Exploring Emerging Business Model Value Chains in New Space

William W. Baber and Arto Ojala

1 Introduction

New Space represents an emerging frontier in the business world. It refers to entrepreneurial activities where risks related to the space business are shared among private business organizations, as opposed to governments and national space agencies (Paikowsky, 2017; Peeters, 2021; Weinzierl, 2018). This shift from national to private also signifies a focus on generating profits rather than achievement of space missions and research objectives.

The burgeoning sector of New Space is characterized by a combination of familiar business activities adapted to new conditions and entirely novel ways of conducting business, necessitating wholly new business models and value chains. Notably, recent developments in New Space have led to various business endeavors, including Low Earth Orbit (LEO) satellites

W. W. Baber (✉) · A. Ojala
Graduate School of Management, Kyoto University, Kyoto, Japan
e-mail: baber.williamwilmer.7x@kyoto-u.ac.jp

A. Ojala
e-mail: arto.ojala@uwasa.fi

A. Ojala
School of Marketing and Communication, University of Vaasa, Vaasa, Finland

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for communication, navigation, remote sensing, and more (Prol et al., 2022). In such a dynamic environment, new business models continue to emerge as demand and technology advance (Karami et al., 2022; Ojala, 2016).

A value chain is an important part of a business model (Foss & Saebi, 2017; Magretta, 2002; Osterwalder, 2004). It describes how firms create, capture, and deliver value within the business ecosystem (Al-Debei & Avison, 2010; Osterwalder & Pigneur, 2010). In New Space, value chains are extremely important because a better understanding of different actors, activities, and value creation aids in structuring the industry and identifying business gaps and novel opportunities. This also facilitates different actors within the value chain to improve efficiency, reduce costs, and gain competitive advantages in the market (Osterwalder, 2004).

To gain a comprehensive understanding of this evolving landscape and anticipate future developments in the New Space business, it is crucial to explore the broader business environment and delve into the intricacies of business model value chains in the New Space era. Our aim is to conceptually extend the understanding of this phenomenon by using previous literature, case examples, and expert interviews. The main question we are interested in addressing in this paper is: What are the current and near-future business model value chains of space business in earth orbit? These are explored at the basic level of industries—from basic inputs to final products and services—and in a macro-level aggregated value chain for the whole industry.

2 Literature Review

2.1 Business Models and Value Chains

In academic literature, there are several definitions for the business model concept. These definitions range widely from an explanation of how a business delivers value (Ojala & Baber, 2024), to stories explaining how a business operates (Magretta, 2002) and graphic-textual depictions of business elements and their relationships in an organization (Osterwalder et al., 2005). Business models can focus on single products and services, business units, or complex corporate entities (Wirtz, 2021). A business model can also function as a tool for communication, diagnosis, and innovation (Ojala & Baber, 2024).

Space business is a locus of business model creation, boosted by the connectivity of its ecosystem, new technologies, developing regulation, decreasing costs, and increased demand. Business models develop either through opportunity discovery or creation (Alvarez & Barney, 2007), existing opportunities and models are discovered, novel ones are created. There are also closely related concepts—effectuation and causation—that are presented in the effectuation theory by Sarasvathy (2001, 2008). An important aspect of effectuation that applies to space business is that firms should recognize that they can create new business models in concert with other firms within an ecosystem they inhabit. Such actions firms take in the market can lead to business model innovation (Karami et al., 2022), referring to changes or modifications in a business model (Foss & Saebi, 2017). These innovative processes lead to feedback loops, whether internal or involving other firms, that can be used to make business models more robust and successful (Casadesus-Masanell & Ricart, 2011).

The business model employs the value chain to explain how money is made (Rappa, 2001), thus business model value chains are vital to understand. Further, the value chain is an important part of the business model as it provides a detailed view of creating and delivering value (Porter, 2001). In her work, Magretta (2002) argues that value chains in a business model can be divided into two parts, one involving making things and another encompassing activities related to selling things. In the context of a business model, Osterwalder (2004) includes five primary activities, namely inbound logistics, operation, outbound logistics, marketing & sales, and services as value chain structures. Additional value chains, such as knowledge (Chyi Lee & Yang, 2000), have been proposed in management literature to specify the steps and infrastructure germane to certain business models and activities. In general business model literature, value chains are commonly conceptualized as value creation and delivery networks that describe where the actors are within the value chain and the how the value is delivered among the different actors (see, e.g., Foss & Saebi, 2017; Ojala, 2016; Osterwalder, 2004).

2.2 *Space Business*

Space business refers to a broad range of commercial activities in space and related ground-based services (Baber & Ojala, 2024b). Space operations are seen as reaching from suborbital (up to about 150 km) to LEO

(150 km to 2000 km) to High Earth Orbit (up to and including geosynchronous altitude) and into deep space (beyond geosynchronous, lunar space, and the solar system). In LEO, space business is dominated by commercial activities rather than by government activities although the latter sometimes contract to private businesses. In deep space, business is mainly driven by government contracting for exploration or research.

