



# New Space Era: Characteristics of the New Space Industry Landscape

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## 1 INTRODUCTION

The space age dawned in 1957 with the successful orbiting of Sputnik by the Soviet Union, and it surged forward with the Apollo moon landings, ushering in the era of satellites and deep space probes. This situation in which space business relied on space science probes, space shuttle flights, and satellite launches largely persisted until the decentralization of space exploration began in the years following the 2003 Challenger Shuttle accident. In the subsequent decade, the US space agency, the National Aeronautics and Space Administration (NASA) shifted its focus from engaging in a wide array of space activities to concentrating on lunar, Martian, solar, and other deep space missions.

Nonetheless, historical events accelerated the decentralization trend as the Russian space agency experienced several highly visible launch failures

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from 2010 to 2014. It was evident that a transition from government-led space exploration to private-sector leadership would occur. The questions were how rapidly and effectively the private industry could make this transition. Time was of the essence as NASA canceled the space shuttle program, with its last flight in 2011, and had to depend on Russia's Roscosmos to deliver supplies and crew to the International Space Station (ISS). Even earlier, however, in 2001, the privatization of Intelsat occurred, marking a clear departure from government-dominated space services. The privatization, the move away from human launches by NASA, and similar events were steps toward the New Space era. New Space is understood here as a model where value stems from investor support for entrepreneurial ventures, in contrast to "old space," where value traditionally originated from government sources directed to research institutions and defense contractors (Paikowsky, 2017; Peeters, 2021; Weinzierl, 2018).

The development of New Space saw the establishment of private firms like SpaceX, Virgin Galactic, and Blue Origin in sectors that were previously limited to government activities. First, they took on launch services, and in subsequent years, milestones were frequently achieved, ranging from tests of new rockets to successful dockings at the ISS, the development of reusable rockets, and the emergence of space tourism experiences. These firms, however, also took on new services requiring satellite fleets and ground-based services. They were joined by many new entrepreneurial firms providing various services from satellite manufacturing to management to data analysis. The skills and technologies of these ambitious private firms are maturing, and the exploitation of Low Earth Orbit (LEO)—the region spanning roughly from 150 km to 2,000 km in altitude (Lawrence et al., 2022)—is now in full swing.

With a decade or more of rapid and profound changes behind it, this field is overdue for a review of its theories and characteristics, especially concerning business activities related to space. The most recent comprehensive assessment of the industry can be found in Gurtuna's (2013) book, "Fundamentals of Space Business and Economics." However, significant developments have occurred in the intervening years. The current book aims to comprehend these changes and establish the theoretical foundations of the rapidly emerging business field known as New Space. This field encompasses commercial LEO space services, trends, and technologies.

This book primarily centers on LEO and New Space; however, the delineation between these topic areas and conventional space business is not distinctly defined. The LEO space business, for instance, shares certain business aspects with higher orbits, contingent on the purpose and flexibility of satellites or fleets, as well as the utilization of ground stations and other services. The established space business, predominantly driven by major science projects and telecommunications, has not vanished; rather, it continues to coexist and, in certain instances, overlaps with New Space businesses and their innovative approaches. Dual use, that is for military and civilian purposes, is less clearly separated than in the past in space activities as seen in the examples of commercial space imagery delivered to support Ukrainian defenders and Starlink internet access exploited by all combatants.

The aim of this introductory chapter is to highlight the characteristics and recent development in space business. We present five propositions supported by literature and in-depth interviews with experts within the space industry. We then synthesize these into tentative theory elements, identifying the feedback loops that illustrate how the propositions interact with current trends and the realities of the industry.

## 2 EVOLUTION OF THE SPACE BUSINESS

In his book, Gurtuna (2013) identified seven features of space business before the New Space era. We will now elaborate on these features briefly. Firstly, business cycles in the post-Apollo era were defined by funding announcements or the lack thereof, which led to lengthy decision-making processes. The waning interest in space after the Apollo programs resulted in a lack of projects until satellites for defense and communications were launched. Secondly, long investment horizons were common in space business. At that time, probes might take 2–4 years for approval, followed by additional years for construction and the subsequent launch. For example, the New Horizons mission was discussed in the 1990s, approved in 2001, and eventually launched in 2006. Thirdly, most technological advances were driven by defense needs, while export restrictions made it difficult to provide services internationally. Major firms in the sector, such as Boeing and Lockheed Martin, had both military and civilian space programs with overlapping equipment, technology, and staff. Fourthly, the primary customers in this time period were national governments of developed countries and their agencies. Over time, other customers began

to include telecommunications groups. Fifthly, the only destinations for humans after the Apollo program had concluded were space stations, such as Skylab and the ISS. Sixthly, there were very few companies in each category, such as lift services, satellite building, ground station services, components, and more. Internationally, there was limited competition for heavy lift, including Roscosmos, Ariane, and NASA. Lastly, most satellites and space probes were one-off products. Over time, some communication satellites were built on the same platform, allowing for batch production and other limited efficiencies. Altogether, much has changed in the decade since the publication of Gurtuna's list. The Table 1 provides a then-and-now comparison.

