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Study and design of a Business Model for an Internet company focused on Very Low Earth Orbit satellite constellation

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Abstract

This thesis is devoted to study and design a business model for an internet service provider company through a mega-constellation of satellites established on Very Low Earth Orbit (VLEO). The project starts by reviewing the state of the art of telecommunication industry, which includes a quick explanation about its history and evolution, followed by a short description about how does the satellite internet work and a brief analysis of the market situation. The main development of the thesis is the business design and the feasibility study; but before, it is performed a situation analysis through PESTEL and Porter forces study, which conclude in a SWOT matrix. After defining each block of the business model canvas, its conducted the feasibility study. Finally, the outcome presents interesting economic indicators, backed up with a sensitive study.

Keywords Very Low Earth Orbit (VLEO), Low Earth Orbit (LEO), Satellite Constellation, Satellite Internet, Space, Business Model, Aerospace Engineering

Resumen

La presente tesis está dedicada al estudio y diseño de un modelo de negocio para una empresa proveedora de servicios de Internet a través de una mega constelación de satélites establecidos en órbitas muy bajas (VLEO). El informe comienza con una revisión del estado del arte de la industria de telecomunicaciones, la cual incluye una rápida explicación sobre la historia y evolución, seguida de una breve descripción sobre el funcionamiento del Internet por satélite y un análisis breve de la situación del mercado. La principal carga de trabajo de la tesis consiste en el diseño del negocio y el estudio de su viabilidad; pero antes, se realiza un análisis de la situación de la industria, mediante los estudios de PESTEL y PORTER, los cuales concluyen en una matriz FODA. Después de definir cada bloque del modelo de negocio, se lleva a cabo el estudio de viabilidad. Finalmente, el resultado presenta interesante unos indicadores económicos interesantes, los cuales se respaldan en un estudio de sensibilidad.

Declaration of a authorship

I declare that,

the work in this Degree Thesis is completely my own work, no part of this Degree Thesis is taken from other people's work without giving them credit, all references have been clearly cited.

I understand that an infringement of this declaration leaves me subject to the foreseen disciplinary actions by The *Universitat Politècnica de Catalunya - BarcelonaTECH.*

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Signed:

Surjit Singh,

June 22nd, 2021

Bachelor's degree in Aerospace Vehicle Engineering.

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CHAPTER 1

INTRODUCTION

1.1 Aim

The main purpose of this project is to study and design a new business model for an internet company whose service will be provided by an VLEO (Very Low Earth Orbit) satellite constellation. This objective will be achieved through a basic study of this technology, followed by an analysis of current projects in the market, working in the similar field.

1.2 Scope

The scope of this project will be extended to the following parts:

- A brief explanation of VLEO satellite constellations to offer internet service.
- A brief comparison between classic internet providing methodologies and the VLEO satellite constellations. Furthermore, benefits and challenges will be discussed of the new proposal.
- A basic study of current projects run by principal competitors to analyse the market.
- Study and design of a new business model for a new company.
- Economic and Marketing plan will be designed.
- Qualitative risk analysis, where the main issues that could have a negative impact to the project will be studied.
- A basic environmental study about the implications of this project.

However, this project will not cope with the following topics:

- Exhaustive study of the engineering behind the technology used for the missions in the business models.

- Other applications of VLEO satellite constellations such as Tv, radio, etc, will not be studied.
- A detailed study of each business model of the competitors in the market.
- The new business model designed will not be implemented.

1.3 Requirements

Taking in to account the aim of this project and as part of the Discoverer Project, the development of this thesis is subject to meet the following requirements:

- This project is part of Discoverer research group.
- Follow UPC thesis guidelines and normative.
- Business Model study using Canvas methodology.
- Satellite constellation companies studied are going to be focused on LEO (Low Earth Orbit) or VLEO.
- Companies analysed will be from EU and USA.

1.4 Background and Justification

From the last decades, Internet has been one of the most visible aspects of globalization since is becoming an essential resource for the human being. Furthermore, the actual pandemic is confirming the indispensable need of it since almost everyone requires it for daily things. Connecting to the net allows to entertain ourselves, communicate with others and, almost for everyone, to keep working from home.

Therefore, the main issue behind internet that concerns to the telecommunication sector is the connectivity and speed of the service. Hence, there is a race between the telecom companies to provide the best quality of internet to everywhere around the globe.

Besides, the common and most used way to offer this service is via terrestrial, through cable or fibre, since it provides the highest speed among the others. However, it has one comeback; although is really effective in densely populated areas, such as big cities, in some secluded urbanization or hardest places to reach would not be a reliable option. [1]

Alternatively, satellite internet, another way to provide internet through satellites, has not as much speed as cable or fibre internet but can supply internet to the hardest places around the globe. However, the denser and more extensive is the net

of satellites around the earth, better is the performance of the service. Consequently, the idea of satellite constellations was born. [2]

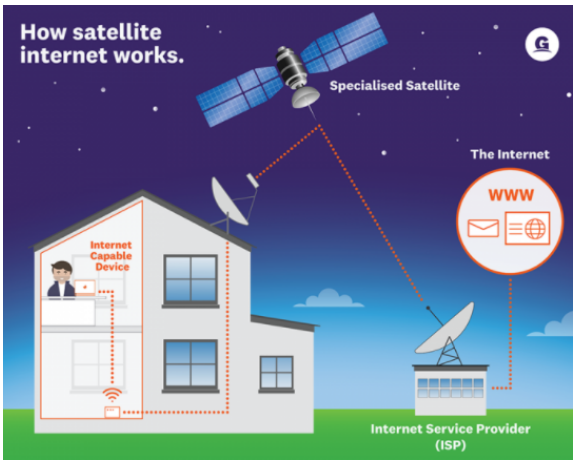


Figure 1.1: How satellite internet works. Source:[2]

Providing internet from space using large constellations of LEO satellites, is not a new idea; in the 90's, several LEO satellite internet constellations were proposed and developed. Some of these projects were Celestri and Teledesic, however these were cancelled after the bankruptcy of the owner companies like Iridium and Globalstar.