Space business comprises a complex range of technical products and services that are delivered by a constellation of firms that contribute to value creation. There are few vertically integrated players that dominate their market such as Boeing or SpaceX. Thus firms are commonly interdependent of complex and dense networks that form a business ecosystem (Baber & Ojala, 2024a). Under such conditions, feedback loops may emerge that strengthen or weaken the ecosystem (Baber & Yao, 2022; Fasnacht, 2020). These ecosystems serve as locations for innovation, particularly where they are open and highly interconnected (Fasnacht, 2020).

New Space refers to the recent trend of private businesses sharing risk through tools such as lending and equity investment (Paikowsky, 2017; Peeters, 2021; Weinzierl, 2018). In this model, risk is borne jointly among private business organizations instead of national space agencies shouldering most of the burden. Additionally, the emphasis in New Space is on generating profits rather than solely achieving the successful completion of a space mission. Finally, the focus in New Space is on commercial services rather than exploration and research.

In the context of space business, value chains encompass the enhancement value as various resources, products, and services pass through customers and partners as they culminate in tangible benefits, such as revenue, and intangible benefits, such as brand, relationships, and intellectual property. The complexity of space technologies and services, as well as the need for novel engineering and packages of solutions, means that constellations of value creating and sharing organizations may cooperate to achieve final results.

3 Discussion

In this section, we consider the value chains of the newly developing space business. In previous decades, the primary value chain of the space industry involved the design and construction of hardware such as rockets, satellites, and probes. The initiators of projects were national space agencies and leading space institutes while the funders were national governments. A parallel hardware-oriented value chain formed in the telecoms industry with regard to communications satellites. In addition to these chains of tangible value, there were intangible value chains that built up prestige and scientific knowledge. While these value chains continue to exist, more recent developments have brought about changes to those previous value chains as well as distinct new value chains. The seven value chains discussed below were developed conceptualizing real-life case examples, interviews with 13 business and academic experts working in the industry, and emerging literature on space business. They are linked by their salience to the contemporary realities of the business of New Space. These seven are not proposed as comprehensive, they are however at the forefront of the interest and thinking of the expert interviews conducted for this study. We then consider an eighth value chain for the overall space business industry. Thereafter we discuss opportunities in those value chains, emerging business models, and feedback loops of importance to the space business.

3.1 Value Chains in Space Business

3.1.1 Data Value Chain

The data value chain relies on the generation, transfer, refining, and organizing of data (Fig. 1). Data are the resource that is transformed in various steps from abstract digital form to polished user products. The generation and delivery of data rely on payloads that can be made of technical sensor packages and launch of those packages on a satellite body called a bus. The value chain of that hardware and related services is dealt with later.

The data value chain starts with goals and technical procedures set on Earth. These are issued as commands to satellites which execute them and thereby generate data. The resulting data are sent via ground stations to various kinds of customers. The customers repackage, refine, analyze, and interpret the data converting it into organized information and higher order knowledge. These steps may occur across multiple firms. Final users may include retail users, policymakers, and various kinds of firms. The value chain enables various business models that include part or all of the chain in one or more firms.

As an example, we can follow the data value chain through a firm such as ICEYE (https://www.iceye.com) a space data services company.

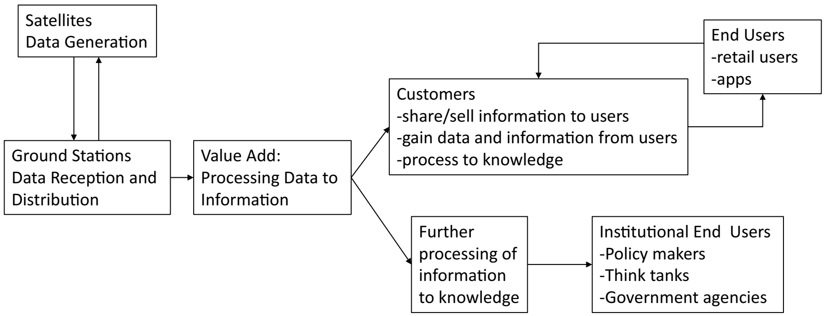

Fig. 1 Data value chain

ICEYE designs, builds, and controls a fleet of earth observation satellites while coordinating launch services with rocket firms and data services with other partners. In ICEYE, data are generated based on the commands issued by ICEYE, those data are processed by ICEYE to create information in various digital formats from maps to analyze of topographical changes. These data products are delivered to a range of paying customers, for example BAE Systems (https://www.iceye.com/blog/utilizing-sar-in-multi-sensor-data-collection). Customers and partners may further process and repackage the data for their own use or into products for sale, such as in the case with ICEYE and Windward AI (https://www.iceye.com/blog/iceye-and-windward-maritime-domain-awareness) or New Light Technologies. These products may also be delivered free of charge as freemium content to firms or governmental organizations making policy and strategic decisions.