Of the seven features, it is clear that six have undergone radical changes. The remaining one, lack of destinations, however, has changed only in that China's space station is now in use. Nonetheless, with various firms discussing plans to construct so-called manufacturing hotels or tourist hotels in orbit, we may see an increase in space-based destinations within a few years or even sooner. Furthermore, the Artemis Accords and separate plans by the USA and China may lead to the establishment of manned posts on the moon within the decade.

Currently, the space business is undergoing significant changes that have emerged over the past decade. Firstly, there has been a remarkable shift in funding. In the past, funding primarily came from governments, often in the form of major space exploration projects. In the private sector, the high costs associated with telecommunications satellites in high orbits were typically funded through stock issuance. However, today, funding is also flowing from conventional loans and, more recently, through venture-style equity investments. This latter practice, in particular, is often referred to as "New Space" (Paikowsky, 2017; Peeters, 2021; Weinzierl, 2018) and has now become a significant part of the space business. Another major shift is found in manufacturing. The smaller size of satellites, rapid developments in 3D printing, use of commercial off the shelf (COTS) components, and miniaturization have allowed satellite manufacturing costs to decrease.

As a result of these changes, new business models are rapidly emerging, offering value propositions in positioning, localization, advanced services, and orbital manufacturing, among others (Davidian, 2020; Frischauf et al., 2018; Madan & Halkias, 2022; Prol et al., 2022). These business models may revolve around novel value chains based on data rather than

**Table 1** Space business features, 2013 and 2024

<i>Features identified by Gurtuna (2013)</i>	<i>Up to 2013</i>	<i>Currently</i>
Business cycle	Long cycles of planning and construction	Shorter, as demand has increased for larger satellites and entirely new demand has emerged for microsattellites used in various applications
Long investment horizon	Very long horizon measured in years	Much shorter cycles of demand, design, and launch for microsattellites, with an increasing number of projects originating from other space agencies (e.g., Japan, India, Israel...)
Defense linkage	Very strong	Less strong than in the past; however, defense spending and funding remain crucial as near real-time data is increasingly in demand
Government as main customer	Few non-government customers other than telecommunications firms	Less so (small and startup services can also be customers)
Destinations limited	Skylab and later ISS	Still very limited, but now space tourism has begun. Orbital manufacturing and orbital tourist hotels are still lacking; the moon is not yet a destination
Limited competition	Few firms involved in assembly. Often depending on the same suppliers	More suppliers and lift options are available. Everything is more cost-effective: SpaceX has reduced launch costs, and there are more rocket builders, ground services, and so on
Curse of single unit of production	Almost all satellites are unique unless a small series was planned	Much less common—mass production of microsattellites, although this still applies to science packages

the traditional models around making and assembling physical components. New Space has also increased resilience through the use of cluster constellations, providing greater flexibility and allowing dual use, military and civilian, of satellites and data. Previously, space services were vulnerable to single points of failure, such as the failure of a satellite or a launch. With the advent of microsattellites and distributed control technologies, the failure of a single node or unit has less impact.

New Space has also opened the door for small and emerging economies to enter the space industry and related business activities. Their emergence has led to the development of new national space agencies and/or private businesses in countries other than major economies, including Finland, South Korea, Israel, Norway, Sweden, the United Arab Emirates, and many others. The increased number of players has created a greater demand for space equipment and services. The trend toward increased firms and countries also differentiates today's space business from the years when Western space programs heavily relied on Russian launch capacity and parts and subassemblies from China (Brennan et al., 2018; Wyne, 2020). This trend to separation is likely to continue, especially in light of the Russian invasion of Ukraine and the challenges of conducting legal business with Russian entities. The de facto decoupling may lead to the independent evolution of technologies which are available within specific groups of countries and have little or no interoperability.