Nevertheless, around 2010, internet satellite constellations re-gained popularity due to dropping cost of space missions and the increasing demand of broadband internet. Currently, private companies are running their own projects; some are planning to launch their satellites and other already launched some satellites. The big ones in this sector are:[3]

- OneWeb with OneWeb Constellation
- SpaceX with Starlink
- Amazon with Kuiper

Figure 1.2: OneWeb, Amazon and SpaceX projects. Source:[3]

Finally, due to the rising trend of the implementation of this methodology to provide internet and its possible potential behind, this thesis was created to study its feasibility through a Business Model study.

Furthermore, all the aspects commented in this section, among others aspects described in the scope, will be discussed and analyzed in more detail in this project.

CHAPTER 2

STATE OF THE ART

This chapter is aimed to set a general base of the state of the art of Telecommunications; focused on LEO and VLEO satellite internet communications. Thus, in this section the history and evolution, some technical aspects and the current market status of the technology are introduced.

2.1 Telecommunication status: Internet

Before getting down to business, it is necessary to understand the main idea on which the business model will be developed. Therefore, it is necessary to study the concept of telecommunication, its journey through the history, its actual status and the future trends; which are focused on internet.

Telecommunication is defined as a transmission and reception of information to communicate over greater distances than the covered by human voice. It should be remarked that slow systems of communication such as postal mail are excluded from the field. Therefore, Telecommunications is the discipline that studies, designs, develops and exploits these type of communication systems.

2.1.1 Early and ancient methods

Going back in the days, the history of telecommunication started with the very first human civilization. They started using smoke signals, drums, blown-horns and whistles to have small and quick communications. Later on, other means like flags or pigeon post, which were introduced by Persians, and still are used in some regions around the world, were also included as telecommunication systems. However, the very first sophisticated systems such as beacons and visual telegraphs did not appear until the medieval era.

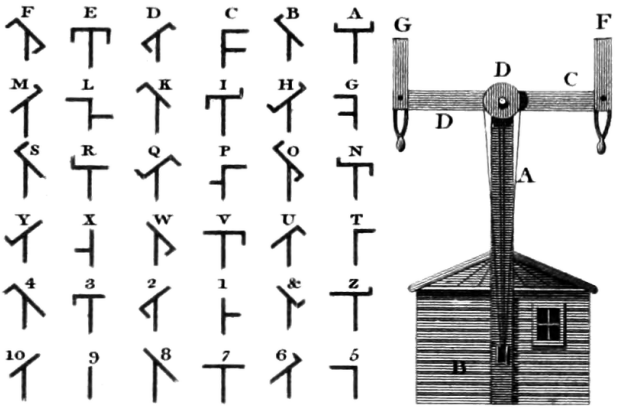


Figure 2.1: First visual telegraph. Source:[4]

The discovery of the new ways of electricity use, brought with it the new era of electrical telegraphs. Thus, messages could be conveyed electrically through long distances. Then, after improving new designs of electrical telegraphs and basing on harmonic telegraphs in 1870s the first electric telephone was invented.

Similar happened with the discovery of radio waves, which lead to the invention of radio for telecommunications. Furthermore, World War I accelerated the development of high frequency radio for military communications. After the war, transmission of moving pictures, television, was invented, whose evolution was boosted, once again, by the World War II. [4]

2.1.2 New generation and current technology

The modern generation of telecommunication began on 1950s due to the semiconductor era. It conducting properties, which could be altered in useful ways, played a key role in semiconductor devices such as transistors. This new device, which amplifies and switches electronic signals, upgraded telecommunication equipment such as radios, signal receivers, telephones and display devices.

Next step in telecommunications technology came with the launching of communication satellites. As the high frequency radio waves travel by line of sight, there were several problems to have communications over huge distances due to Earth's curve. Therefore, with satellites, which amplify the signal via a transponder and create a communication channel between the transmitter and receiver, allowed communication between widely separated geographical points.

As well as that, in terrestrial connection, fibre optics changed the transmitting method of telecommunication waves, switching electricity as the mean of transport to light. This upgrade improved the bandwidth, long distance coverage and immunity to electromagnetic interference.

Finally, the latest progress in telecommunication has been the computer network and the internet. First appeared centralized computer networks but, when researchers started to investigate that packet switching would allow to send chunks of data without passing through a centralized mainframe, multiple-node network emerged. Then, different networks of various organizations, which were evolving individually, such as NPL (National Physical Laboratory), ARPANET (Advanced Research Projects Agency Network), Merit and others merged together to finally form the Internet. [4]

2.1.3 Internet

The ever-growing popularity of telecommunication changed remarkably when Internet appeared. The progress achieved thanks to the technological exchanges and transfers, as well as the efficiency and speed of the communication media have allowed a more dynamic relationship between subjects in the international arena. Moreover, internet globalization has brought several benefits and advantages in terms of economic, commercial, social and cultural development.