3.1.2 Hardware Value Chain

The hardware value chain relates to the equipment needed for commercial exploitation of space (Fig. 2). As such, this value chain is similar to conventional value chains in which value is added successively through manufacturing and assembly after which much of the value is paid for the customers of the equipment while other pieces as capital equipment to generate more value.

The value chain starts with steel, titanium, rocket fuel, and similar basic materials. To these are added various kinds of processing, design, and many sub-assemblies. Services and sub-assemblies, from rocket nozzles to chipsets, arrive typically from smaller firms or business units of larger firms

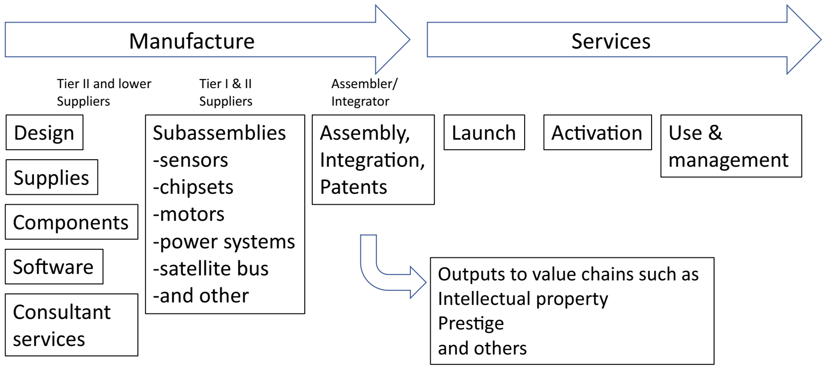

Fig. 2 Hardware value chain

until they are assembled by established firms such as Boeing and Airbus or newcomers such as Blue Origin or Space X. Satellites start similarly with basic materials, sub-assemblies, and services, with an increasing number of builders arriving to challenge major established firms. Generally, the hardware arrives with required software which the recipient firm may add to or revise. The final services include brokering of launches and joint payloads, launch, telemetry, and placement in orbit. Without these final services, the value chain cannot culminate. Thus a failed launch dampens all the value chains of New Space due to increased insurance costs and decreased equipment availability. Use and management is where the hardware value chain overlaps with the data value chain as physical systems are managed to generate and transmit data.

As an example, we can follow the hardware value chain through firms such as Advanced Structural Technologies, IHI, and Boeing that make titanium rocket engine parts to rocket assemblers such as Rocket Lab, CALT, and others. Modern rockets, especially reusable ones, also require complex electronic systems for guidance and control as well as onboard computing. Electronic systems are developed, for example, by rocket makers such as Astrobotic for their own systems as well as by specialist firms for rocket builders. Satellites range from tiny 1U (10 × 10x10cm) to 12U structures (12 times the dimensions of 1U), traditional large satellites that weigh several tons. This value chain finishes with delivery of a satellite to orbit and handover of control to a team or firm that operates it.

3.1.3 Intellectual Property (IP) Value Chain

The value chain of IP in New Space is built on the development of innovative equipment, code, engineering solutions, as well as basic science discoveries (Fig. 3). Two main kinds of actors, firms that make equipment and institutes that conduct research, generate IP which appear as discrete sets of knowledge and solutions that can be bought and sold similar to products for various purposes. Both kinds of actors keep the IP in order to accomplish missions and contracts as well as to patent it. Research institutes also generate new basic knowledge which they publish thus they are seen as fundamental contributor to the value chain (Lipic & Nikitas, 2020). The published research results may eventually be used to create more valuable IP. The value chain is tied to New Space through data collection that result from launched and ground-based systems. The IP value chain is only similar to conventional value chains in that knowledge and research results are upgraded in value as they move through various organizations until the value is realized by a customer.

In the value chain modeled in Fig. 3, data form the raw resource from which IP ultimately is fashioned. Data from institutes first lead to pure research output and knowledge creation which are generated mainly by satellites and processed by organizations such as universities and research institutes. These may be breakthroughs or incremental results that require many years to become IP. Pure research usually leads to

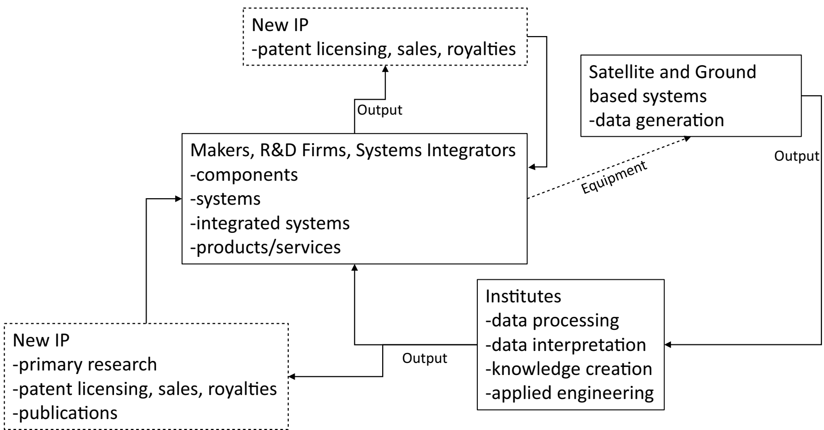

Fig. 3 IP value chain

publications which make no direct profit to the institution. These research results however are transformed later, often by equipment makers through processes of applied research and engineering, to become value creating assets such as equipment or patents which can be sold, licensed, or subject to royalties. Thus, the knowledge created by primary research feeds the IP value chain as a raw resource in need of refining.