Given the tense global political situation and the re-territorialization of space (Brennan et al., 2018), there is an increasing threat of hacking or terrorist attacks, as malicious actors may plan to target or destroy a satellite or an entire orbital fleet (Crain, 2016). This threat is exacerbated in part because major space-faring countries such as Russia and China appear willing to increase orbital debris to claim orbital territory (Brennan et al., 2018) or as a display of attack capabilities (Patel & Koller, 2022), despite the potential drawbacks to their own operations. Additionally, rogue states, hackers, and political or religious extremists are increasingly equipped to hijack a system (Willbold et al., 2023) which could then be destroyed or sent out of control. Because such tech savvy actors are uninterested in adhering to norms around safety and access, there are no moral or practical limitations on their potential for destruction.

### 3 EMPIRICAL BACKGROUND

To achieve a better understanding of current development of space business, we interviewed 10 experts working in different positions, tasks, and fields of space business. All the interviews were conducted in face-to-face meetings with interviewees in 2023. Each interview was recorded and transcribed verbatim. During the interviews, we also took notes and if needed, photos. The details of each interviewee and length of the interviews are displayed in Table 2.

**Table 2** List of interviewees

<i>Interviewee</i>	<i>Interview length (hrs)</i>	<i>Background and expertise of the interviewees</i>
Interviewee A	1:00	CEO of a space firm specializing in the development of small spacecraft movement and lifecycle control systems
Interviewee B	1:05	CEO of a technology firm engaged in the development of light sensing and spectroscopy technologies for satellites
Interviewee C	0:40	CEO of a consulting firm offering services in spacecraft engineering, radio technologies, microwave components, etc
Interviewee D	1:00	Director of Space and Defense at one of the oldest space firms in Finland, with a focus on technology design and software development for space projects
Interviewee E	1:00	Chief Strategy Officer and co-founder of a space firm providing earth observation data through their own SAR satellite constellation
Interviewee F	0:55	Director of a space firm offering earth observation data via their own SAR satellite constellation
Interviewee G	0:55	CEO of a space firm providing earth observation services based on a hyperspectral satellite constellation
Interviewee H	1:50	CEO and founder of a space firm specializing in ground station services
Interviewee I	0:55	Chief Business Officer of a firm providing design and development services, with a specialization in small satellites and the space industry
Interviewee J	1:05	Chief Product Officer and founder of a firm providing weather forecasting services based on satellite data

## 4 FINDINGS AND PROPOSITIONS DEVELOPMENT

Conventional theories of business and economics broadly apply to space business and its constituent organizations. Nevertheless, the theory surrounding space business differs from conventional business theory in several aspects. Theory serves various purposes, such as explanation and provocation (Sandberg & Alvesson, 2021), among others. This chapter primarily focuses on theory development to explain observed phenomena. Secondly, the chapter utilizes theory to stimulate changes in thinking and perspective among readers. Theories that provoke should encourage further work to either substantiate or challenge these theoretical points (Sandberg & Alvesson, 2021). With this in mind, the authors present five propositions about space business, which, when considered together, set it apart from other business domains. While the propositions may apply to other business domains, they are of particular importance to space business. Other propositions will certainly emerge, these five are not exhaustive and the authors encourage others to identify more. The salience of the themes in these propositions emerged from recent literature on the space industry and interviews with experts working in the space business.

### 4.1 *Space Business Is in a Phase of Decreasing Costs*

At the time of writing, the space business is experiencing an ongoing reduction in costs. This cost reduction is driven by the recent significant decrease in launch expenses, mass production, and further accelerated by miniaturization as has been summarized previously (Bushnell & Moses, 2018; Garzaniti et al., 2021). The cost of launching a kilogram of mass into orbit has substantially decreased with the introduction of reusable rocketry. Spearheaded by SpaceX, the cost per kilogram of launch has seen a remarkable decline with the introduction of reliably reusable rocket bodies. The savings per launch for the customer amount to approximately one-third in the case of the Falcon Heavy rocket according to the company. However, it's essential to note that this substantial price decrease is a one-time occurrence in the industry. We cannot anticipate whether other rocket components can achieve similarly significant cost reductions. Also, inflation is driving up nominal prices (Foust, 2023), though perhaps not as fast as national indices. One of the interviewees explained the cost reduction as follows:

New Space offers possibilities that did not exist 20 years ago. We can act faster, be more competitive, and more cost-effective while remaining efficient when we bring new services to the market. We are like a low-cost carrier in the space business, and we bring a new type of agility to the market. (Interviewee F)

