaluation.

### Theoretical Foundations

Multiple theoretical perspectives inform the proposed framework to encapsulate the complex finance and strategic dynamics of the space economy. Theory of Lifecycle Costing expands conventional cost consideration model by including cost analysis throughout all phases of mission: carbon footprint generating design stage, expensive launch phase (both horizontal and vertical launch), operational phase, decommissioning (reuse or litter) which needs standard to ensure holistic view on value generations. In this regard, Real Options Theory holds special significance; it acknowledges the value of managerial flexibility in conditions of extreme uncertainty, providing firms with the ability to modify their investment decisions according to changing technological and market environments. The resource-based view (RBV) emphasizes that unique capabilities, such as proprietary launch technologies, superior data analytics and optimal orbital positioning are strategically significant because they can create sustained competitive advantage. In a highly specialized ecosystem, Transaction Cost Economics explains why firms structure partnerships, outsourcing arrangements and vertical integration decisions to minimize coordination and governance costs. ESG Accounting incorporates environmental and sustainability risks into a much broader scope of financial analysis, which impacts space debris as well as regulatory compliance issues, to name just two. Together, these theories enable the formulation of a multi-dimensional accounting architecture that correlates financial assessment with the specific traits within the commercial space industry.

## Conceptual Constructs for Space Accounting

**Table 1: Basic Accounting Constructs in the Space Economy**

Construct	Definition	Accounting Implication	Example KPI
Orbital Asset Valuation	Multi-phase valuation of space assets	Dynamic asset pricing	Revenue per orbit-hour
Risk-Governed Costing	Probability-adjusted cost structures	Inclusion of launch and operational risk	Risk-adjusted ROI
Lifecycle Monetization	Revenue across mission lifecycle	Multi-period revenue recognition	Lifecycle revenue yield
Space Sustainability Accounting	ESG beyond Earth	Cost of debris mitigation	Sustainability-adjusted margin
Regulatory-Embedded Accounting	Compliance-driven costing	Integration of licensing costs	Compliance cost ratio

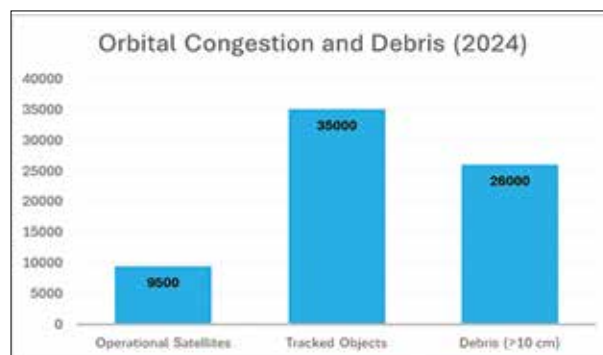
This table identifies what the core construction for a management accounting fits will look like for this new space-economy, and how financial evaluation should be redesigned, allowing us to match operational reality with some economic measures. Orbital Asset Valuation focuses on the time-phased value of space assets; quantifying revenue produced over periods such as revenue per orbit-hour. Risk Governed Costing introduces probabilistic factors like launch failure and operational uncertainty into the cost structures, allowing for more realistic metrics such as risk-adjusted ROI. Lifecycle Monetization understands that revenue is captured over several epochs, necessitating multi-period accounting methods which are manifested in lifecycle revenue yield. Sustainability – adjusted profits can be achieved when Space Sustainability Accounting can be applied to ESG principles which will help in cost mitigation effort for environmental impact and debris. Regulatory realities can be ensured by applying Regulatory – Embedded Accounting which can incorporate licensing costs and compliance with financial analysis as a modifier in decision-making processes by calculating various compliance cost ratios.

### Competition to be the furthest from impact: Orbital Congestion and Sustainability as Accounting Variables

One of the consequences of a denser orbital space is new economic risk. The OECD (2024) placed an estimation for objects greater than 1 cm in the order of more than 10,00,00,000 debris object

and ESA has identified a total of 35,000 tracked potential projects objects including around 26,000 fragments large than 10cm. This congestion has direct implications:

- ⊙ increased collision risk
- ⊙ higher insurance premiums
- ⊙ regulatory compliance costs
- ⊙ reduced asset lifespan



**Figure 3: Orbital Congestion and Debris (2024)**  
(Source: OECD (2024), ESA (2024))

### Proposed Conceptual Framework



**Figure 4: Conceptual Framework for Space Management Accounting** (Source: Author's Compilation)

The above model explains a casual chain where Accounting Capabilities may affect the Strategic Decision Making which can enhance the Long

– term Value Creation and Commercialization Performance. It highlights the strategic function of accounting as a value enabler rather than just a reporting tool.

### Accounting Capabilities:

Here we are introducing four costing techniques: regulatory integration, lifecycle costing, sustainability accounting and risk-governed costing methods so that organization can go for an overall approach to evaluate the financial aspects of the project without undermining the complexities associated with the space sector.

### Mediators:

Good accounting system will help in taking better strategic decision-making and allocation of capital which can lead to effective operational investment success.

### Moderators:

The framework of the space economy is very highly regulated and dynamic in nature where the technological uncertainty and regulatory intensity can play big role in determining the relationship strengths.