An example of the value chain described above can be found in the development by Space Dynamics Laboratory at University of Utah of patents around atomic clocks which are necessary for coordinating space-based assets and communications (Space Dynamics Laboratory, 2020). The basic research behind the patent has been developed at numerous universities in previous decades after which the patent holder conducted applied engineering research to create a product with applications in satellites. A similar example is found in the satellite detumbler which was patented by Airbus in 2023 based on the reaction to the Earth's magnetic field. (Garcia, 2023). The invention was developed with the National Centre for Space Studies and may find buyers even among small satellite makers.

3.1.4 Prestige Value Chain

Since the first days of space research and exploitation, prestige, alongside security, has been a powerful though intangible motivation for investment and action (Cross, 2019). This section examines the building up of prestige, broadly the positive feelings of observers, rather than reputation which may be positive or negative, through its own value chain. In the model of the legacy space industry, prestige belonged to and was sought by the two leading countries, USSR and USA, and their lead space agencies (Curtis, 2018; Gurtuna, 2013; Rementeria, 2022). Other countries, such as Brazil, followed similar motivations as they entered space activities (Nakahodo, 2021). While prestige is still sought on the national level, it has more recently also been sought and captured by private businesses entering space exploration or commercial development (Curtis, 2018).

The Prestige value chain graphic, Fig. 4, tracks the creation and capture of prestige by nations and private firms. The space race of the 1950s–1970s involved only two countries and their national space agencies. Despite competition among firms and institutions within those countries, achievements, mainly creation of new knowledge about the cosmos and Earth as well as attention grabbing firsts, mainly served to boost intangible perceptions about though lead nations. In the New Space model,

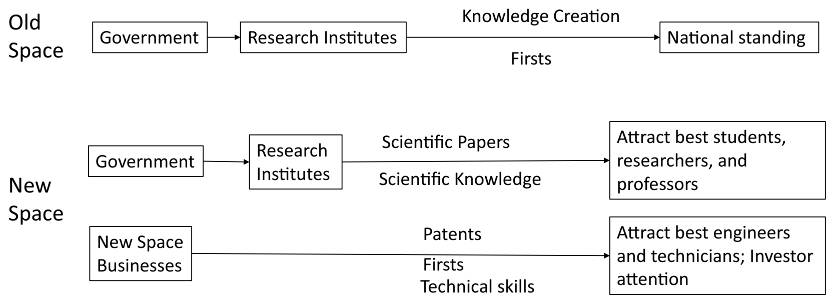

Fig. 4 Prestige value chain

however, prestige serves additional purposes, attracting talent as well as the attention of investors. In the New Space era, the capture of prestige takes two different paths. Governments support research institutes which generate scientific publications and knowledge which helps them attract the best students, researchers, and professors. This is the case in emerging space countries such as Oman, Israel, and India, as well as the USA. Meanwhile private firms also build prestige, mainly through firsts and technical ability, but also through patents. Their prestige helps draw talent into the company and investment whether from funds and wealthy individuals or from retail buyers of stock market shares.

An example of the prestige value chain can be found with Blue Origin, a firm noted for filing space-related patents (Haney, 2020). One reason for Blue Origin to file patents is to announce its technical success and build its prestige, another is to create revenue from patent licensing or sale. The prestige, however, may help to attract leading technologists to the firm (Palomeras & Melero, 2010).

3.1.5 Mission Planning Value Chain

From the start of the space age, mission planning has included a vital set of processes and practices to ensure safety and success. Generally, these practices deal with orbital insertion, telemetry, and control of a satellite but can also include design of the mission from sensors and equipment to movements and disposal at end of life. In the case of the legacy space business launches of science, defense, and communications missions, mission planning resided largely in national space agencies. In New Space, mission planning is a service which may be handled by launch firms or specialized

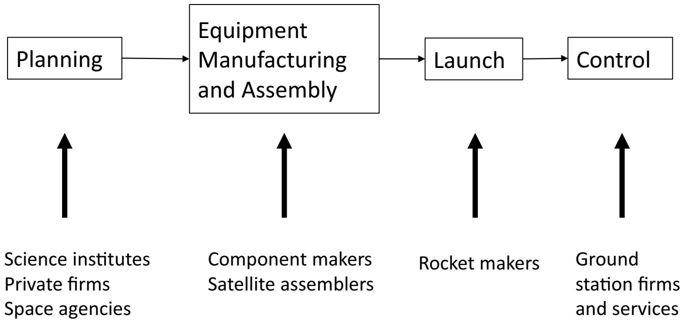

Fig. 5 Mission planning value chain

service providers. Overall, the value chain extends from service designers, whether private firms or scientific research institutes, through to ground station controllers (Fig. 5).

