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ORIGINAL PAPER

Strategic similarities between earth observation small satellite constellations in very low earth orbit and low-cost carriers by means of *strategy canvas*

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Abstract

The space industry is growing and space data are becoming accessible to businesses that were previously unthinkable. Constellations of small satellites in Very Low Earth Orbit (VLEO) have created a gap that is allowing small and medium-sized space companies to gain momentum by developing new strategies and technologies. According to Euroconsult forecasting, the NewSpace market will grow from $12.6 billion to $42.8 billion in the next decade (2019–2028). Despite the study's limitations and the uncertainties of the small satellite market, the results obtained in this exploratory research suggest that the Low-Cost Carriers (LCC) market, an already established market in the aviation industry, and the growing market of EO small satellite constellations in VLEO have similar behaviours. This behaviour shows that the evolution of EO smallsat constellations in VLEO is comparable with the evolution of the LCC airlines. In addition, the result also identifies a set of competitive factors that allow the researchers to observe similar strategic behaviour in both markets.

Keywords Earth observation (EO) · Small satellite constellations · Very low earth orbit (VLEO) · Low-cost carrier (LCC) · Strategy canvas · Blue Ocean Strategy (BOS)

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1 Introduction

Twenty years ago, the idea of a constellation of satellites appeared on the market with Iridium and Globalstar. These companies offered communication links worldwide with limited success, mainly due to operative costs [1, 2]. At that time, their business models were not sustainable due to the small market and the high capital and maintenance costs.

Access to space has since expanded thanks to technological miniaturisation that allows satellites to be made smaller and lighter with a corresponding reduction in cost [3]. According to Sweeting [4], small satellite constellations have a great potential in three industries: (i) communications (Internet of Things and machine-to-machine applications), (ii) Earth Observation (EO) for science or business, and (iii) spatial observation for continuous monitoring and surveillance.

In this study, research will focus on the commercial EO small satellite market. Euroconsult [5] states that, between 2009 and 2018, 190 EO satellites were launched worldwide and 54% of them came from leading large space programs such as NASA, ESA, JAXA, etc., compared to 22% launched for commercial purposes. However, this trend will be reversed in the next decade. Euroconsult [5] estimates that, between 2019 and 2028, 830 EO satellites will be launched and only 21% of them will be part of large agency programmes, while commercially deployed satellites will rise to 68%, meaning that small satellites will receive attention from large companies [6]. Furthermore, the forecast estimated a significant increase in the launch rate for small satellites (from 1 kg up to 100 kg) [7]. Specifically, Bryce Tech [8] states that 2,013 small commercial satellites were launched between 2011 and 2020, of which 609 were for EO commercial purposes.

Figure 1b shows that smallsats are experiencing a remarkable growth in the next decade, just as Low-Cost Carriers (LCCs) did in the late 2000s and early 2010s, a decade after their appearance in the late-1990s/early-2000s (Fig. 1a).

On the one hand, LCCs (e.g. Vueling, EasyJet, or Ryanair) focus on reducing operational costs to increase their revenues by offering a simple business model against traditional Full Service Carrier (FSC) airlines (e.g. Delta Airlines, Iberia, or United Airlines) that offer a better experience to passengers at higher prices. On the other hand, small satellite EO constellations like the Dove satellites from Planet [11], Aleph-1 from Satellogic [12], or UrtheDaily/OptiSar from Urthecast [13], are low-cost constellations orbiting in Very Low Earth Orbit (VLEO) and provide high-quality data at low-cost for commercial purposes to Small Medium Enterprises (SMEs). These satellites compete against established companies such as Maxar Technologies [14], ESA [15], CNSA [16] or US Space Force [17] that manufacture large, complex, and costly EO satellite constellations in Low Earth Orbit (LEO) and Middle Earth Orbit (MEO) that provide high-resolution images at a cost that only governments and defence organisations can afford. So, we wonder if the *evolution of the EO small satellite constellations in VLEO could be compared to the LCC airline industry*.

We will use exploratory research to carry out this study since we will be tackling a new problem that has not previously been researched [18]. The study does not aim to provide a definitive solution to the problem, but it aims to understand the research question better. The exploratory research attempts to investigate if the evolution of the LCC airline market has any analogy with the future evolution of EO small satellite constellations in VLEO. For this purpose, a survey has been conducted that allows researchers to see if smallsat constellations in VLEO are operating in a Blue Ocean, similar to when the first LCCs appeared in the aviation market (see Fig. 2).

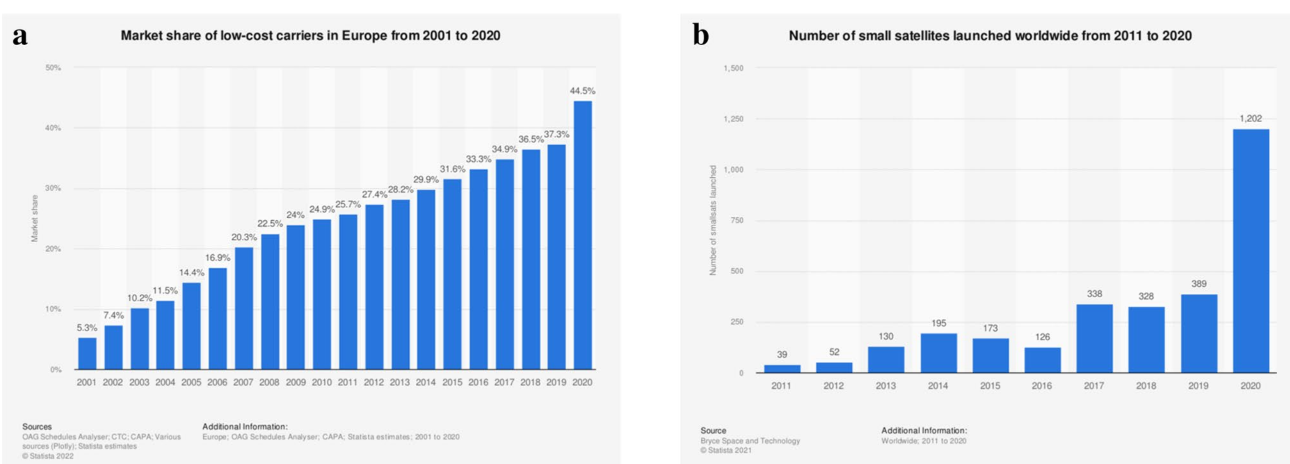


Fig. 1 **a** Growth of the LCC airlines market share [9], **b** Growth of smallsats [10]

The article begins by examining the evolution of the LCC airline industry and the evolution of the satellite constellation industry. It follows a brief introduction to the blue ocean strategy and *Strategy Canvas*. The competitive factors for operating in the blue ocean in both industries, LCC and EO small satellite constellations in VLEO are identified. Subsequently, the methodology used to carry out the study is presented. Next, the results obtained in the survey are discussed and plotted through the Strategy Canvas tool. Finally, conclusions are drawn, where the main analogies between both industries, the LLC airlines and the EO small satellite constellations that operate in VLEO, are exposed.

Fig. 2 Number of routes and number of flights during 1990–2013 [25]

2 Conceptual background

After regularising the aviation market, the first LCCs occupied a free market space making flights accessible to the middle class. Thanks to the NewSpace phenomenon, this is also happening in the space market. For commercial purposes, small companies that operate constellations of small satellites such as Planet, Satellogic, etc., have grown in the space market to serve SMEs (a neglected market sector). This was previously unfeasible since only national space agencies or the large private companies like Maxar Technologies could offer these services to governments and the defence departments.

After observing the evolution of the low-cost airline industry in recent decades and the growth of companies that operate EO small satellite constellations in VLEO, a series of competitive factors (see Table 1) have been identified following the Blue Ocean Strategy that factors are equivalent to both industries. According to Kim and Mauborgne [19], the Blue Ocean strategy simultaneously searches for differentiation and lower cost to create a new market space and generate new demand. Therefore, both industries, LCCs and Smallsat constellations, can be considered blue oceans.