Recent figures from Digital Report 2021 revealed that the total number of registered internet users were 4.66 billion, around 59.5 % of the world's population. These numbers are expected to increase in the near future since almost everyone requires internet in their daily life for essential things such as entertainment, communication, learning, working, etc. [5]

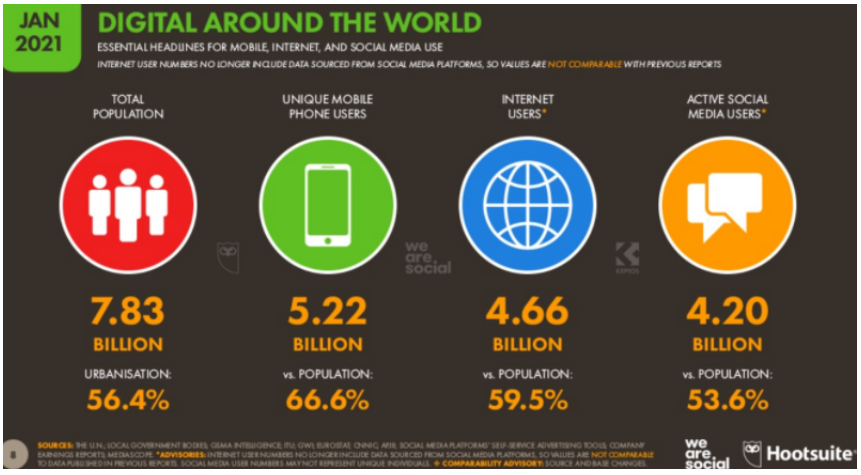


Figure 2.2: Digital report figures. Source: [5]

The success behind internet relies on its many applications and services such as the World Wide Web, social media, electronic mail, file sharing, video games, etc.

Furthermore, people have relatively easy access in comparison with other services which is another key role behind its globalization. Nowadays, users can access to internet with a computer modem via telephone circuits, coaxial cable, fibre optics, copper wires, Wi-Fi, satellite internet and through mobile phone technology such as 4G and 5G. [1]

Although having these variety of options to access, users tend to choose only the ones who provide the greatest speed and quality. Therefore, the business trends in telecommunication sectors tend to provide the attributes mentioned above in order to get the most clients as possible.

2.2 Satellite Internet

The common way to provide internet nowadays is via terrestrial physical wiring, either cable, fibre optic or copper wires, as mentioned previously. However, with communication satellite technology a new way to provide wireless internet appears. This way wiring connection availability is avoided and more simple connection designs are achieved.

The history of satellite communication began with the Soviet Union which kick off the space race in 1957 with the launch of the first artificial satellite named Sputnik 1. Later, US followed them with the launching of their satellite Explorer 1. Although these satellites were for logistical and military reasons, it was not until 1962 when Bell Labs launched the first commercial communication satellite. After that, the next step was realized by Hughes Aircraft, which fabricated the first geosynchronous satellite for NASA.

Then, succeeding generations of satellites featuring better capacities improved the performance of telecommunication over the following years.

2.2.1 Working principle

Satellite internet technology is composed by 4 blocks which make possible the access to internet via this system:

- **Indoor Unit (IDU)**: The indoor unit also known as satellite modem is the device which works as an intermediary between the user's electronic device and the outdoor equipment.
- **Outdoor Unit (ODU)**: An antenna dish represents the outdoor unit, which works as the interface between radio waves propagating through space and electric current moving in conductors. The dish receives and sends data from and to the satellite in two-way system.

- **Satellite**: Is the element orbiting in the space that relays and amplifies the radio frequencies signals via transponders; creating a communication channel between the transmitter and receiver.
- **Ground station segment**: The ground station is compound by a teleport and a Network Operation Center (NOC). The teleport is another two-way system which demodulates or modulates the data between the satellite and the internet network. The ground stations are in close proximity to internet data servers and are connected via fiber-optics or cloud technology with them. So what they do is open an interaction between the user and the network, control the communications, monitor satellite signals and its possible failures. [6]

The whole process begins when the user interacts with the electronic device to access to the internet. Afterwards, the action made by the user is modulated by the modem and transferred to the antenna dish. Next, the dish transforms the data into RF (Radio frequency) and sends it to the ground station through a satellite located at a geosynchronous orbit. The gateway receives the signal and proceeds with the request interacting with the internet network. Finally, the response travels following the same steps backwards towards the user. The duration of this process is defined as latency which depends on the distance traveled by the signal.

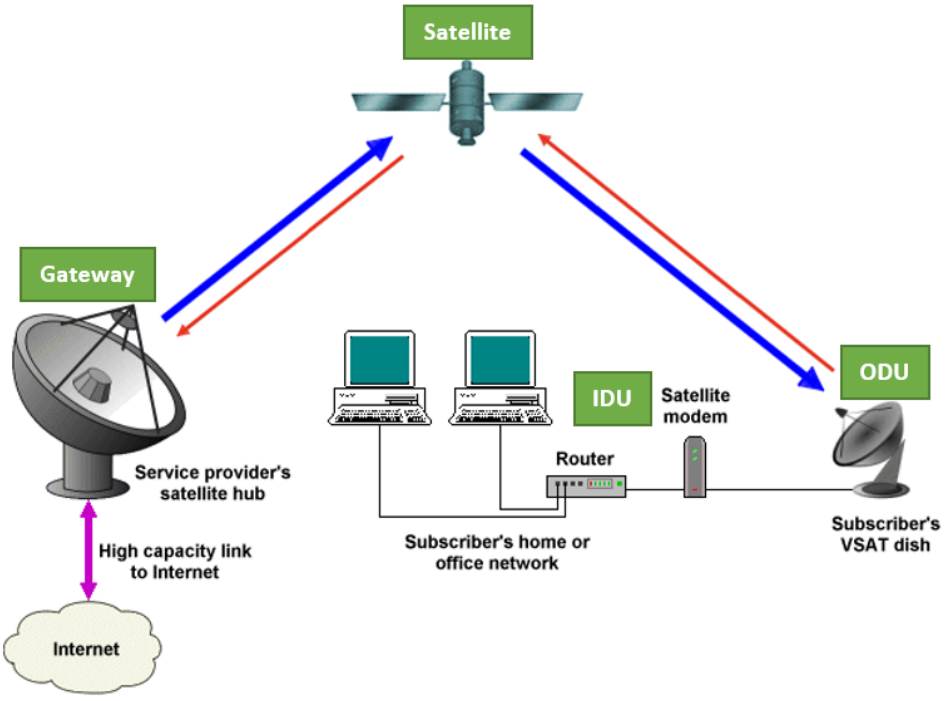


Figure 2.3: Satellite Internet working scheme. Source:[7]