The value chain of mission planning conventionally begins with the creation of goals and proceeds to selection and design of equipment. Specialized equipment must then be created. Meanwhile, New Space relies increasingly on satellites that can be built in advance and used with little or no customization. This means that planning and equipment selection or design can be concurrent. The next step in the value chain is launch, in which value is created by placing the equipment in orbit. Launch and orbit insertion, as well as control thereafter, require the services of ground station operators. Mission planning may include other specifics such as return of reusable equipment. The mission planning value chain of New Space either concludes at this point with value realized or with the passage of satellites to mundane daily control. For commercial LEO payloads, planning may start only a few months before launch whereas in the case of deep space scientific missions, mission planning may commence many years prior to launch and continue for many years afterward involving complex maneuvers around planets.

An example of New Space mission planning begins with, for example, Advanced Space, which specializes in mission planning. The customers of Advanced Space include NASA. After planning certain elements of NASA's CAPSTONE mission, Rocket Lab launched the probe, and operational control returned to Advanced Space. Other firms may use their own systems or complete the mission planning work using services such as Microsoft's Azure or Amazon's AWS. Currently, the range of firms and their offerings in New Space means that any combination of services and firms is possibly including a single vertically integrated firm doing it all.

3.1.6 Tourism Value Chain

The value chain of space tourism starts like conventional tourism with multiple origination points such as the acquisition of tourists, preparation of conveyance, and design of experiences (Fig. 6). Unlike Earth-based tourism, however, space has no destinations other than the International Space Station, the target of a few visits so far. Thus space tourism remains for the moment, experience based. It appears to be technically and financially feasible for relatively low-cost habitations, inflatable ones, for example, to be constructed; however, it is not clear that these would attract visitors. Similar to some examples of experience or adventure tourism, significant training would be part of the value chain.

Like the mission planning value chain, the space tourism value chain starts with mission planning and experience design. This step is an analog to conventional Earth-based tourism in which travel packages are designed and planned. Thereafter marketing specialists and firms acquire the tourists in advance. Because space tourism is relatively expensive, the pool of prospective customers is small. Rigorous physical demands make the pool even smaller as health requirements must be met. At the same time as customer acquisition, specialized equipment may necessarily be designed and built. After confirmation of customers, training is necessary in order for customers to safely operate equipment and react to situations as they arise, including insurance of passengers. Further, evaluation and improvement of health and fitness are likely services to be required.

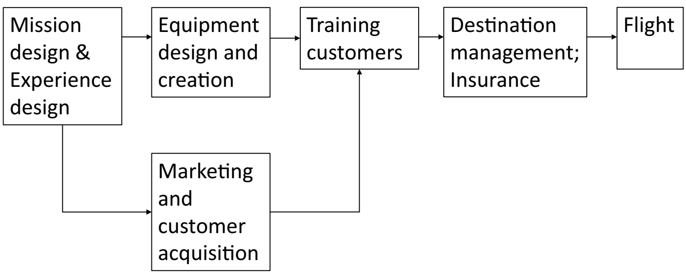

Fig. 6 Tourism value chain

The value chain culminates in the flight and return of the travelers and post-flight health evaluation. Thus the tourism value chain seems likely to add activities before flight, such as pre-flight experience and evaluation, as well as to extend into the space after the flight with services such as documentation and luxury recovery experiences.

In the case of the first space tourist, Dennis Tito, tourism design and planning, was done by Space Adventures, Ltd. while training was completed by NASA and Roscosmos. Blue Origin by contrast is vertically integrated regarding space tourism. The firm takes in interested tourists, trains them at a site they operate, and launches them into space. In another example, Axiom Space takes in-flight customers, trains them for scientific work aboard the International Space Station in conjunction with NASA at NASA facilities, and launches the participants with SpaceX.

3.1.7 In-Orbit-Servicing Value Chain

Space services and the related value chain are an emerging part of the New Space business-scape. The roots of this business area lie in the repairs made to the Hubble Space Telescope in 1993. Since then servicing of satellites and instruments in flight has remained rare and has been largely limited to unique high-value systems epitomized by the Hubble. Currently, tests have been made or are planned to repair, refuel, de-orbit, or park systems in space. Removal of space debris is an area of interest due to the risks of damage to orbiting assets.