In addition, the development of both industries has a positive social impact as well as economic and industrial growth. For instance, LCC airlines have made it possible for more people to travel and have also boosted tourism, improving the economy of many countries. The same happens with

Table 1 Competitive factors to operate in a blue ocean

Action	Competitive factor	Factor definition for LCC	Factor definition for constellations
Eliminate	Quality	Reduce the passengers' comfort severely (seat pitch, airport checking, etc.)	Reduce severely the lifespan of small satellites and the number of redundancies
	Policies	Reduce severely the in-flight free services (baggage checking, entertainment, meals, etc.) and the flexibility of the flight	Reduce severely the flexibility in choosing the orbits and altitudes
Reduce	Platform	Reduce costs using secondary airports	Reduce costs using secondary launching methods as piggyback or launched through the International Space Station (ISS)
	Infrastructure	Reduce costs using small aircraft	Reduce costs using cheap ground stations and communication networks
	Post-service	Reduce extra services such as included baggage, car renting, hotel reservation, etc	Reduce post-process services (Value-Added Services) such as imaging post-processing, artificial intelligence, etc
Rise	Technology	Promote technology development to increase efficiency	Promote compact technology development to reduce weight and increase spatial and time resolution
	Efficiency	Increase the efficiency of the fleet utilisation (reduce ground times and delays)	Increase the efficiency of the resources (agile design method, standardise the process, etc.)
	New players	Increase the number of airlines able to make the same route	Increase the number of satellites of similar size and utilisation launched
Create	Utilisation	Operate local and point-to-point flights	Operate short life-span missions
	Standardisation	Standardisation of the airline fleet, just one type of aircraft	Standardisation and modularity of the design and manufacturing of the satellite
	Pricing	Define low ticket prices	Define low mission budgets

small satellite constellations in VLEO, that have made possible the democratisation of data and access to space for many companies that was previously unthinkable.

2.1 Airline industry evolution

The airline industry has changed over the decades to turn into what can be seen to be a globally competitive market with many players and where there are differences between airlines.

In the 1970s, commercial aviation became a trend with the creation of the first LCC of the United States of America (USA). Due to economic and political interest, which led to the US Airline Deregulation Act of 1978, Europe followed this example and started the process of market liberalisation in 1983 [20]. After a decade of bilateral agreements between countries, the European Union (EU) established the first package of deregulation measures in 1988. However, the real impact for airlines was achieved with the third package of legislation in 1993 [21] because the European Commission (EC) wanted to progressively liberalise the industry to avoid problems experienced in the US [22].

Thus, the gradual liberalisation of the EU's internal aviation market resulted in an open internal market in 1993, generating a series of supply-side responses, which are in part comparable to the changes demonstrated in the deregulated aviation market of air transportation within the US.

In Europe, liberalisation began in very different socio-economic and political circumstances than in the USA. A national state airline already operated a starburst international and intercontinental network at its home base in each EU member state. According to Burghouwt and De Wit [23], most international and intercontinental starburst networks are not hub-and-spoke networks in the strict sense, since time coordination of flight schedules was lacking in those operating bases. The expansion of the European market can be divided into three different phases.

The first phase occurred between 1990 and 1993. It started with the second package of liberalisation measures in November 1990 until the third package came into force in 1993. This second package gave all carriers in the EU the opportunity to carry unlimited third and fourth freedom traffic,[1] but still with substantial restrictions in terms of multiple designations and fifth and seventh freedoms. This was also influenced by the economic recession of the early 1990s. This period is characterised by relatively low growth rates in frequencies and routes compared to the second half of the 1990s.

The second phase, between 1994 and 2000, was characterised by rapid growth in the number of flights and the increase in the number of routes, translating into an increase in the average weekly frequency per route.

The second half of the 1990s offered favourable economic and regulatory conditions for the emergence of flag carriers in Europe that operated hub networks centred on their domestic airports. Economic growth stimulated aviation demand, fuel prices were falling, and many routes were still underserved. The third package gave them unlimited third, fourth, fifth, sixth, and seventh freedom rights and, as of April 1, 1997, also eighth and ninth freedom rights, exactly what was needed to develop national operations centres. At the same time, some low-cost airlines were testing the market and slowly took off.

Full access to the EU aviation market allowed low-cost airlines to fully penetrate the European market, including domestic markets, following the Ryanair business model (from 1995). LCCs entered the market with a friendly legal environment that allowed them to set their fares and fly freely throughout the territory and establish themselves as a viable alternative to traditional airlines in the late 1990s, rapidly gaining market share since the introduction of online booking platforms [21]. They used this opportunity to establish a larger number of crew and aircraft bases throughout Europe, while flag carriers remained designated at their home bases.

Thus, beginning in 2000, the rapid growth of the low-cost airline segment, in combination with a decline in the share of full-service airlines, resulted not only in further growth of the EU route network but also a stagnation of the growth of the frequency and the decrease of the average frequencies of the routes in this third phase of post-liberalisation. As shown in Fig. 2, the trend after the 2000s is a stabilisation of average route frequencies and a growth in frequency promoted by low-cost airlines.

The commercial airline industry continued to grow in the new century's first decade, doubling pre-deregulation traffic in 2008 [26]. Although growth has slowed down in the last decade, the LCCs have not. According to Euroconsult reports [27, 28], LCCs have grown in Europe, from 23% in 2010 to 30.6% in 2017 of the airline's market share.

As a result of liberalisation, the national flag carriers developed their domestic hub-and-spoke networks in the 1990s into full-fledged hub-and-spoke systems with intensified wave systems, leading to a rapid increase in connectivity of the hubs. The rise of hub-and-spoke systems in Europe

[1] On May 20, 2009, in Manila, Philippines, a Multilateral Agreement on Air Services was signed to remove restrictions on air services that allow passenger air services to be operated to any designated point in the ASEAN sub-region. It means that any Contracting Party of the Member States of the Association of Southeast Asian Nations (Government of Brunei Darussalam, the Kingdom of Cambodia, the Republic of Indonesia, the Lao People's Democratic Republic, Malaysia, the Union of Myanmar, the Republic of the Philippines, the Republic of Singapore, the Kingdom of Thailand and the Socialist Republic of Viet Nam) belongs and vice versa with full third and fourth freedom traffic rights [24].

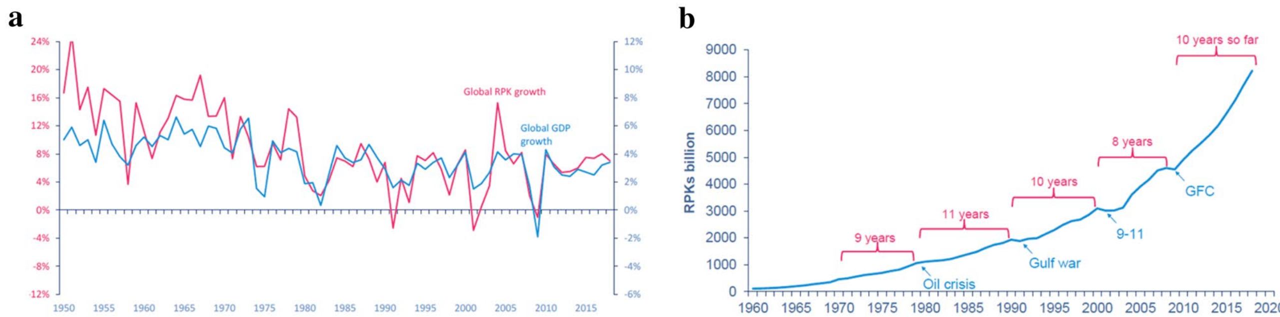


Fig. 3 **a** Global GDP versus Global RPK (Revenue Passenger Kilometer) [31]. **b** Global RPK from 1960 to 2020 [31]

also allowed for the rise of intercontinental multi-hub systems with alliance partners worldwide.