2.2.2 Orbits for telecommunication

There exists a wide range of different geocentric orbits for communication satellites which are classified according to the altitude:

- High Earth Orbit (HEO): Orbits with an altitude over 35,786 km and periods greater than 24 hours.
- Geosynchronous Orbit (GSO): Orbits at 35,786 km from earth surface and Earth's period.
- Medium Earth Orbit (MEO): Orbits between 2,000 - 35,786 km and periods between 2-24 hours.
- Low Earth Orbit (LEO): Orbits with altitude between 160 - 2,000 km.
- Very Low Earth Orbit (VLEO): Type of Orbits, inside LEO, with altitude between 160 - 450 km. [8]

However, in terms of delivering broadband internet services, LEO and VLEO constellations stand out among the rest for their advantages:

- Less amount of energy required for satellite placement.
- High bandwidth and low communication latency.
- Shorter transmission distance, therefore, less powerful amplifiers and transmitters required.
- At lower altitudes signal diffraction and divergence is decreased, which means data acquisition becomes easier for receiving systems.

As well as that, flying in these orbits also present some challenges:

- Aerodynamic forces still affect due to the existence of the atmosphere at such altitudes. Moreover, they also suffer from the orbital decay so they need periodical re-boosting.
- The main atmospheric constituent of the thermosphere (from 95 to 600 km), the atomic oxygen, is highly reactive so it can damage the satellite structure.
- Reduced communication window over certain ground stations. However, this issue can be solved increasing the number of ground station or interlinking with another spacecraft in the geosynchronous belt. [9]

Finally, the advantages and benefits are showing that LEO and VLEO clearly do have a role to play providing broadband internet services. The potential of these orbits are significantly greater over those which are at higher altitudes. Therefore, LEO and VLEO offer opportunities to exploit internet via satellites.

2.2.3 Satellite constellations

Current trends in the sector follow the idea of deploying constellations of thousands of satellites to cover the entire earth surface. This is because, small-size, light-weight, low-power and low-cost satellites working on complementary orbital planes and connected to globally distributed ground stations can form a network of satellites to provide permanent global coverage.

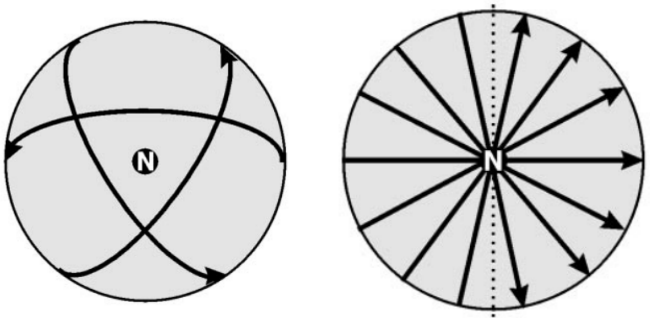
In order to reach the global coverage through large quantities of satellites avoiding collisions or interference, constellations are usually designed through exhaustively complex architecture designs. Thus, they are designed so the satellites present similar orbits, eccentricity and inclination so that any perturbation can affect in similar way to each satellite. Between non-geosynchronous space belts, circular orbits are popular because satellites orbiting at a constant altitude requires a constant strength signal to communicate.

There exists a large number of constellation geometries that depend on every type of mission. Nevertheless, a class of circular orbit geometries that has become popular is the Walker pattern constellation. This method consists in to position all satellites on circular orbits with same orbital inclination, at a same altitude and grouped on series of orbital planes distributed uniformly along the equator. As well as that, this method classifies and describes the pattern of every constellation with the notation I:T/P/F, where:

- I: Orbital inclination.
- T: Total number of satellites.
- P: Number of evenly spaced orbital planes.
- F: Phase spacing between adjacent planes. [10]

Moreover, from this method, two distinct patterns can be differentiated:

- **Walker-Delta constellation**: The values of orbital inclinations between the range of 42-80°define a distribution of satellites, so called Walker-Delta, with an optimum coverage of the major part of Earth's surface except near the polar regions. It should be noted that, low-latitude planes are avoided because of Earth's oblateness circular orbits can not be performed.
- **Polar and Near-polar constellation**: The polar orbits are formed with inclinations of exactly 90°. Here the satellites travel from the North to South pole, with the possibility to cover every region of the Earth's surface. This orbits are also called Walker star pattern since the plane of every orbit, viewed from one of the poles, draws a star. [11]



(a) (b)

Figure 2.4: Walker delta constellation (a) and Polar constellation (b). Source:[11]

Hence, to achieve the global connectivity using the less resources as possible, both orbits can be combined reducing the density of satellites covering the polar regions and focusing more on the most populated areas since the major part of the demand usually comes from the last ones.

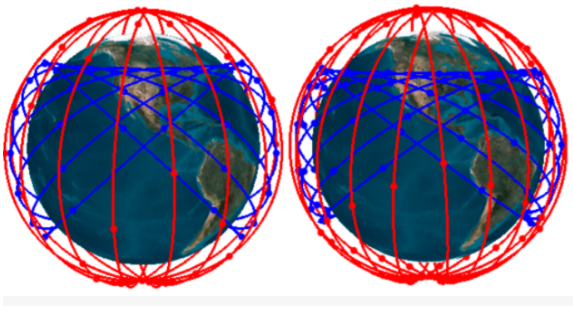


Figure 2.5: Combined constellation configuration. Source [12]

Besides, inter-satellite communication is enabled to increase the efficiency of the constellation.