Some service needs of satellites can be seen in advance, for example refueling and de-orbiting. A satellite's lifespan is determined in part by its remaining fuel, the last of which is kept for the purpose of de-orbiting or movement to parking orbit where the system can be abandoned. As service missions become cheaper due to decreasing launch costs and automation, reaction to unforeseen issues and even scheduled repairs are poised to become feasible. The value chain begins with the need of the space-based system (Fig. 7), whether foreseen and planned as part of the system's lifecycle or emergent due to debris strike, equipment failure, excessive fuel consumption, sabotage, hijacking, or other reasons. New missions and payloads for service vehicles may require planning in the next step of the value chain. An additional planning step may be needed to link or coordinate the abilities of various firms analogous to managing complex earthbound itineraries. On the other hand, highly automated systems with built in fixtures for grappling and connecting with satellites would minimize or obviate these steps. The next link in the value chain

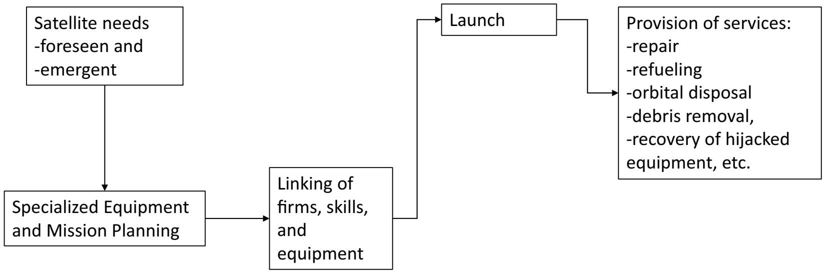

Fig. 7 Space services value chain

is the launch to orbit without which the final value cannot be realized. In space, the final value is realized for customers built on the value creation added and shared in previous steps. Because these kinds of services are not regularly in place, no examples can be offered other than hypotheticals. Only one high profile satellite, the Hubble Space Telescope, has received irregular service visits. In the future however, service units may be prepositioned to deliver fuel, to de-orbit satellites, or to replace standard sensor or communication modules. These services will mostly likely first develop for larger and more expensive satellites in mid-earth and high-earth orbits rather than for the less expensive fleets of micro and nano satellites typically found in LEO.

3.1.8 Aggregated Value Chain

In summary of value chains in space business, we present the view in Fig. 8. This graphic aggregates the value chains showing approximate value constellations, described as relationships among firms that contribute toward value creation and realization (Normann & Ramirez, 1993), of value creating entities. The number of participants in the value constellation is potentially large, though some firms are currently partly vertically integrated. The aggregate value chain starts with raw inputs from steel to data which feed the creators and deliverers of final products and services who present these to customers. Industrial customers may also present variations of the services and products to retail users initially or as follow-up services.

The aggregated value chain depicts a conventional progression from simple materials, whether raw data from sensors or titanium used in a satellite bus, to creation of final packages of products and services.

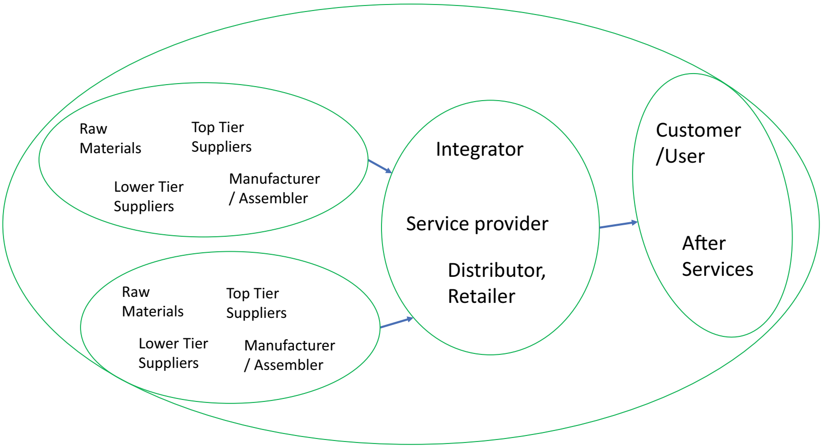

Fig. 8 Aggregated value chain

These upstream processes result in the products and services delivered to firms that undertake the focal activities of New Space and deliver outputs and services downstream (Garzaniti et al., 2021; Prol et al., 2022) to customers. The aggregated value chain may, for example, flow from data that feeds space research, which leads to engineering applications which combine with software to form function launch systems, satellites, and grounds stations which in turn provide data that can be sold raw, processed, or on demand. These data flows may in turn lead to new hardware systems. A concrete example is the NOAA data that fueled developments of Telstar satellites built by SSL which then created data and revenue flows allowing improved satellites. Telstar 19 V was launched by a SpaceX Falcon 9 rocket built of various components made in house and purchased from suppliers. The launch system as well as the satellite includes software as do the ground stations which in turn were built of assembled components and systems by firms such as General Dynamics. While these groups are separated by their activities and position in the flow of value creation, the entire system works together to create, refine, and realize value.