Consequently, it is the ongoing process of miniaturization that reduces weight and, consequently, lowers the cost of delivery to orbit. Moore's Law states that integrated circuit density doubles about every two years (Moore, 1965). However, Moore's Law does not inherently indicate that costs must decrease, and the low cost of launching smaller components and systems is offset by the high expenses associated with development and production as well as inflation caused by chip shortages. Other factors, including advances in materials, batteries, communication equipment, and so on, enable engineers to create smaller units. The unit size of satellites has shrunk from over 3,000 kilograms for a single Telstar communications satellite in 1995 to about 250 kilograms in 2023 for a Starlink micro-satellite and as small as 1 kilogram for 1U (one unit) CubeSats (Kopacz et al., 2020). Meanwhile miniaturization allows more computing power onboard even small satellites and in-orbit data processing is becoming possible saving time and download bandwidth (Van Camp, 2023), and thus costs. The current generation of microsattelites benefits from lower power consumption, resulting in smaller, lighter electrical systems and batteries, as well as lighter communication equipment (Kopacz et al., 2020); that weight decrease also cuts launch cost per unit. Since satellites are not required to last too long, due to large fleets, COTS components allow further cost reduction. The trend of miniaturization and mass production in electronics is well-established and will continue to benefit the space business for the foreseeable future. As one of our interviewees emphasized:

Unlike the old model, where developing a single satellite could cost billions and take up to 15 years, the current emphasis is on creating small, cost-effective satellites through mass production. (Interviewee I)

Based on the above, we propose:

*Proposition 1* Long-term trends indicate decreasing costs for satellite manufacturing, delivery, and services, particularly for New Space.

## 4.2 *Resilience Is Greater than Previously in Space Business*

Historically, the space business has been plagued by expensive failures and the high cost of replacement, as well as the high cost of success. For example, the failure of Intelsat 603 in 1990 relied on the owner to pay all costs of rescue or replacement (Burgess, 1992) in order to secure long-term success. While high replacement cost and long lead time remain for geosynchronous communications satellites and other major equipment, in the New Space era, the firms increasingly rely on fleets of smaller, more cost-effective LEO satellites. One of the interviewees highlighted this as follows:

In such endeavors [old space], failure was not an option, as second chances are not available. However, New Space ventures offer more flexibility, opportunities for duplication and replication of projects, compared to traditional space projects. (Interviewee D)

As LEO satellites collaborate to perform tasks, such as collecting imagery from locations they briefly pass over due to their low-altitude orbits, they form a network. If one satellite fails, another can assume the task. Additionally, these satellites can be reprogrammable and redirected (Tumenjargal et al., 2019), or replaced if necessary. For instance, the Galileo satellite navigation system maintains a fleet of 24 satellites plus spares well above LEO altitudes which are therefore more expensive to reach. In contrast, Starlink is expected to have tens of thousands of satellites, all in low orbits, when completed. Therefore, the emerging space business based on LEO constellations is all but immune to expensive single-node failures. With multiple affordable nodes, downtime is less common and shorter. Additionally, a single catastrophic event, such as a solar storm, collision, or intentional attack, is less likely to completely disrupt the functioning of the system. One of our interviewees expressed this as follows:

In the New Space paradigm, satellite reform and technology updates in orbit are crucial. This approach allows for continuous updates and deployment of new technology over the service's lifespan. Furthermore, with a cluster constellation, if one satellite fails, the service can continue operating. However, managing fifty satellites poses a greater challenge than a single one. (Interviewee I)

The increased resilience of these systems, thanks to their numerous units, also extends to ground stations. The number of ground stations and access to them through services such as Amazon Web Services and Microsoft's Azure has increased remarkably in recent years (Willbold et al., 2023). Although ground stations may be under control of various firms, they have established procedures for interaction, task sharing, and managing data uplinks and downlinks. Consequently, they too form complex networks with the advantages of being able to reroute around non-functioning units. New technologies will also lead to greater resilience of systems and services, however that discussion is found in the section on illegal activities.

This leads us to the following proposition:

*Proposition 2* Space business systems are becoming more resilient in terms of service continuity due to the greater number of interconnected units they include.

### 4.3 *Increasing Regulation for Space Business*

The rapid expansion of the space business is accelerating the need for updated governmental regulations (Patel & Koller, 2022). Governments are becoming more aware of the space business, leading to adjustments in policies to support and regulate business activities. Recent implementations include fines in the USA for failing to properly maneuver satellites, imposed by the Federal Communications Commission (FCC, 2023). Governmental awareness and actions encompass providing funding or contracts to support promising technologies through defense organizations like the Space Rapid Capabilities Office and traditional space agencies such as NASA, European Space Agency (ESA), and Japan Aerospace Exploration Agency (JAXA). The growth of orbital debris, items that are not under any control, will likely lead to stricter regulations on satellite design and management in the near future such requirements for fuel availability for end of life maneuvers. Regulations are poised to focus on sustainability issues such as orbital debris, launch pollution, and re-entry pollution. Launches, especially those using solid propellants, have strong negative impact on the ozone layer while re-entry incineration leaves fine metal particulates in the upper atmosphere (Lawrence et al., 2022; McElroy, 2022; Ryan et al., 2022). Increased or internationally harmonized regulations will decrease uncertainty for business managers.