Although satellite to satellite cross-linking can be carried out via radio frequencies, the preference is laser communication since allows high frequencies, high bandwidth; thus, more data can be transported. Furthermore, as laser wave-length are much lower than RF, they require a narrow beam, which means the beam's diffraction is reduced. However, this type of communication cannot be used ground to satellite because it presents a greater sensibility to the atmosphere than RF. [13]

2.3 Market situation

Although satellite communication started in the 1950s, the industry does not take a relevant role until the service is not provided to the common consumer (2.6). Therefore, when this period starts satellite communication begins to move an important part of the global economy.

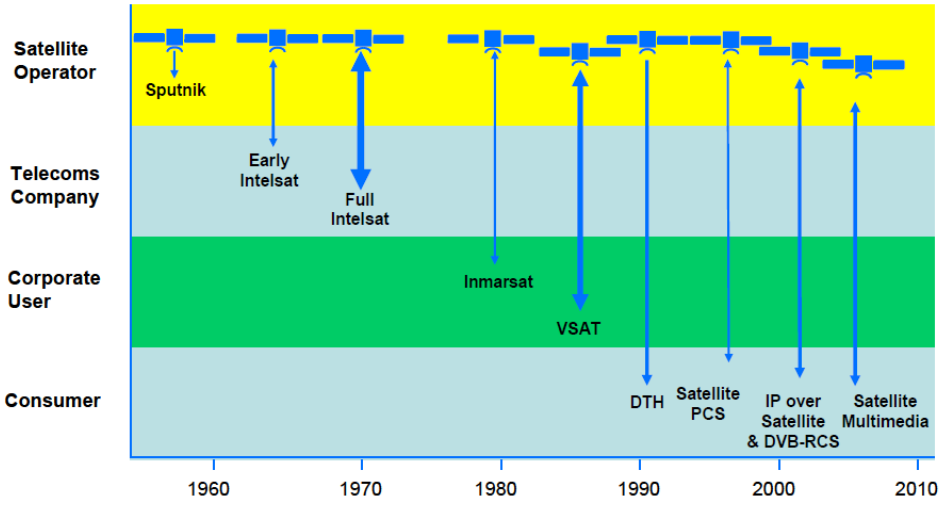


Figure 2.6: Evolution of satellite communication service end user. Source:[14]

The first wave of companies aiming to provide global connectivity through constellations under the GSO, appeared during 1990s. However, despite achieving remarkable technical achievements, highly engineered systems and extensive planning, all these corporations suffered the common fate: financial failure, excessive time to carry out the program and high costs. Some constellations of these companies, which could not compete with highly efficient terrestrial systems, are shown in the following table:

Table 2.1: List of first communication satellite constellations projects. Source:[15]

Constellation	Satellites	Status
Globalstar	48 at 1414km	Bankrupt
ICO	10 at 10,390 km	Canceled
Iridium	66 at 680 km	Bankrupt
Odyssey	12 at 10,354 km	Canceled
Orbcom	35 at 740-815 km	Bankrupt
Skybridge	64 at 1469 km	Canceled
Teledesic	840 (scaled to 288) at 700 km	Canceled

In the last years, the proposals of satellite constellation have re-gained popularity. This second wave has been encouraged by 2 major factors:

- Whether the first wave was funded by equity or loans secured by cell phone entrepreneurs or the traditional communications industry, this time was fueled by the media and social media. New investors have raised financial resources acquired by advertising revenues rather than subscription revenues.
- Two decades of progress which include dramatic reductions in manufacturing process and launch costs. In addition, increased performance and better quality technology followed by the increasing demand of broadband data. [15]

The economical impact of this second wave can be analysed from the SIA [1] report, which includes global satellite industry revenues from 2007 to 2019:

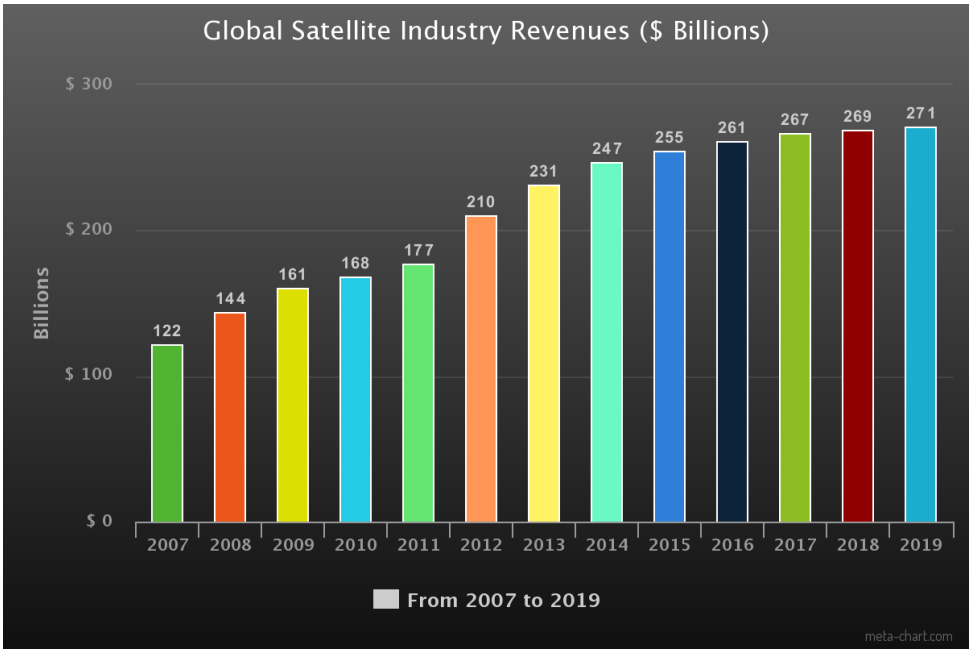
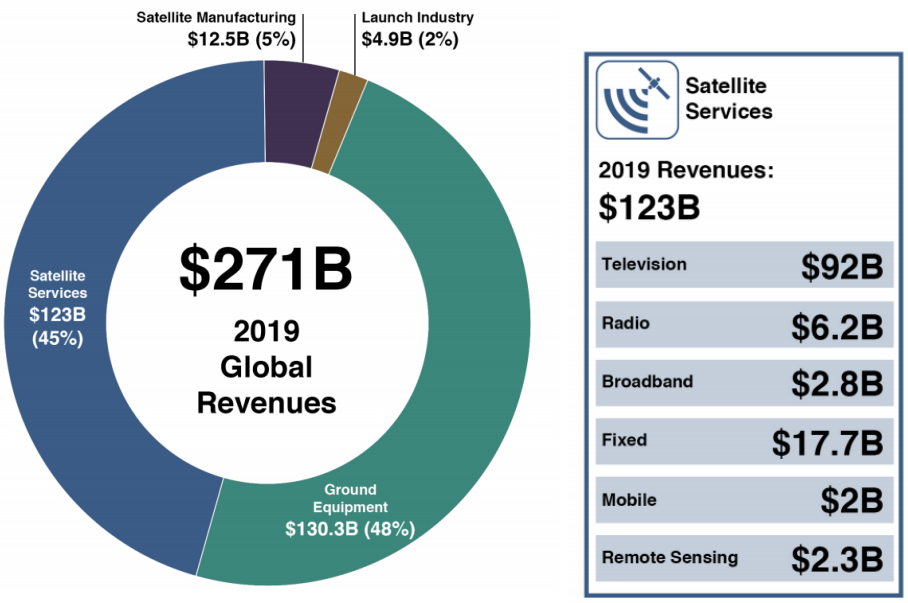


Figure 2.7: Global satellite industry revenues from 2007 to 2009. Source:[16][17]

[1] Satellite Industry Association is an organization which represents domestic satellite operators, service providers, manufacturers, launch services providers, and ground equipment suppliers. Big corporations such as Telesat, SpaceX and OneWeb are part of the association.

As it can be seen, in less than 10 years the revenues have been doubled and they are still growing. However, this amounts represent the global revenues which can be broken-down in: satellite services, ground equipment, satellite manufacturing and launch industry. Hence, analysing the last year data of the report, satellite services represented a 45% of the total revenues of 2019:



(a) (b)

Figure 2.8: (a) Break-down of 2019 revenues (b) Break-down of satellite service revenues. Source:[18]

Finally, from the data obtained from the SIA report, the numbers are showing that the second wave in satellite communication is having positive results for the companies. Furthermore, satellite communication services constitute a representative income for space corporations.

2.3.1 LEO and VLEO status

In relation to LEO and VLEO satellite constellations, due to its lack of market maturity, it is impossible to analyse economical facts during considerable periods. However, in recent few years some corporations are starting to get distinguished among the rest due to their advanced stage developments. The major players in LEO and VLEO satellite constellations to provide global broadband are:

- **SpaceX**: Is an American aerospace private company founded in 2002 by Elon Musk. Some of its achievements include the first successful launch

and return of a spacecraft from Earth orbit and the first crewed spacecraft docked in the International Space Station. Its main objective is to reduce space mission costs to enable the colonization of Mars. [19]

One of its many projects include a large satellite internet constellation named Starlink with the purpose to increase cash flow and fund Mars missions. The internet service will be provided by 11,943 satellites distributed across several sets of LEO (4,425 at 1,200 km and 7,518 at 340 km). From 2015, when the product development began, until the latest update (29th March 2021), the company has already 1,318 satellites in orbit. [20]

The beta version of the service provides internet services with speeds between 50 and 150 Mb/s and a latency of 20-40 ms. Currently, over 10,000 customers are paying $99 per month, plus taxes and fees, for the beta service and an initial payment of $499 for the equipment. Furthermore, the Federal Communication Commission (FCC) has funded the project with 900 million dollars in federal subsidies to support rural broadband customers. [21]

- **OneWeb**: It is a British global communication company founded in 2012 by Greg Wyler. Although, originally it was known as WorldVu Satellites, after the joint venture with Airbus Defence and Space it was named OneWeb Satellites.

  The project of providing global broadband satellite internet through LEO constellations started in 2015 and in 2017 raised around 1.7 billion dollars through investors and partnerships. [22]

  In the first phase of this project was planned to have 648 operational satellites at 1,200 km during 2019-2022. However, after having launched 74 satellites, OneWeb suffered bankruptcy in March 2020 due to the market crash occurred during the coronavirus pandemic. [23]

  After the purchase through auction by Government of UK and Bharti Global, the new holders injected capital and raised funds to continue with the project. Under the hand of the new owners, the company has launched 72 more satellites and in total they have already 146 (last update 25 March 2021).

  Finally, they company is planning to start providing global servicing during 2021 and having launched the 648 satellites by the end of 2022. Afterwards, the phase II which is planned to have 6,372 satellites will begin. [24]

- **Amazon**: It is an another American multinational technology company founded by Jeff Bezos. Although its main focus is e-commerce, Amazon is developing a subsidiary, named Project Kuiper, which consists in LEO satellite constellation to provide global broadband connectivity. It is not

clear if the company will offer the service directly to consumers, but they will work through partnerships with other companies.