3.2 Apparent Value Chain Opportunities

Business opportunities are based on discovery or creation of opportunities and creation or re-assembly of products, services, and value creation partners to better meet current needs (Alvarez & Barney, 2007). Opportunities potentially can be discovered or created at all points in a value chain and can be filled by new businesses, services, and products. Because the space-related regulation and technology are evolving quickly, there are potentially numerous opportunities that will emerge in the near future. Considering the value chains described above, some gaps in services and products are readily identifiable while others will remain obscure except to visionary leaders.

Regarding creation and delivery of space-based data and services, there remains unknown but emerging demand for novel services. Thus firms can develop business activities driven by demand of customers as well as retail or institutional end users. On Fig. 1, delivery to end users and institutional users currently depends mainly on cellular and Internet infrastructure, even in non-urban parts of developed countries. The launch in late 2023 of direct-to-cell satellites by SpaceX is evidence of interest in this gap. Asset tracking remains largely in the realm of business-to-business services, but could soon devolve to retail customers for tracking their own property, pets, and belongings. Globally, watchdog organizations and government enforcement agencies may become more common business-to-government customers as cost decreases allow faster and more precise monitoring of illegal traffickers operating on seas and highways.

At the start of the data value chain, ground stations direct commands spaceward and receive data from satellites which they redirect to various customers. Location can be important to these ground stations. Due to national regulations regarding data storage, data location, and security, countries may insist on locations within their borders. In order to have frequent contact with a satellite or fleet, they may be placed in polar regions such as the Antarctic continent or even on rigs and barges in international Arctic waters. Emerging Artificial Intelligence tools are speeding the processing of data while adding more value with less cost thereby making it possible for firms to offer specialized niche tools or outputs.

Opportunities in the hardware chain include, above all, lower cost launch services which would allow more entrants to satellite ownership and operation which in turn would increase demand for launches.

Numerous firms are attempting to copy or improve on the reusable rocket success of SpaceX and are likely to achieve technological success in the near future. Other approaches include catapults, e.g., SpinLaunch and even artillery-style guns, both of which are potentially cheaper and less polluting than current rocketry. Another opportunity lies in creating and delivering cost effective and powerful low pollution fuels, for example based on methane, and compatible hardware, such as that being developed by JAXA and Mitsubishi Heavy Industries or in use at SpaceX. Advances in satellites, especially constellation types, onboard processing, and space-based networks seem likely to drive new value chain developments (Kodheli et al., 2021). Further opportunities will constantly arise in the inputs at the beginning of the value chain and onward as technologies around electronics, power supply, and materials improve.

Firms that produce or support production of IP, for example in the form of patents, brands, and novel solutions, will inevitably find openings to deploy their abilities and gain revenues—the space business thrives on new technologies and systems. In addition to accepting new technologies, this value chain in particular can be exploited by firms able to integrate new IP with existing systems. Integrators, central to the value chains as depicted in Fig. 8, are able to bring technologies together to create solutions that are usable by more customers and end users.

The value chains of prestige, mission planning, tourism, and space services are considered briefly next. The prestige value chain can be enhanced by firms that aid in building prestige through patent filing, patent law, public relations, and strategic identification of targetable firsts. The mission planning value chain has gaps for novel or competitor services in each part of the chain. Ride-sharing and payload coordination services have recently grown and further integrated or end-to-end services that link planning to operation may be in demand. Openings in the tourism value chain are particularly under scrutiny currently as this industry appears to be on course to develop quickly. Above all, customer acquisition is important in tourism. The time periods before and after tourist flights could become fertile grounds for services related to preparation, physical and mental well-being, documentation of the experience, and packaging of pre- and post-flight luxury experiences. Space services are currently limited mainly to remote fleet management. As launch costs decrease and key related technologies improve, some services could become regular. These might include refueling, repair, removal from orbit, recovery of control after hacking or a system failure, and similar services.

3.3 Emerging Business Models in Space Business

Some novel business models are under development or already available in limited fashion. These include:

Space cleanup

LEO is increasingly cluttered with dangerous debris. Currently, no business model and related value chains exists that would pay for cleanup. Funding however is likely to come from governments, which already fund this kind of technology development, and or from insurance companies seeking to minimize risk.

Tracking of mobile assets

Various kinds of objects and assets are in motion on the Earth that cannot easily be tracked. Broadly, GPS and similar systems allow tracking of equipment under two preconditions: that there is a transponder and that it is working. Thus illicit activities are easily maintained by removing or switching off transponders on ships, containers, and other assets. One application is anti-smuggling services through combinations of data, especially if interpreted automatically by AI, that could track ships of various sorts and possibly other smaller assets such as vehicles and containers in real time.

Detecting military assets and movements

Real-time tracking and identification of mobile and fixed military equipment, troops, and infrastructure have come to attention especially since the Russian invasion of Ukraine. Quickly arriving images and interpretation of those images have become staples of daily analysis and decision-making.