The current trend for FSC airlines is to try to enter the low-cost market by taking some of the factors, creating LCC subsidiaries, and making alliances with other low-cost airlines.

2.1.1 Drivers that allow LCC to succeed

Several external and internal drivers allow LCCs to succeed in the airline industry. A PEST (Political, Economic, Social, and Technological) framework has been used to identify the external drivers.

According to Alessandro's ebook [29], three main drivers affect the degree of government interference in the aviation industry and influence how airlines conduct their businesses: deregulation, countries' agreements and cabotage. Deregulation drastically changed the competitive environment of the aviation industry. While airlines were operating more routes at the fares they wanted, they were also more exposed to increased competition, forcing airlines to focus on cutting costs and fares. Open skies agreements between nations are bilateral and sometimes multilateral agreements between two or more nations to liberalise the regulation of the international civil aviation industry and ultimately lead to eliminating or reducing barriers that prevent competition. These agreements have made it possible for airlines to partner with foreign entities. The cabotage rules mean that all countries have the right to deny airlines from foreign countries the operation of flights between two national airports. Europe is one of the only aviation markets that allows cabotage for all airlines from countries with open skies agreements with the EU.

Considering the historical data, some economic factors hugely impact the airline industry. These include the relationship between Gross Domestic Product (GDP) demand, cycles in aviation, and fuel prices. Historically, the demand for air travel has increased or decreased with considerable GDP growth, as shown in Fig. 3a. The aviation industry has also historically been cyclical. The industry shifted from years with high growth rates to facing declining growth rates and even negative growth, as shown in Fig. 3b. The impact of fuel prices on airline operating costs must be seen in connection with the increase in the price of crude oil. In 2008, when the average price of a barrel of crude oil was $99, it represented 32.7% of total operating costs, the highest level reported [30]. It is worth mentioning that the cost of fuel as a percentage of the total operating cost varies greatly between airlines. The exposure of LCCs to crude oil price volatility is greater than FSCs, as the fuel price has a greater impact on LCC costs.

Social drivers are likely to be the most important factors for change in the airline industry as, unlike a couple of decades ago, the vast majority of society can afford air travel. The appearance of the LCC has had a great economic and social impact as it has allowed more people to travel. This fact is reinforced by the growth of airlines, which is linked to GDP, which in turn is related to the evolution of the economies of the airlines. Of all the social drivers, we highlight e-commerce, travel trends during economic downturns, and passenger types. Thanks to the emergence of online platforms, airlines in general, especially LCCs, experienced greater ticket purchases online than offline travel agencies. However, travellers become more price-sensitive during economic downturns. They seek to obtain the cheapest rate even if this means that they must give up some benefits. Finally, different types of passengers have emerged, including millennials. They are open to new experiences and have a global perspective which values diversity and can be valuable to the airline industry.

Lastly, there is an interplay between technological development, fuel-efficient solutions, and the green approach in the airline industry. The airline industry's main technology drivers are online ticketing, aircraft and engine upgrades, and jet biofuels. Online platforms have changed the way customers buy tickets and how airlines make sales. Customers can easily compare fares and book the lowest fares on any route through online platforms such as internet search engines, Expedia or Skyscanner. On the other hand, environmental awareness has become increasingly important. Airlines must participate in the issue of environmental sustainability by reducing CO_2 emissions through a fleet of fuel-efficient aircraft. Finally, to reduce CO_2 emissions, the airline industry explores alternative, more sustainable fuels that leave a lower carbon footprint than conventional jet fuel. According to IATA [32], jet biofuels are the best option to meet the reduction of CO_2 emissions.

The internal factors that helped the development of LCCs over FSCs have been divided into strategic and performance drivers since they act differently in airlines.

Strategic drivers are focused on the business side of the aviation industry and how it can be optimised. These drivers include organisational structure,[2] culture, strategic alliances, technology, and outsourcing.

According to Abhimanyu and Fariba [33], the organisational structure is a key factor that unifies the organisation system, and the market companies serve. Airlines must be organised along functional lines, such as marketing, finance, and operations, allowing the company to operate in a clear chain of command and focus on its strategies to generate competitive advantage and promote technology development to increase efficiency.

According to Henry [34], a common organisational culture is the only internal element of an organisation that can unify all its employees and their actions towards the company's vision. For example, Singapore Airlines employs various forms of rewards and recognition such as performance-based shares that have earned the airline a position as "the best airline" with "the best cabin crew service over the years" despite the reduction in passengers' comfortability, the in-flight free services, and the flexibility of the flight.

Thanks to strategic alliances, EU-US Open Skies and Sky Team stifled competition on the routes they fly. The benefits of strategic alliances range from shared codes, coordination of centres, reciprocal sales agreements, maintenance, higher traffic levels from the development of new markets, ease of baggage transfer, single check-in for multiple trips, and a combination of frequent flyers programs. All of this leads to cost savings with differentiation that is substantial in generating a competitive advantage within the airline market. Other elements that lead to cost savings for LCCs are using a fleet of standard and small aircraft, operating on local and point-to-point flights, and using secondary airports.

Airlines use technology to increase comfort and reduce costs, as carriers incur high costs for labour, inefficiencies, and fuel. Information, Technology and Communication (ITC) systems have improved executive decision-making and customer service activities. For instance, customer profiles can be used to design products and make decisions about the most profitable products, customer loyalty programs, the most profitable routes, and human resource management.

Finally, airlines must focus on their core activities to develop excellence. Support activities that are not provided by in-house capabilities should be outsourced as the provider is better positioned to deliver its specialty services. The benefits of outsourcing are related to airlines' high labour, fuel, and capital investment costs. Carriers also benefit from the flexibility of outsourcing, so there is less risk and uncertainty (risk transfer to service provider) to deal with in a dynamic and changing environment.

Performance drivers are focused on the service side of the aviation industry. To be successful, an airline must be effective in four general areas: customer attraction, fleet management, people management, and finance management.

In the first area, two factors need to be optimised: customer attraction, (1) the attractiveness of the airline's services, and (2) the effectiveness of the airline's promotional spend. The relative price of tickets is by far the most important factor. A lower relative price is generally more attractive to most travellers.

In the area of fleet management, aircraft utilisation (in hours per day), is concerned with how well the major assets of the companies (the aircraft fleet) are used as a group, as well as how well the average individual aircraft is used regarding the relative load factor[3] of the industry.

In the people management area, productivity[4] and morale[5] are factors that airlines are encouraged to measure. Still, in some cases, for example, in LCCs, the former prevails over the other.

The last area is financial management, where six factors are considered. The unit revenue, the unit cost, and its relationship since a better unit revenue may not be advantageous for an airline whose unit costs are out of line. In addition, financing for growth is also an important factor in the long-term success of an organisation. Most successful organisations choose to grow over time. For airlines, growth is measured in terms of capacity growth. Also, to grow, an airline needs adequate funds. A reasonable debt-to-asset ratio is also desirable to be attractive to most debt investors.

[2] Organisational structures are patterns that define the way work is done by clearly structuring positions, responsibilities, authorities, power, communication systems and the location of human resources within the organisation.

[3] The load factor is the proportion of seats on an aircraft sold and filled at the time of departure. The difference should be as large as possible.

[4] Productivity is a measure of how effectively employees work together to move passengers from one location to another. Productivity is measured in miles of available seats per employee.

[5] Morale is a measure of how committed employees are to providing good service to airline customers.

These drivers allow researchers to approach the set of competitive factors listed in Table 1.

2.2 EO small satellites constellations industry

Human exploration through space has evolved since the first specifically designed EO constellation began in 1972 by NASA with Landsat[6] [35].

It was not until the late 1980s that EO satellites were used in France for commercial purposes. They began to build a business model related to selling satellite images and their information to cover operational costs [36].