The project was announced during 2019 and it has an initial investment of 10 billion dollars. The Kuiper program is expected to be composed of 3,236 satellites orbiting between 590-630 km, which will be launched during the following decade. [25]

Recently, the company has announced a technological progress in a ground antenna. The unveiled device will be capable to deliver high-speed and low-latency broadband with smaller superficial design. Furthermore, it is expected that the array antenna will support up to 400 megabits of data at over five times less cost than traditional antennas. [26]

- **Telesat**: Founded on May 1969, Telesat, is a Canadian satellite communication company. While the rest of companies mentioned above were created in the past few years, Telesat has been one of the oldest and largest satellite service provider in the world.

  Apart of providing other telecommunication services such as telephone or TV connection, in 2017 Telesat announced a project based on providing internet service through LEO constellations. This project has risen a total of 5 billion dollars from Telesat's investment and from the Canadian government. [27]

  The initial constellation, named Lightspeed, is planned to have 298 satellites by the end of 2024. This deployment is expected to provide 30-50 ms latency direct to customers.[28]

Finally, although having opportunities to exploit the LEO and VLEO satellite internet market; Starlink, OneWeb, Project Kuiper and Lightspeed are the main competitors which a new company would have to face-up.

CHAPTER 3

Business Idea

After reviewing the State of Art related to telecommunications, satellite constellations and the opportunity to provide internet from space, it is considered a new business idea:

Provide broadband internet service through VLEO satellite constellations

The main pillar on which the idea will be based is the Very Low Earth Orbit, since the major part of direct competitors (excluding Starlink) are planning on higher altitudes. As observed in previous chapters, the lower the satellites are placed, better performance of internet service are obtained. Thus, VLEO orbits will have a key role to play to provide internet from space.

Besides, one might think that the proposal is highly risky due to the negative results of the companies that went bankrupt during the first wave of satellite communications. However, this new generation projects are fuelled, not only due to the dropping costs of launching, manufacturing, and latest technology, but also to the increasing demand of internet users around the world and the society globalization.

Before getting in the business design, it is necessary to inspect the environment where the company will be operating. This will help to have slightly more vision of future consequences of the business idea. Thus, in this chapter the situation analysis is developed and the conclusions obtained are represented in a SWOT matrix.

3.1 Situation analysis

The situation analysis studies the internal and external aspects of setting down a company in a specific sector. As commented recently, this study gives a general view of the environment where the company will operate and the pros and cons which would have to face.

3.1.1 External analysis

The external analysis consists in understanding the sector where the company will run. The main objective of this inspection is to comprise and anticipate the competitors moves, future market behaviour, possible threats and opportunities. Therefore, the PESTEL analysis and the Porters' Five Forces study will be conducted to achieve successfully this first approach.

3.1.1.1 PESTEL analysis

The PESTEL analysis, also known as PEST, is a framework or tool used to analyse and monitor the macro-environmental factors that may have an impact on the performance of an enterprise. The letters stand for Political, Economic, Social, Technological, Environmental and Legal and represent the aspects that should be taken into account in order to perform successfully the study. Hence, each of these concepts related to the satellite internet sector are treated briefly below:

- **Political**

  Starting with the regulatory framework, VLEO is still a very premature market and many governments simply do not have any regulatory framework. There are some vague rules and simple laws which Federal Communication Commission (FCC) regulates. Therefore, companies do not have to face much difficulties in this case.

  Besides, the world globalization through internet it is something that governments are also interested in, since they are better connected with the people. Furthermore, governments also back-up national space programs. Thus, start-ups in this sector have more possibilities to get funding and investments of local administrations as observed with some projects such as Starlink, OneWeb and Lightspeed (2.3.1).

- **Economic**

  As studied in the State of the Art (2.1.3), internet users are dramatically increasing all around the globe. Currently, around 60 % of the global population uses internet. No such growth ratios were known since the Industrial Revolution. The impact of these events on the global satellite industry and the competitors segment is analysed in section (2.3).

  However, complementing the information of the previous chapters and going more in depth, global trends are showing that fixed-broadband [2] subscriptions are having high growth ratios since the internet is taking roots in the society. Going from 6 subscription over 100 inhabitants in 2008 to almost 15 during 2019. Consequently, due to the growth, the subscription costs have become more competitive. [29]