Planning and assessment of risks and disaster impacts

Business model value chains around planning and assessment of risks and disaster impacts are already in place though developing rapidly. Older models relied on requesting time on defense satellites and overflights to generate imagery. Recently, this model is substituting those data gathering methods with LEO observation satellites which require less advanced planning, less or no maneuvering, and which generate more data faster. The higher flow of data in turn necessitates improving analysis tools but increases the applications and value of the processed data. Tracking services already include dryness, weather, wind, vegetation, and wildfire fuel volumes for applications in agriculture, weather forecasting, insurance risk forecasting, as well as disaster prevention and mitigation.

Systems to replace or supplement GPS/GLONASS signals

Geolocation-based satellite signals are already a high-value service. However, these systems can be jammed locally, and in increasingly large areas, by terrorists or uncooperative governments, as well as for defense against weapons enabled with these navigation aids. Approaches such as space-based laser communication or identification of routes and locations using visual or LIDAR image databases of physical topography and infrastructure would enable supplementary or substitute data for guidance despite jamming of other kinds of signals.

Cybersecurity for space-based assets and space-ground communications

Various existing and emerging software technologies and suites of services could boost reliability of space-based data delivery and prevent hijacking of hardware. As this has become the norm on personal devices, it is likely to become increasingly common on space-based systems.

Pre-positioned orbital supplies

Positioning objects in orbit remains expensive but will become less so in the near and midterm future. While positioning such supplies is a business activity of its own, it would allow more complex services to be created and delivered as discussed above. The variety of things that might be pre-positioned include emergency human habitats, emergency supplies, fuel, rescue systems, orbital junkyards composed of existing dead satellites to be recycled, automated dispensers of parts, robotic tugs, and more.

Shared economy in space

The International Space Station allows commercial experiments to be placed and conducted in space, in effect a shared-economy activity. Such activities could increase with so-called manufacturing hotels in which processing, prototyping, manufacturing, and experimentation could occur. These hotels might include human attendees or be fully automated. Human habitats and hotels or health clinics for special treatments might also exploit shared spaces, though luxury space experiences seem unrealistic for the foreseeable future.

3.4 Key Feedback Loops

Feedback loops are found in value chains when one element in a system inputs to a second element which then increases the strength of the first which therefore increases the input and output of the second. Negative feedback loops, decreasing output loops, are also possible. The first chapter of this book describes feedback loops in the current space business. Business actors may be able to adjust feedback loops to rapidly increase or decrease demand for a service, consumption of products, or ability of a technology to perform. Even if they cannot impact a feedback loop, firms may be able to identify and benefit from these features of value chains.

Key feedback loops to consider for exploitation in space business value chains include:

- Demand for data due to political and climate risk which increases launches which in turn decreases cost of data generation;
- Increases in data generation with decreased cost may raise demand for data services, i.e., just in time data, asset tracking, awareness as a service, and so on;
- Development of advanced algorithms and AI that can automate the structuring of data and compiling of reports may cut cost while increasing quality the combination of which may fuel demand for data services;

- Space debris, a negative feedback loop, may get out of hand and shut down certain kinds of orbits while requiring new launches and new technologies to cope;
- Increased hacking of equipment and data, a negative feedback loop, will increase all costs due to replaced equipment, increased insurance, and requirement for new technologies and cybersecurity services.

Other feedback loops will likely emerge that allow entrepreneurs and established business organizations to discover or create new products and services.

4 Conclusions

In this chapter, we demonstrated eight different business model value chains in New Space business, business opportunities within these value chains, and provided insights into totally new types of business model value chains emerging in the space business. Based on our knowledge, this is among the first studies revealing and explaining business model value chains in New Space business.

The value chains investigated in this study include seven internal to the space business and one general value chain for the space business that aggregates the other seven to provide an overall business model and value chain logic of space business in current times. Of these seven value chains, previous studies have considered the value chains of data, services, hardware, and tourism. To our knowledge however, none of those has been investigated in the context of space business. Moreover, the value chains of IP, prestige, and mission planning have not been considered in academic literature at all. Additionally, this study has considered feedback loops found within the value chains of the space business.

Based on our conceptualizations related to the value chains, further studies are needed to refine and empirically validate the chains. We believe that qualitative case studies work best to get more detailed insights about activities, actors, and processes within value chains. Thereafter, quantitative studies can be used to validate the refined value chains.

This study includes certain managerial implications. Above all, managers should consider the key value chains and investigate how they may claim positions in them and exploit feedback loops to their advantage. Where gaps may appear, executives should handle these as opportunities for discovering or inventing business model innovations.

The value chains of space business models wind through the space business ecosystem offering countless potential interactions to create and realize value.

The authors expect the space business to continue rapid development regarding numbers of participants, new technologies, and new combinations of services and technologies. We hope the readers of this study will expand their businesses and research as they investigate all forms of space business.

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