In the 2000s, the NewSpace market concept emerged as a low-cost concept for the space industry [36] and allowed smaller companies like Planet, Satellogic, or Spire Global to enter the market and democratise the information for commercial purposes. The implementation of Google Earth in 2005 was a starting point for large EO constellations that led to a boost in the NewSpace industry around 2010 [36].

In recent years, the launch of small satellite constellations in VLEO has seen a tremendous increase in the EO and communications markets. According to the Euroconsult report [37], more than 500 smallsats were launched in 2015–2019 with the market value estimated at $7.4 billion. This is due to the reduction in cost of the manufacture and launch of satellites and the large number of high-resolution images that can be obtained with cheaper payloads. Economic trends in the space industry also reveal a notable decline in government space revenue from the commercial sector [38, 39].

By mid-2015, new launch options were available for small satellites and secondary payload opportunities had become more widespread and could be scheduled at shorter notice. This phenomenon is reflected in the evolution of the number of launches of small satellites per year (Fig. 1b). This fast evolution of the small satellite missions plays a key role in developing new technologies and the growth of the private sector since small satellites tend to be more flexible, their development time is shorter, the operational costs are cheaper, and they show faster results.

In the coming years, according to a Pricewaterhouse-Coopers report [40], the need for EO data in geoinformation products and the increasingly central role of Big Data reinforce the potential for the development of commercial activities, making the young EO market particularly promising.

The increasing number of satellites launched in VLEO and LEO orbits raises a question as to whether it is possible to maintain this rate of development or not. For this, the constellations will require a paradigm shift in how space missions are currently managed, with significant technical, administrative, and regulatory challenges.

Critically, there is no regulation regarding the space traffic management. The United Nations created, in 1959, the Committee on the Peaceful Uses of Outer Space to develop the legal framework for the space industry, which was followed by the inauguration of the United Nations Office for Outer Space Affairs in 1962. The currently accepted treaty is the Outer Space Treaty of 1967–1984, reinforced by the Registration Convention of 1975, which obliges all objects to be registered [41]. Currently, each country has its own legislation on what can be launched and under what conditions [42]. Besides, the common practice is to search for a technically and economically viable solution to reach the identified free orbital slot. Muelhaupt, Sorge, Morin, and Wilson [43] envision an architecture similar to air traffic management with traffic zones (orbital slots) and flight plans. This situation may be true, but with thousands more spacecraft soon to be in orbit, an EO satellite may unexpectedly find another in its field of view, or a region of space may become so overcrowded, affecting the reception quality of EO images.

2.2.1 Drivers that allow small satellite constellations to succeed

Some of the drivers considered for LCCs that correspond to trends in the satellite industry can be analysed, especially the EO small satellite market. The main observed trends in the literature are (1) high demand for (V)LEO value-added services (VAS); (2) new technology developments to increase image resolution, compact technology to reduce satellite weight and increase spatial and time resolution of satellites in orbit; (3) low-cost approaches to manufacture and assembly small satellites that reduce the level of investment capital compared with the large satellites; (4) new ground station (GS) network infrastructure that reduces the operational costs of downlinking the data; (5) new options for access to space that reduce operational costs; and (6) new regulation policies that ensure spectrum availability, on-orbit activities, and manage space traffic [44, 45].

According to a research and market report [46], the size of the global small satellite market is projected to grow from $2.8 billion in 2020 to $7.1 billion by 2025, at a CAGR of 20.5% from 2020 to 2025. The main factors behind the growth of the small satellite market are driven by various factors such as the increasing demand for LEO-based services, the demand for EO imaging and analysis, and the increasing number of space exploration missions. Specifically, small satellites are used in a constellation architecture to collect EO data and telecommunication purposes. They are also used for in-orbit inspection of large satellites and for testing new technology development.

[6] Landsat represents the world's largest continuously acquired collection of moderate-resolution space-based terrestrial remote sensing data.

To meet the growing demand for high-resolution imagery, new technologies, specifically related to VLEO [47], that provide better image resolution, onboard processing technologies [48], better radiometric performance, and reduce spectral bandwidth congestion using advances in optical communications like laser inter-satellite links [49]. Components and subsystems have been miniaturised to reduce the weight and the manufacturing costs and to speed up the assembly cycle of small satellites. New technologies such as Atmosphere-Breathing Electric Propulsion (ABEP) are also being investigated to eliminate propellant storage and enhance the life-span of the satellite, given that in VLEO orbits the satellite could utilise particles collected from the residual atmosphere itself [50] with solar cells to power the electrical subsystems of the satellite through sunlight.

The low-cost development approach in manufacturing and assembly techniques will not only reduce the cost of developing and operating a constellation but also open new market opportunities. This driver will make constellations in (V)LEO commercially successful since the private sector is interested in increasing modularity and standardisation to reduce the operational costs of their smallsats and accelerate the time-to-flight [51].

According to the Euroconsult report [52], the GS infrastructure is one of the key elements of any space mission. Depending on the type of satellite mission, the communication requirements may be different. Therefore, the type of GS may vary. The rapid changes in the space segment due to flexible payloads, constellations, etc. drive the need for a more adaptable terrestrial infrastructure to support communications that are currently not offered by incumbents such as Viasat or Indra that are complex and costly. To fill this gap, new GS service providers like Leaf Space or Infostellar are emerging with the intent to offer simpler, more flexible, and cost-effective communication technologies that continue to reduce operational costs for satellite operators and make data affordable for the commercial sector.

Currently, launch service availability is a bottleneck for smallsat constellations [53]. However, it is forecast by Bhavya [44] that in the 2030 time frame, this will no longer be such a constraint. Small satellite operators would likely be able to choose between dedicated launch and rideshare opportunities to support their needs. Another weak driver in the access to space is the price of launch services. In both markets, traditional and smallsat-dedicated are very expensive and represent a large share of the cost of setting up a constellation. For instance, approximately 75% of the total cost of building out the OneWeb space segment is the launch costs [54]. The reduction of launch prices, particularly for smallsat constellations, would make the market more appealing. Drivers like technology advances that reduce the operational costs of launchers and government price policies that make access to space more affordable to foreign customers would contribute to the cost reduction of the development of launchers and, in that way, the success of constellation deployment [55].

Government policies and regulations are critical drivers in developing the small satellite market. In the next decade, it is expected that new technologies and policies are going to be developed to ensure spectrum availability and avoid radio frequency interference (RFI) [56]. On the other hand, there are no regulations related to on-orbit activities. According to Bhavya [44], although there are efforts to face this challenge at the internal level, there is no consensus on how to proceed or what role the government should have in regulating them. Internationally, with more than 80 countries having space-based interests, there is even less consensus and little expectation that there will be a comprehensive global regime beyond the high-level dictates in the Outer Space Treaty. Another element that could affect the success of small satellite constellations is the lack of efficient space traffic management in (V) LEO, where thousands of space objects operate in overlapping orbits and need coordination to avoid interference. The only body that considers space objects at the international level is the Inter-Agency Space Debris Coordination Committee, under the auspices of the United Nations Office for Outer Space Affairs [44]. Furthermore, according to the NASA study [57], there is no comprehensive standard for debris regulation, either in the United States or internationally, that includes debris mitigation. However, efforts are underway to address this gap with the Long-Term Sustainability of Space Activities working group and the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS).

2.3 Blue Ocean Strategy and Strategy Canvas

According to Chan Kim and Mauborgne [19], "*Blue Ocean Strategy is about creating and capturing uncontested market space, thereby making the competition irrelevant*". Competitive or red oceans have multiple players with defined rules struggling to get their share of the market. Meanwhile, the Blue Ocean Strategy doesn't aim to out-perform the competition. It aims to make the competition irrelevant by reconstructing industry boundaries [19]. So, it means there is competition, but this competition is irrelevant because of the wider, deeper potential to be found in the unexplored market space.

Kim and Mauborgne have introduced the Strategy Canvas into the Blue Ocean Strategy as a tool that helps companies to understand: (1) what their differences are; and (2) what factors customers consider when choosing between offerings. A Strategy Canvas is essentially a graph that shows how companies compare to each other on the key customer buying criteria.