On the other hand, some costs may rise. Interviewees also highlighted the impact of regulations on space business:

Navigating regulations is a constant concern and there is always a question of how we can act on a global scale. We need to consider what is permissible in Finland, the EU, and the USA, and what types of services we can offer in different locations. (Interviewee G)

Particularly concerning ground stations, the legislation varies significantly between countries. In Finland, we now have legislation governing ground station activities. However, in other countries like Sweden, there still appears to be no specific legislation in place. This disparity creates challenges for firms operating within this industry. (Interviewee H)

Nevertheless, regulations introduced by advanced economies may play a lesser role in some countries due to the process of decoupling and de-risking. Decoupling and de-risking involve reducing supply chain exposure to risks associated with sanctions, political instability, and similar issues (Baldwin & Freeman, 2022). With diminished benefits from the value chain, countries subject to decoupling and de-risking may have less incentive to comply with international rules and regulations perceived as foreign and of limited benefit. The countries least likely to comply after decoupling and de-risking include China, Russia, and, of course, countries that have traditionally operated outside of international norms, such as Iran and North Korea. Businesses operating in such countries may adhere to different rules than businesses elsewhere. This is summarized in a proposition as follows:

*Proposition 3* Regulation related to space business is likely to increase in the near term with impact on space business management and security as well as cost and inconvenience.

#### 4.4 *Space Business Can Deliver Unique Benefits to Society*

Activities in space have the potential to provide benefits to society and institutions that are unattainable without space-based infrastructure (McElroy, 2022). At the same time, emphasis in space has moved from human progress to value for money (Suzuki, 2007), though this change does not preclude societal benefits, which appear to come in

parallel. These benefits can be achieved through the manufacturing of products and the delivery of services. An example of this is satellite telephony, which allows those with receivers to make phone calls worldwide. Rapid dispatch of rescue services to remote areas is also possible through space-based communications, and existing but still developing application (McGarry et al., 2023). More importantly, disasters, including their intensity and boundaries, can be assessed more rapidly and accurately from space. Near real-time services enable satellites to collect imagery at short notice and deliver it within ever shorter timeframes. The results of such speed and flexibility lead to faster responses in emergencies, improved disaster planning, and better assessments of the needs of affected areas and people. Such space-based technologies and services can have a positive effect on delivery of the United Nations Sustainable Development Goals (SDGs) (United Nations Statistics Division, 2020) and the quality of life of people in developing as well as developed economies (Manotti et al., 2023).

Previously space technology was more clearly identifiable for military or non-military purposes. For example, spy satellites and telecommunications satellites had distinctly different orbits and onboard systems. More recently however, constellations of satellites in LEO or Medium Earth Orbit (MEO) may carry a variety of imaging sensors which can be put to dual use for such disparate purposes as disaster response or providing information about military assets; indeed, space technology can be considered fundamentally dual use (Paikowsky, 2017). Debris removal systems, for example, could also be used to remove working satellites (Pražák, 2021). In both use cases, the data can be updated multiple times per day, allowing rapid responses. Since firms may choose to sell raw imagery and processed data to many kinds of customers, sharp delineation between civil and military use can no longer be made.

In manufacturing, despite limited testing, there are signs that drugs and materials with highly valuable properties that are otherwise unattainable may be manufactured in space in ultraclean, microgravity environments at a practical cost and scale (Weinzierl et al., 2022). Various solutions have been tested, such as launching and retrieving manufacturing modules, or proposed, such as multi-use, semi-permanent platforms, commonly referred to as manufacturing hotels, where various manufacturers could produce substances in manned or fully automated settings (McElroy, 2022; Prater et al., 2019; Sowards et al., 2022). Constraints

in this context include the cost of launch and the limited cargo sizes that even large rockets can handle. This leads us to the following proposition:

*Proposition 4* Various space-based business models offer unique social benefits to humankind; however, military and other negative or even abusive business models may increase.