### Lifecycle Value Chain in Space Economy



**Figure 5: Space Asset Lifecycle (Source: Author's Compilation)**

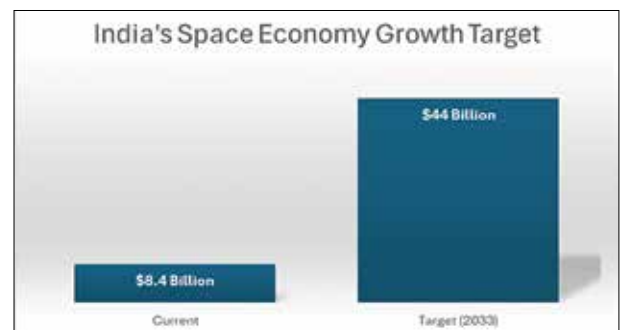
There are multiple phases in space economy's lifecycle value chain like decommissioning, design, operation and launch which have different revenue streams, risk exposure and different cost drivers at various phases. This multiple phase structure explains how value is accumulated over time and it is not instantaneously captured. It is necessary to adopt a lifecycle approach which is capable for accounting for risk, value generation and long – term profitability for any financial evaluation from the space segment operations.

### Commercialization and Investment Trends

New accounting frameworks are very important as they bring us back to the finalization of space. Data for 2024 talks about the volume of 259 orbital launches and about 2,900 spacecraft with small satellites comprising of 97% of the total indicates a very cost – effective and scalable model for deployment. There is a clear signal towards the shift to commercial dynamics where commercial launches accounted for 70% of all the launches. A 25% higher investment of around \$8.4 billion in 2024 as against 2023 suggests financial sophistication and higher level of confidence from the investors.

### India as a Strategic Case

India has strong policy framework and high growth prospects which makes her a strong contributor to the evolution of the space economy. The sector has a target of reaching \$44 billion by 2033 from the present worth level of \$8.4 billion. Over 400 space startups in 2026 have contributed to the innovation supported by a corpus fund of around ₹1000 crore (Indian Rupees) for a venture fund. Indian Space Policy 2023 and FDI liberalization are some recent initiatives which have paved the way towards private sector involvement and commercialization.



**Figure 6: India's Space Economy Growth Target (Source: IN-SPACe (2023), Government of India)**

### Propositions

Within the proposed conceptual framework, the following propositions are Proposed to study the impact of accounting capabilities on performance outcomes in space economy:

P<sub>1</sub>: Lifecycle costing (LCC) capability makes an impact at the level of mission-level economic viability among space-based enterprises, because

construction was a substantive portion of cost, and LCC enables all types of costs to be considered across the lifecycle.

$P_2$ : Uncertainty-capable costing effectiveness enhances capital allocation efficiency through the integration of uncertainty and risk into financial judgement.

$P_3$ : The ability to monetize the lifecycle positively influences revenue stability as it allows for cross-phase revenue recognition throughout the asset lifecycle.

$P_4$ : The integration of sustainability impact and ESG considerations into financial reporting enhances investor confidence and perceived firm value.

$P_5$ : The quality of strategic decision mediates the positive relationship between accounting capabilities and commercialization performance, such that better insights from accounting will improve decision-making and therefore lead to better performance.

$P_6$ : Regulators decrease – accounting capabilities and organizational outcomes relationship.

These statements serve as the foundation for empirical testing with methods including (but not limited to) Structural Equation Modeling.

### Managerial Implications

Space organizations now must shift from cost accounting to value based accounting while implementing new KPIs like cost per orbit – hour, lifecycle ROI, sustainability adjust profits and also risk integrated costing systems which should be rather predictive rather than based on historical costing. This shift can put accounting as an enabler of sustainable value creation and informed decision-making and not just function as a reporter.

### Policy Implications

Financial disclosures need to be revamped by the regulators as there is a need to establish accounting standards for the space economy to embed sustainability indicators and promote lifecycle – focused reporting. These measures will address asymmetry of information; investor confidence can be restored and also improve transparency to ensure the sustainable growth of the fast-evolving space sector over the long term.

### Future Research Agenda

We can use the findings of this study for future research to adopt various approaches that can enhance the level of evidence in this space sector. We can test these relationships with Structural Equation Modelling (SEM) between the accounting capabilities and performance outcomes. DID can be used to measure the policy implication and can establish causality, panel data allows for more stringent analyses and case – studies to provide rich firm – level context.

### Conclusion

Space capitalism is a finance revolution rather than an industrial revolution and could shake the fundamentals of management accounting. Traditional accounting system needs to adapt to include probabilistic risk, sustainability factors, capturing lifecycle value and regulatory complexity.

We propose a conceptual framework that can be used to guide accounting for the space economy and that provides an ideal point of departure for empirical research and subsequent implementation efforts. The future of the space economy will rely not just on technology, but how well we measure and manage value.

**Final frontier is not only technological; it is accounting.** MA

### References

1. BryceTech. (2025). Article precise in trend space launch and deployment globally 2024 Bryce Space and Technology.
2. European Space Agency (ESA). (2024). Space debris by the numbers. [https://www.esa.int/Safety\\_Security/Space\\_Debris/Space\\_debris\\_by\\_the\\_numbers](https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers)
3. IN-SPACe. (2023). Published by: Indian Space Economy, An overview of Indian space economy and growth predictions. Indian National Space Promotion and Authorization Center <https://www.inspace.gov.in>
4. OECD Organisation for Economic Co-operation and Development (2024). Space economy in numbers: trends and forecasts OECD Publishing. <https://www.oecd.org/space>
5. Seraphim Space. (2025). Space investment quarterly report 2024. Seraphim Space Investment Trust. <https://seraphim.vc>
6. Space Foundation. (2025). The investment is seen as a significant but logical step, considering the country has space plans of its own. Space Foundation.
7. World Economic Forum. (2024). The space economy of the future: Outlook to 2035. World Economic Forum. <https://www.weforum.org>