To build the Strategy Canvas, the factors customers consider when choosing among options needs to be identified

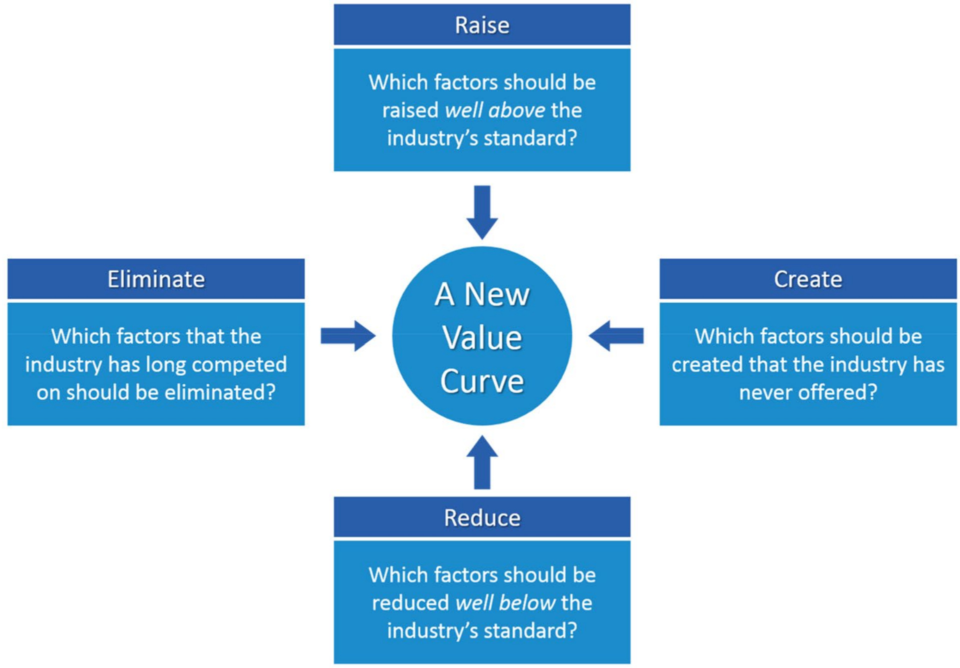


Fig. 4 Four actions framework of the Blue Ocean Strategy [19]

first and put on the x-axis. They are referred to as product, service, and delivery attributes or the customer buying criteria. For instance, when flying, customers tend to consider various factors such as in-flight free services (entertainment, meals, etc.), the flexibility of the flight, comfort, price, and type of aircraft, among others. Next, the importance of these factors to customers is determined by ranking the factors from highest to lowest importance. The y-axis will represent the performance rate of the companies in each of these factors from the customer's point of view, obtaining a better understanding of the strengths and weaknesses of the market. Performance evaluation is done through market data, customer reviews, expert opinions, etc. In this research, the study is carried out using survey results. The survey participants were experts in both markets, airlines and space.

The Strategy Canvas is useful because it reveals how companies differ in their unique value propositions and helps entrepreneurs fully understand their positions. It also protects how you deliver unique value to your customers, eliminates wasteful expenses, and finds new ways to deliver unique value to customers. The Strategy Canvas charts a path to outperform your competitors by analysing what does not add value; detecting where companies are investing excessively; identifying which offerings are insufficient for customer demand and which key customer needs are not being met well or could be met in a new way.

Specifically, in this article, the Strategy Canvas has been used to determine whether LCC airlines and small satellite constellations in VLEO are players in a blue ocean in contrast to FSC and large satellites orbiting at higher altitudes. To build the Strategy Canvas, it is necessary to identify the competitive factors in the competing markets. These factors are classified into four different actions, as shown in Fig. 4, which would determine their order on the x-axis of the canvas: factors to eliminate, factors to reduce, factors to upload, and factors to create.

The order of the competitive factors is determined by the type of action that the company must take to operate in a blue ocean, which means that the lowest value that a competitive factor must have is the one that must be eliminated. Within each of the four actions represented in Fig. 4, the order of the factors has been determined by the importance of the factor within the action.

2.4 Competitive factors of LCC and small satellite constellation industries

To define the competitive factors of the study, the airline market was used as a model instead of the small satellite constellation market in VLEO because (1) it is an already established industry and (2) several studies can be found in the literature [58–64]. It should be noted that competitive factors must be significant for both industries and, at the same time, comparable. So, parallelism is observed in the competitive factors of the LCC industry and the small satellite constellation market in VLEO. This is why the same factors are used, but the definitions have been adapted for each industry (see Table 1).

The traditional FSC is derived from traditional flag airlines and is based on offering a wide variety of destinations and connectivity between their hubs with tight and complex schedules to avoid delays in connecting flights

[19, 58]. This type of airline is generally known as premium and aims to differentiate itself by its brand that provides full services [59].

On the other hand, the business model of low-cost airlines is based on providing simple products that allow airlines to reduce their costs and increase demand by lowering prices. Southwest Airlines defined itself as a simple low-fare company providing point-to-point flights using a single fleet of aircraft in secondary airports [19].

Different studies have been carried out to determine the success of the low-cost business model and its key factors. Common factors include low rates, internet distribution, single class, high seat density, no food or drinks, high flight hour rate, simple fleet, local operation (less than 1000 km), point-to-point flights, secondary airports, no-frills services, additional cost for additional services (luggage, cancellations, hotel rental, etc.), and competitive routes [19, 58–63].

The competitive factors of the LCC are related to the reduction of the overall goal by reducing passenger services, reducing operating costs and taxes, and increasing revenues. For instance, LCC companies can increase their revenue by reducing passenger comfort, convenience, and choosing economical hours and charging extra for other related services at the airport or while travelling. On the other hand, operating costs are reduced using smaller airports with lower taxes and secondary airports with less traffic to avoid delays. Besides, keeping the aircraft on route increases revenue by having more flights per day. To do so, LCCs try to increase their efficiency on the ground and to standardise their fleets by flying to local and point-to-point destinations.

From the previous LCC key factors identified, the competitive factors of the LCC airlines are defined and classified according to the four actions framework [19] (see Table 1). These competitive factors are ordered by the type of action that both companies, LCC airlines and small satellite constellations in VLEO, must take to be competitive in a Blue Ocean Strategy.

To examine whether the evolution of the LCC airline market has any analogy with the future evolution of small satellite constellations in VLEO, exploratory research has been used.

3 Methodology

No previous research has been found in the literature review that attempts to compare the evolution of these two markets. For this reason, exploratory research has been used. Exploratory research intends merely to explore the research questions and does not aim to provide a final and conclusive solution, rather it seeks to create scope for future research [66]. To carry out the exploratory study, a combination of quantitative and qualitative methodologies were used to assess the parallelism of the competitive factors in both industries. The quantitative method used is a survey, and the qualitative method is the Strategy Canvas. Although the survey sample was small, according to Nargundkar [67], it could help make major decisions about how researchers can conduct their subsequent studies.

To analyse the survey results, researchers used the snowball sampling method. Although this method does not produce a representative sample for statistical studies, it does facilitate conducting research with a population that is hard to identify, as such is the case with specialists that have knowledge of both LCCs and the space sector. Thus, snowball sampling allows dissemination of the survey among the desired population via referrals of the few people that the authors may directly know. In addition, the Strategy Canvas method was used to visually determine if the values obtained in the survey supported the research question "could the evolution of the EO small satellite constellations in Very Low Earth Orbit (VLEO) be compared to the LCC airline industry?" and in applying the four action framework of the Blue Ocean strategy (see Fig. 4).

To observe whether or not there was a correlation of competitive factors between LCC and smallsat constellations and FSC and large satellites, a survey of 69 people was conducted. The sample consisted of aeronautical master's degree students from the Polytechnic University of Catalonia (UPC BarcelonaTECH), a group of researchers, and professionals from the aeronautical field.