#### *4.5 Illegal and Irresponsible Business Activities Will Evolve with Space Business*

Irresponsible business refers to activities that create injustice or damage in relation to the community, society, and/or business practices (Michailova, 2020). In the space business, these activities include hijacking satellites, appropriating or misusing data, spoofing, creating space debris, stealing or corrupting data, deploying malware, attacking satellites and their control centers, and so on. Irresponsible and illegal activities are not surprising in and of themselves. Rather, what is surprising is that engineers and businesspeople involved in space activities often do not think about and prepare for these challenges. One of the interviewees highlighted this issue as follows:

There are always possibilities for a war actions or sabotage in space. The ways to do it are interference of radio communication, block usage of GNSS [Global Navigation Satellite System], etc. Or someone can try to impact on ground systems either by using cyber or kinetic affection that is much easier than trying to impact flying objects in space. (Interviewee I)

A study by Willbold et al. (2023) found that space-based assets were vulnerable at the most fundamental levels. They suggest that space engineers and IT professionals might lack awareness of security issues. The lack of basic security on satellites reflects the early days of the internet when security was an afterthought. Similarly, the lack of security in space business provides a foothold for criminal activities, allowing them to establish a presence. With a foothold and a strong motivation to survive, malicious actors are likely to adapt their targets and skills to the evolving virtual ecosystem (Moore, 2016). Each party will adapt to changes implemented by the other. In this race to adapt and survive, it is imperative for business professionals, government regulators, and academics to be aware of threats in order to outmaneuver them as frequently as possible. Various

technologies that will boost resilience to hacking appear to be coming into play, such as debris detection and evasion, debris deorbiting, narrow aperture, and laser-based communications, AI-based decision-making in orbit for fleet management, to name a few (Aerospace, 2022; Bailey, 2020; Patel & Koller, 2022; S-ISAC, 2023; Van Camp, 2023). Additionally, legal structures are likely to develop which will aid in deterring and prosecuting malevolent actors (Freeland & Ireland-Piper, 2022; Way & Koller, 2021).

In addition to criminal and irresponsible organizations, space business faces man-made threats such as orbital debris. With 27,000 pieces of debris being tracked and perhaps a million more in orbit, orbital debris poses a serious safety concern as well as a business opportunity. Key events, such as the 2007 Chinese anti-satellite test, the 2009 collision of the Iridium and Kosmos satellites, the 2021 Russian anti-satellite demonstration, and the disintegration of a Kosmos satellite in 2023, have increased the potential for a Kessler Syndrome event (Kessler, et al., 2010). This could result in much of LEO space becoming unusable. Business activities related to global active debris removal are expected to reach a market value of \$273 million in 2030 (Patel & Koller, 2022). Firms offering debris collection, removal, tracking, and other services are likely to be in demand. The interviewees explained this as follows:

The technology we are developing, a plasma brake for de-orbiting, is one solution to this problem. The number of satellites in orbit is growing exponentially, and they need to be de-orbited somehow. Dealing with this increasing amount of space junk presents a significant challenge. Additionally, there is upcoming legislation addressing the retrieval of satellites from orbit. (Interviewee A)

One negative thing in small satellites is that if you do it really cheaply, it does not include any kind of control or deorbiting system. Then there is no way to control it e.g., when the battery runs out or solar panels' electricity production stop to work. There should be a standard for minimum requirements that should be in the place so that we can bring satellites safely down in the end of its life cycle. (Interviewee I)

Space business may see the arrival of funds supported by insurance firms, industry associations, and national governments that will support technology and missions for deorbiting debris and aging equipment, as

has happened in other business areas. Based on this, we propose the following:

*Proposition 5* Criminal and irresponsible business practices will evolve in constant dynamic adjustment with legitimate business needs and practices.

## 5 CONCLUSION

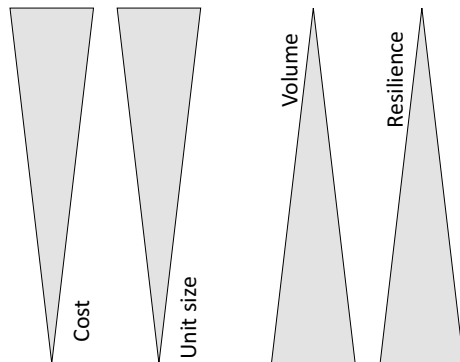
Here follows a brief written and graphical summary of space business theory.

- As unit size decreases, the cost per unit (considering production, delivery to orbit, operating cost, insurance, etc.) decreases;
- As unit cost decreases, the volume of orders and deliveries to orbit increases which also decreases cost per unit;
- As numbers increase and therefore the substitution effect for downed nodes improves, the overall resilience of systems increases.