In the survey (see Appendix 1), people were asked to mark between 1 and 5 each of the observed competing factors according to whether they thought LCC and FSC carriers were reducing or increasing those factors. The same procedure was followed for the satellite market, but a response was only requested from those with a specific background in this area, 42% of the total respondents.

4 Findings and discussion

Table 2 shows the mean and standard deviation of each competitive factor identified in Table 1. Taking the statistics of the mean of all the values, the result for the airlines is 3.1 with a deviation of 1.065 and for constellations is 3.4 with a deviation of 0.991. This means that knowing the sample and its methodology, the precision of the survey with 95% confidence is 0.3 and 0.4 for airlines and constellations, respectively. Additionally, the results show a high correlation. For that reason, the same competitive factors have been considered for both markets, adapting their definitions.

Table 2 Mean value of each competitive factor

Competitive factor	Airlines		Constellations	
	Mean	Standard deviation	Mean	Standard deviation
Quality (FSC-large sats)	3.55	1.051	4.48	0.829
Quality (LLC-small sats)	2.26	0.902	2.55	0.736
Policies (FSC-large sats)	3.35	1.055	3.83	1.071
Policies (LLC-small sats)	1.77	0.807	3.24	1.300
Infrastructure (FSC-large sats)	3.58	1.077	4.21	0.978
Infrastructure (LLC-small sats)	2.41	0.990	2.76	0.988
Platform (FSC-large sats)	3.73	1.042	4.35	1.045
Platform (LLC-small sats)	2.90	1.178	2.76	1.023
New Players (FSC-large sats)	3.00	0.907	2.45	1.021
New Players (LLC-small sats)	3.30	1.228	3.97	0.906
Technology (FSC-large sats)	3.26	0.902	3.79	0.940
Technology (LLC-small sats)	2.78	1.199	3.62	1.015
Utilisation (FSC-large sats)	2.84	0.933	3.07	1.067
Utilisation (LLC-small sats)	3.61	1.274	4.00	1.035
Efficiency (FSC-large sats)	3.04	0.992	2.90	0.976
Efficiency (LLC-small sats)	3.32	1.254	3.72	0.960
Standardisation (FSC-large sats)	2.80	0.994	2.48	1.271
Standardisation (LLC-small sats)	3.64	1.272	3.79	1.082
Prizing (FSC-large sats)	2.13	0.856	1.48	0.738
Prizing (LLC-small sats)	3.90	1.165	4.31	0.891
Post-service (FSC-large sats)	3.19	1.141	4.00	1.000
Post-service (LLC-small sats)	2.73	1.211	3.10	0.939

To evaluate the Blue Ocean Strategy analogy between both industries, the Strategy Canvas has been used, applying the four actions framework introduced in Fig. 4 (Eliminate, Reduce, Raise, Create).

Figures 5a and 5b graphically show through the Strategy Canvas the mean value of each competitive factor and the deviation of each value of each data set. It should be noted that the Strategy Canvases (Fig. 5a and 5b) are difficult to compare at first glance because the Strategy Canvas does not focus on the values themselves but on (1) the overall behaviour, (2) the trend of each of the factors and (3) the relative value between the points that can be seen in Fig. 7.

The similarities between the two industries can be easily seen by comparing the trend lines of both Strategy Canvases in Fig. 5a and 5b. It can be identified that the LCC and small satellite industries have a similar strategy canvas curve, which in principle makes them comparable. It can be seen that the trend of the LCCs and small satellites markets is opposite to that of the FSC and large satellites market, and as such it can be distinguished that the LCCs and small satellites industries follow a blue ocean strategy.

Furthermore, by looking at the competitive factors that differentiate one industry from the other, it can be perceived that the LCC and small satellite markets base their differentiation on factors that lead to cost reduction in organisations, such as efficiency, utilisation, standardisation or prices (see Fig. 5a), while the FSC and large satellite markets establish their differentiation in factors related to service, quality and customised customer experience (see Fig. 5b). However, since the competitive factors identified for the satellite market come from the airline market, trends in the Strategy Canvas of the satellite market are not the only critical factor in determining the Blue Ocean behaviour of the small satellite market. Therefore, it is necessary to show how the similarities between airlines and satellites are comparable by identifying the resources and capabilities that both markets share. Table 3 indicates the resources and capabilities shared by the LCC and small satellite markets ordered according to the action framework of the blue ocean strategy (Fig. 4). In the same way, Table 4 indicates the resources and capabilities shared by the markets of FCC and large satellites.

From Tables 3 and 4 it can be noticed that both the airline and satellite industries share similar results in response to the actions of the associated factors being evaluated (e.g. quality, technology, infrastructure, service, etc.). In this way,

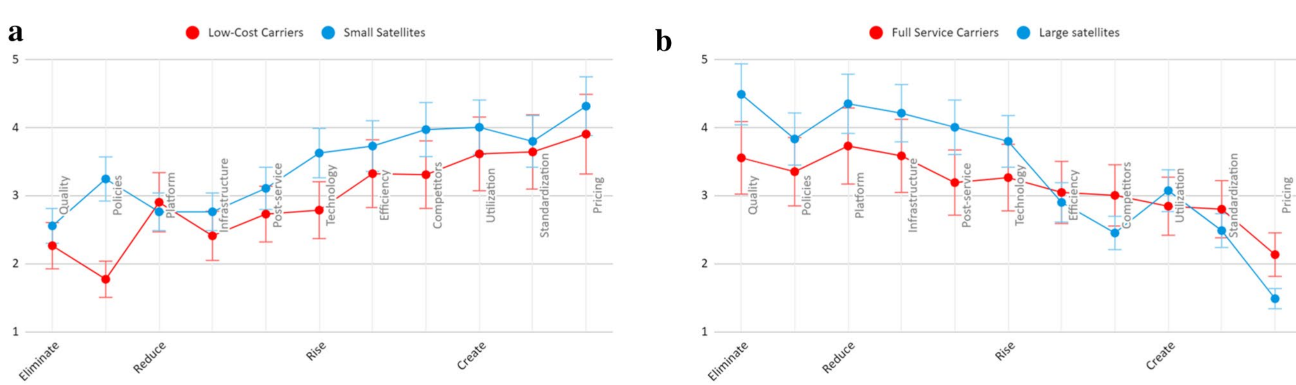


Fig. 5 **a** Strategy Canvas of the LCC airlines and the Small Satellites markets. **b** Strategy Canvas of the FSC airlines and the Large Satellites markets

Table 3 Similarities between LCC and Small Satellites markets according to the action framework

Action	Low-Cost Carriers	Small satellites
Eliminate	Pay-for-what-you use model	Pay-for-what you use model for VAS and Ground Services
Reduce	Outsourcing of ground services	Use of COTS (Component Out The Shelf)
	Use of secondary airports	Secondary payloads (piggybacks) at launchers
Rise	Technology and data for cost-efficiency	Technology and data for cost-efficiency
	Short TAT (Turn-Around-Time)	Short Time-to-Launch
Create	Fleet standardisation	1U, 2U, 3U, 6U, 12U structures
	Simple operations (point-to-point routes)	Low-cost approach to manufacturing and assembly of the satellites
	Short-medium haul routes	Short lifespan missions
	Low ticket prices	Low mission budgets

Table 4 Similarities between FSC and Large Satellites markets according to the action framework

Action	Full-service carriers	Large satellites
Reduce	Longer TAT	More time-to-launch
Raise	Diverse fleet	Custom made satellite architecture
	Short, medium and long haul routes	Long lifespan missions
	Use of main airports	Main payloads
	Higher ticket prices	High mission budgets
Create	Included complementarity services	Larger services contracts
	Hub model (complex operations)	Custom manufacture processes
	End-to-end value chain services	Custom designed components
	Technology and data for service improvement	Technology and data for service improvement

both LCC and small satellite players tend to eliminate any ancillary service (something completely contrary to what happens in the FSC and large satellite market) by implementing a pay-per-use model. This is something that allows them to provide low barriers to entry for new customers such as SMEs (via low ticket prices or low mission budgets). Another method to reduce costs is to take advantage of underutilised infrastructure, either secondary airports (LCC) or piggyback launches (small satellites), which allows a reduction of the launch cost of smallsats (75% of the budget of a mission). Furthermore, these can be launched faster than large satellites since the latter are usually the main payload of a launch vehicle.