The above concepts are depicted on sliding scales indicating their relationships in Fig. 1. Further work is required to know the exact mathematical relationships including whether they are linear or non-linear.

Figure 1 shows that cost decreases with the size of the satellites. The main source of the cost decrease is that multiple small units can be launched with one rocket. Full size satellites weighing 500 to 3,000 kilograms, or more, can only be launched a few at the time or individually.

**Fig. 1** Key relationships



Other cost gains from small unit size include lower costs of construction, insurance, replacement, and so on. This parallel is shown by downward pointing triangles in Fig. 1. An inverse relationship is shown by upward pointing triangles for volume and resilience. Namely, as cost and size go down, volume and resilience rise. For example, SpaceX is able to launch 50 or more satellites at a time with plans to add several thousand to the roughly 5,000 currently in orbit. This network is so robust that SpaceX can plan the destruction of 100 satellites without diminishing service (Foust, 2024).

The relationships can be depicted with greater detail in a feedback loop diagram such as Fig. 2. Feedback loops can explain and depict factors influencing business model innovation and dynamic change (Ammirato et al., 2021; Pateli & Giaglis, 2005). In this diagram, the impact of one block on others appears as positive reinforcement, labeled R, which increase the next block in the flow. Arrows, labeled B, are balancing forces which decrease the subsequent block. For example, as shown in Fig. 2, the greater the volume of satellites launched, the greater the resilience of space-based networks. At the same time, increases in production and launches mean a decrease in related costs.

Figure 2 shows that as technology improves, the size of satellites becomes smaller, and they are therefore cheaper to build and launch

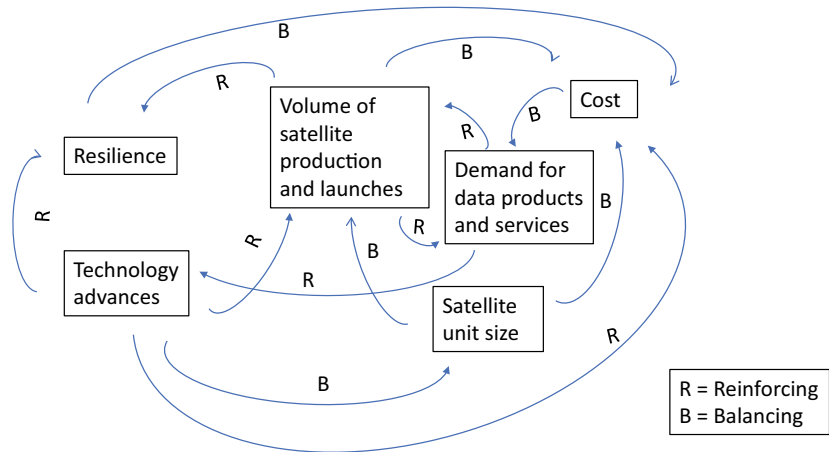


Fig. 2 Theoretical framework as feedback loops

which means more can be launched which in turn makes them more affordable per unit. At the same time, more units in space and the arrival of new technologies mean that systems are more resilient so costs decrease. As costs decrease, demand goes up and as demand goes up, volume increases. In Fig. 2, the block “technology advances” emerges as a key driver of cost reduction and demand growth. Technology advances include, for example, the upcoming wave of reusable rocket services, such as iSpace, Galactic Energy, Deep Blue Aerospace, and others that will challenge the only current reusable rocket firm, SpaceX, on price. For the time being, satellite demand and volume are fixed in a cycle of increase. Further research is needed to unlock precise relationships among these feedback loops.

In conclusion, this chapter has laid out key features of current space business indicating how it has changed over recent years. Further, the chapter has identified elements of theory that help explain how the business is changing and how it will likely proceed in the near future.

Limitations of scope and space prevent integration in this chapter of other potentially important issues such as decoupling from China and the potential separation of space programs into USA, Chinese, and Russian with consequent differentiation of technologies and lack of interoperability. In particular, the impact of decoupling on cost, resilience, regulation, societal benefit, and illegal business is too unclear at this point in time to address. There are, inevitable, more issues in technology, regulation, market demand, and other space business propositions than can be considered.

In general, space business is likely to grow due to the mechanisms of cost and scale described above. New technologies, as well as new challenges, are arriving rapidly while the legal and regulatory environment continues to coevolve alongside the business developments. Meanwhile continued investment, including national initiatives such as Japan’s \$6 billion space initiative announced in 2023, may further boost growth in New Space.