Another element to take into account is utilisation. Just as FSCs carry out almost exclusively long-distance routes, large satellites carry out a long-lived satellite mission that incur much more cost and complexity than the simplified operations carried out by LCCs (through local and point-to-point routes) and smallsats through low-cost manufacturing processes using COTS and standardised structures (1U, 3U, 6U, etc.). One of the most clarifying points here is the use of technology and data that LCC and smallsats make compared to FSCs and large satellites. The former use them to lower costs (small satellites) or seek ways to obtain more profits (LCCs), while the latter use technology to improve the services they offer (large satellites) and to build customer loyalty (FSCs), among others.

By identifying the resources and capabilities of both markets, we have seen how the LCC and small satellite markets differ from the FSC and large satellite markets, and also how both pairs (LCCs and smallsats versus FSCs and large satellites) share similar trends and strategies (see Fig. 5a and b). Next, a study is carried out comparing the Strategy Canvas of the LCC with the FSC (Fig. 6a), and small satellites with large satellites (Fig. 6b), to appreciate how big or small the relative differentiation between each of the factors identified for each pair of industry markets is. This will help to better understand the state of evolution of the markets and establish the degree of parallelism between the processes that both industries are experiencing (see Fig. 7) and see if the small satellite market is following the same steps as the LCC market.

To determine if the airline and satellite markets behave similarly, the correlation coefficients between markets have been studied. In Fig. 6a, the correlation coefficients of the lines are 0.86 for LCC and 0.83 for small satellite constellations, while for FSC and large satellites, they are 0.79 and 0.82 (Fig. 6b). This means that the competitive factors have similar behaviour and importance in both markets. Furthermore, the differences between airlines and satellites

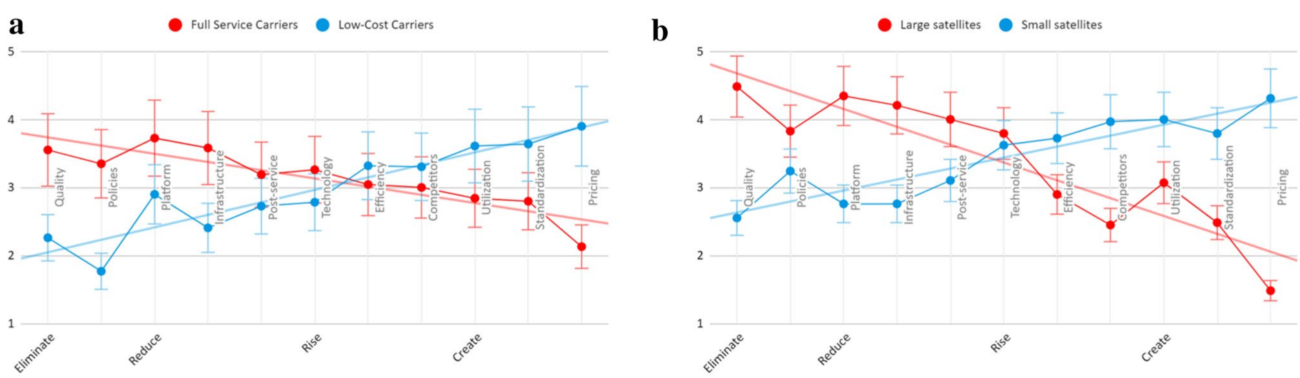
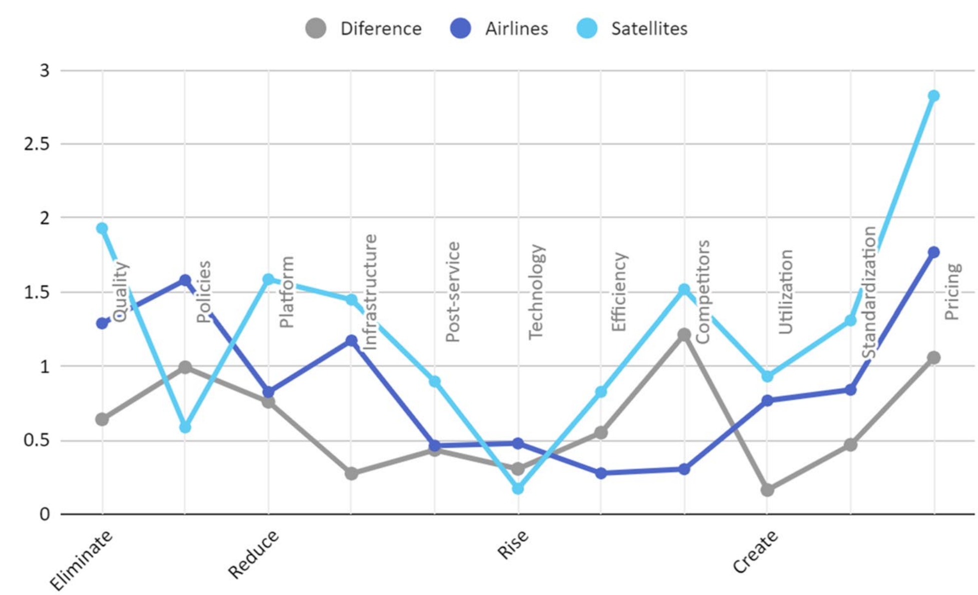


Fig. 6 **a** Strategy Canvas of the airlines' market. **b** Strategy Canvas of the satellites' market

Fig. 7 Strategy Canvas curve differences between markets



observed in Figs. 6a and b can also explain the different points in the evolution of both industries.

In addition, it should be noted that the competitive factor, *policy*, does not behave as an elimination factor in the satellite industry but as a reduction factor. This is because space legislation and investment risk force satellite manufacturers to have sufficient backup systems to guarantee their mission and safety [65]. On the other hand, the cost reduction available for the commercial strategy of airlines does not exist in the space sector.

It is also necessary to compare the gaps between the blue ocean and traditional markets. Figure 7 shows the gap differences in the airline market, between LCC and FSC, in the satellite market, between small satellite constellations and large satellites, and between the two industries.

From Fig. 7, the gap between the small satellite constellations and the large satellites seems larger than between the FSC and LCC airlines. This explains the evolution of the markets. The space industry is newer, and the changes and differences between the different segments are easier to identify. On the other hand, the airline industry is well known, so companies can easily adapt to stay in the game and blur the line between the two groups.

In summary, the differences between both markets are due to the different stages of their evolution and the different legislation of each one. Therefore, the observed similarities are sufficient to verify that the factors selected to carry out the study are valid for both airlines and satellites. The results obtained suggest that the LCC and small satellites market have similar behaviours and evidences that the evolution of EO small satellite constellations in VLEO is comparable with the LCC airline industry. Large satellites give more importance to the factors that small satellite constellations want to eliminate and/or reduce, such as policies, infrastructure, platforms, entry of new players and technology. On the other hand, small satellite constellations focus on emerging and growing factors such as utilisation, efficiency, standardisation, pricing, and post-service (Fig. 6b). These results are supported by the report of Euroconsult [28]. The same trend occurs when comparing LCC versus FSC airlines (Fig. 6a).

Beyond the fact that both the LCC and smallsat market, as well as the FSC and large satellites market, behave similarly and are therefore comparable, the implications of this finding make it possible to establish trends in the future evolution of both markets, smallsats and large satellites, based on previous evolution trends of the airline market.

While a direct correlation between competitive factors should be avoided until further research assesses to what extent the satellite industry will exhibit similar evolution to the airlines market, the results may be beneficial for business roadmapping purposes. This implies that when the patterns and timing of the airline market are understood, better estimates can be made in anticipating the actions and strategy required to reach a certain milestone in the small satellite or large satellite markets.

5 Conclusions

This exploratory study has shown through a survey and the analysis of the Strategy Canvas between EO small satellite constellations and LCC as well as large satellites and FSC markets that (1) airline market competitive factors are replicated in the satellite market and (2) that the differences between the two markets are due to the different stages of their establishment and the different legislation in each of them.

From the current study, some direct implications can be drawn from the evolution of airlines (Fig. 7). First, although the commercial market for EO small satellite constellations is still much smaller than large ones, it is increasing [5]. The EO satellite industry can therefore be expected to evolve more slowly than the airlines. Second, the most important changes that allowed LCCs to develop and grow were the deregulation laws that liberalised the sky and allowed airlines to fly with few restrictions at low prices [20]. This is one of the weak points of the space sector, the regulation is not very clear and it is not yet fully developed [41]. To grow small satellite constellations, space must have clearer and more impulsive regulations valid throughout the world [36].

This exploratory research, however, is subject to several limitations. The first is related to the survey sample, which does not allow the results to be classed as definitive. This is because researchers had limited ability to gain access to the appropriate type of participants. For this reason, a snowball sampling method was used to analyse the survey results, as the number of respondents was not large and diverse enough. To overcome this limitation, future research is proposed with a larger sample of industry professionals in the airline and satellite markets that ensure the statistical result and to complement it with interviews with experts at European and international levels. This could allow a more precise comparison or nuance of the results obtained in this exploratory study and could lead to the identification of competitive factors with a stronger correlation behaviour between the aviation and satellite markets, allowing the investigation to advance. The second limitation concerns the lack of previous research studies comparing low-cost airlines and small satellite constellations. However, this is an important opportunity to present the need for further development in this study since there are still many obstacles to overcome in space, such as communications, overcrowding, launches, and high economic investment [36]. However, large constellations of small satellites have already been launched that have set a benchmark not only in EO such as Doves, Aleph-1, or UrtheDaily/OptiSar but also in the telecommunications market such as Iridium, Kuiper, or Starlink. Although there is still much more to come, the regulatory process is increasingly necessary.

It is worth noting that the period of this study is based on an introductory phase of small satellite constellations in VLEO. We opted to use the Blue Ocean Strategy since competition in this unexplored market space is irrelevant. However, due to the need for a regulatory process and the exponential growth of this market with an economic and social impact, it would be interesting to conduct more research on the impact of market rivalry using Porter's 5 Forces once the small satellite market is established and regulated. It would also then be interesting to monitor how the market for small satellites evolves and compare it with the growth made by LCCs between the 2000s and 2010s. This will help researchers to see if the trend in both markets is still comparable. It would also be interesting to explore the market for small satellite constellations in general and not just focus on EO. Constellations in VLEO for the telecommunication market have been growing exponentially in the last two years.

Other future research could be related to elaborating a business roadmap for the evolution of the smallsat constellations in (V)LEO by following the evolution between the mid-1990s and the late 2010s of the LCC roadmap. In this way, it would be possible to obtain figures on the investment, the milestones and the times that were followed by the low-cost airlines and would allow us to prepare a roadmap for the constellation of smallsats in (V)LEO from the early 2010s to the 2030s. This could incorporate observed figures on investment, times and milestones followed by constellations of smallsats in (V)LEO up to the present date and comparing them with the same type of information from the LCC roadmap. This could make it possible to adjust or make more accurate actions to be carried out in the market for small satellite constellations in (V)LEO and the times and funds foreseen in the evolution of the roadmap smallsat constellations in (V)LEO at a business level.

Appendix 1

Conducted survey

Study about the airlines market

Quality: How would you rate the quality of the routes (comfort, etc.) in the different types of airlines? Being the highest score for the highest quality airline group.

Policies: How would you rate the policies of the routes (flexibility, free catering services, and bar, etc.) in the different types of airlines? Being the highest score for the group of airlines with more policies.

Infrastructure: How would you rate the infrastructure of the routes (large or small aeroplanes) in the different types of airlines? Being the highest score for the group of airlines that use larger planes for more passengers.

Platform: How would you rate the different platforms (main or secondary airports) used in the different types of airlines? Being the highest score for the group of airlines that uses major airports, located in the most important cities.

New Players: How would you rate the number of new entrants (number of similar airlines, sea or land transport that make the same journey, etc.) of different types of airlines? Being the highest score for the group of airlines with the largest number of competitors.

Technology: How would you rate the technology (innovation, research, etc.) used in different types of airlines to improve the efficiency of the routes? Being the highest score for the group of airlines with the greatest investment in new technologies.

Utilisation: How would you rate the use of aeroplanes (point-to-point flights, local flights, intercontinental flights, etc.) made by different types of airlines? Being the highest score for the group of airlines that makes shorter flights.

Efficiency: How would you rate efficiency (time on the ground, rapid loading and unloading of passengers, cleaning, etc.) in different types of airlines? Being the highest score for the airline group is considered more efficient.

Standardisation: How would you rate the standardisation (different types of aircraft in the fleet) of the different types of airlines? Being the highest score for the group of airlines with less diversity in the fleet.

Prizing: How would you rate the ticket prices of the different types of airlines? Being the highest score for the group of airlines with cheaper prices.

Post-service (Value Added Services): How would you rate the added value (hotel offers, car rental, hotel reservation, etc.) that different types of airlines try to sell while selling their airline tickets? Being the highest score for the group of airlines with the highest product offer.

Study about the satellite market

Quality: How would you rate the quality of the systems (redundancy, duplicity, etc.) in the different types of satellites? Being the highest score for the highest quality satellites group.

Policies: How would you rate the policies of the routes (variety of orbits, flexibility on choosing the altitude, etc.) in the different types of satellites? Being the highest score for the group of satellites with more policies.

Infrastructure: How would you rate the infrastructure of the satellites (ground station antennas, communication links between satellites, etc.) in the different types of satellites? Being the highest score for the group of satellites that use more expensive systems.

Platform: How would you rate the different launching platforms (dedicated rockets, secondary methods like piggybacks) used in the different types of satellites? Being the highest score for the group of satellites that uses more expensive and larger rockets.

New Players: How would you rate the number of new entrants (number of similar satellites flying, number of aeronautical companies, etc.) of different types of satellites? Being the highest score for the group of satellites with the largest number of competitors.

Technology: How would you rate the technology (innovation, research, etc.) used in different types of satellites to improve the efficiency of the missions and reduce costs? Being the highest score for the group of satellites with the greatest investment in new technologies.

Utilisation: How would you rate the use of satellites (one or more principal objectives, lifespan, etc.) made by different types of missions? Being the highest score for the group of satellites with more limited use (defined mission with a short lifespan).

Efficiency: How would you rate efficiency (design bureaucracy, staff dedicated, amount of procedures, etc.) in different types of satellites? Being the highest score for the satellites group is considered more efficient.

Standardisation: How would you rate the standardisation (different types of satellites made by a company, modularity, CubeSats, etc.) of the different types of satellites? Being the highest score for the group of satellites with high standardisation.

Prizing: How would you rate the prices (design, production, and launching) of the different types of satellites? Being the highest score for the group of satellites with cheaper prices.

Post-service: (Value Added Services): How would you rate the added value (software, image processing, objective demand, etc.) that different types of satellites offer when selling their final product? Being the highest score for the group of satellites with the highest product offer.

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Author contributions SRD, DGA, and MGB designed the experimental method and analysed the results. SRD and MGB conducted the surveys, produced the results, and wrote the manuscript. SRD and FAP integrated the provided reviews. NHC performed the grammatical correction. DGA, PCER, GHH, DK, VH, JB, and SS reviewed, provided feedback, and approved the manuscript.

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