## 6 OVERVIEW OF THE CONTENT OF THIS BOOK

Including the introduction, this book presents 12 chapters. The second chapter, authored by Punnala et al., focuses on the space ecosystem by examining its current status and future prospects. The study presents a systematic literature review of 72 academic publications released between

2018 and 2022 related to the topic. The findings of the chapter enhance understanding of the nuances of the space economy, facilitate informed decision-making, and promote sustainable growth in the space sector.

The third chapter, by Alghani et al., investigates the architecture of the New Space Ecosystem through a systematic literature review method that analyzes 51 articles. This chapter contributes to our current understanding of New Space Ecosystems by identifying key dynamics that shape their architecture, delineating the distinct layers composing the ecosystem, and suggesting further research directions based on parallels drawn with digital platform ecosystems.

The fourth chapter, authored by Hassinen et al., presents a systematic literature review of the commercial aspects of navigation satellites. Through examination of 32 papers, the study identifies six themes and elaborates on their contributions to our understanding of the topic. The research reveals that while there is considerable interest in the technical features of GNSS (Global Navigation Satellite Systems), the commercial dimension of this market is still emerging. This chapter proposes further research directions aimed at better understanding the business models and ecosystems of companies operating in this industry.

In the fifth chapter, Punnala and Ratikainen investigate emerging innovation ecosystems in the realm of New Space. Using qualitative methods and the Kvarken Space Center in Finland as a case study, they offer insights that are applicable to similar New Space Ecosystems worldwide. The findings underscore the significance of collaboration among various ecosystem stakeholders and highlight the potential impact of such synergy on the New Space Economy.

The sixth chapter, authored by Brennan and Utrero-González, examines the recent evolution of the Spanish space sector. The authors demonstrate how the emergence of new businesses in the space industry has been influenced not only by traditional university-industry-government relationships but also by the experience and expertise developed by established “Old Space” companies. The chapter also highlights the emergence of bidirectional relationships between old and new market participants as a distinctive feature of the Spanish sector, which can enhance its competitiveness in the “New Space” scenario.

In the seventh chapter of the book, Baber and Ojala focus on emerging business model value chains in the New Space era. They provide an overview of eight different value chains within the context of space business. The chapter also elaborates on business opportunities within these

value chains and offers insights into emerging business model value chains in the New Space industry. Based on these business model value chains, the chapter presents feedback loops that firms can identify and benefit from when planning and implementing value chains.

The eighth chapter, written by Rasila and Ojala, emphasizes ground station regulations and how they vary across 20 different countries worldwide. The chapter highlights that varying regulations for ground stations might inhibit the successful global operations of firms operating such stations. Based on their findings, the chapter elaborates on different regulations and explains their impact on ground station operations. It also underscores the possibilities for foreign operators to establish ground stations in different countries and emphasizes the need for harmonizing regulations globally.

In the ninth chapter of the book, Cordova and Gonzalez-Perez focus on interplanetary supply chains from a business and management perspective, with a particular emphasis on sustainability. By synthesizing insights from existing literature, the chapter contributes to the ongoing discourse on interplanetary supply chains, their potential contributions to the UN Sustainable Development Goals (SDGs), and the multifaceted challenges and opportunities associated with sustainability in interplanetary business. Additionally, the chapter underscores the importance of responsible and sustainable space exploration for the future of humanity.

The tenth chapter, written by Haq, delves into the development of the New Space economy and explores how space data can be leveraged by firms. Employing an opportunity creation and development framework, the study evaluates the availability of space data across various business activities. Drawing from empirical findings, the chapter identifies key parameters to consider before integrating space data into new product development processes.

The eleventh chapter, authored by Jaskari et al., investigates suborbital space tourism. Based on qualitative data and mixed methods that combine face-to-face interviews, previously published interviews, and archival data, the chapter provides insights into the unique circumstances of space travel and the lived experiences of such journeys. It also introduces the concept of “doozy tourism” to illustrate the specific nature of space tourism, characterized here as a niche within luxury tourism. Finally, it delineates how experiences within space tourism can be divided into four phases.

In the twelfth chapter, Yang provides insights into the sociological shaping of space tourism. By integrating insights from institutional and

performativity theories, the chapter offers a nuanced sociological analysis of the burgeoning market for space tourism and emphasizes the importance of these theoretical lenses for understanding the social foundations of space tourism. The chapter also argues that a more comprehensive understanding of space tourism, informed by sociological insights, can pave the way for more equitable and sustainable practices that transcend purely commercial or technological achievements.

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