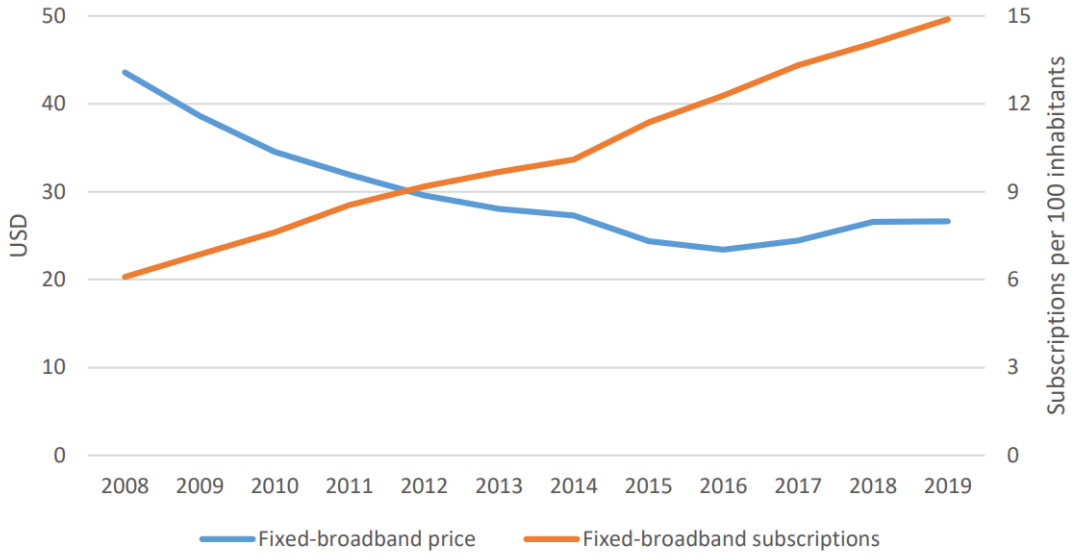
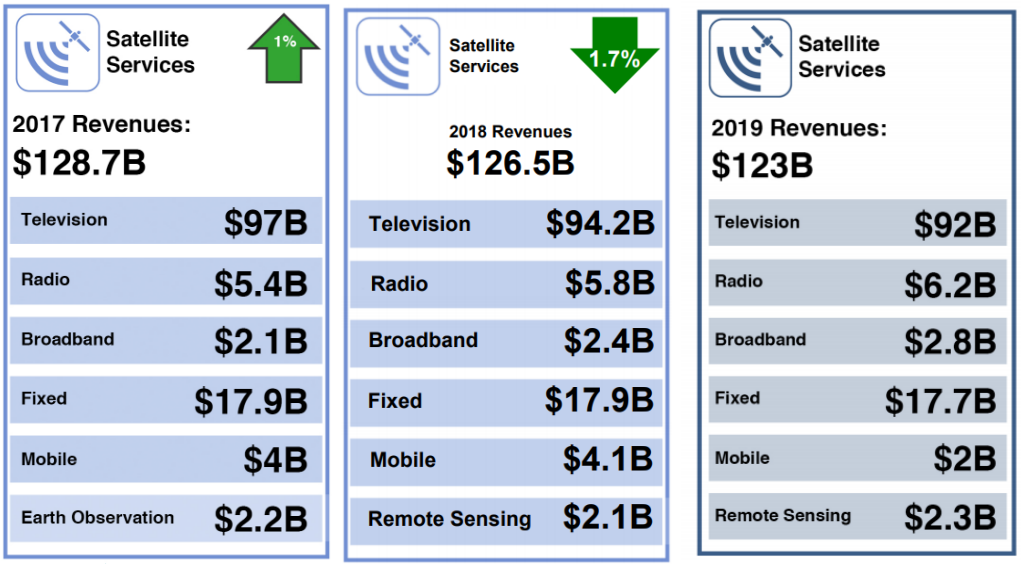


Figure 3.1: Global fixed-broadband subscription growth (2008-2019). Source:[29]

[2]Fixed-Broadband encompasses any data transmission to a fixed location (residence or business) using a variety of technologies, including cable, satellite, fibre-optics, etc.

Thus, this directly affects to internet service providers (ISP), where the satellite internet are included, since they are experiencing an extreme increasing demand. Furthermore, resuming the SIA reports previously analysed in (2.3), part of the increasing demand can be reflected on satellite broadband revenues:



(a) (b) (c)

Figure 3.2: Break-down of satellite service revenues: (a) 2017 (b) 2018 (c) 2019. Source:[16] [17] [18]

As it can be noticed, despite the fluctuations of the global revenues, broadband service profits maintain an upward trend.

- **Social**

  As recently observed, the 59% of the world population is active internet user. However, this value, could be greater since a large amount of people do not have digital access for various issues . The main one is the lack of the service in remote areas such as small towns, villages, distant urbanization, etc. [5]

  Currently, this segment is not exploited by terrestrial ISPs because it involves great economic efforts; most of them are connected by DSL or cable rather than Fibre-Optics. Therefore, satellite internet providers have a possible potential in this areas where they can take-over the market.

- **Technological**

  The entire telecom industry is based on technology which means that every technological change influences deeply the sector. Innovation from electronic devices such as smartphones, computers, etc, to new connections such as the 5G, have become the core productivity of the sector. This is because it is the telecommunication sector that stands to gain the most from these technological trends.

  Besides, more related to satellite communications, during the last few years, satellite manufacturing and launching costs are decreasing in a very consistent way. That is because, throughout the new technological progress such as the reuse of rockets, optimization of engines and the performance on lower orbits; important improvements have been achieved. Hence, these dropping costs are becoming the key to succeed of the satellite telecommunication sector. [30]

- **Environmental**

  Light pollution due to satellites and space junks are two facts that are not having much attention from the media but they are problems that are worsening day by day. The first one has an impact on astronomy observation and the second one harmful for active satellites. The growing attention to these problems and the associations that fight against them, could press the political institutions to limit the spread of these satellite constellations. Anyway, companies working on this field are already searching for solutions to mitigate their impact such as the fast de-orbiting of satellites or manufacturing with less reflective materials. [31]

- **Legal**

  Globally, legal compliance gives rise to big risks for telecommunication companies because there are several laws and licenses that are essential to be complied with. However, they vary depending on the countries or continents, for instance, in US the broadcasting regulations are overseen by the Federal Communication Commission.

  Besides, for satellite internet provider company with mega-constellations, it is fundamental to operate in a large number of countries to be profitable. Thus, they have to overcome this challenge and adapt their policies accordingly to each country's legislation.

3.1.1.2 Porter's five forces analysis

The Porter's Five Forces is an analysing method that helps to identify the attractiveness of the industry throughout five competitive forces. It should be noted that this study is a strategic tool designed to give a global overview, rather than a detailed report. However, it is enough to identify the opportunities and threats surrounding the sector or predict future market trends in order to determine the corporate strategy.

Hence, the five forces that shape the satellite internet sector, are the leading ones:

- **Bargaining power of suppliers**

  The bargaining power of suppliers, also described as the market of inputs, defines the power that providers have in the market and how they can influence the prices of the primal resources. This force is defined by how many suppliers are in the market, the type of assets required and how much it would cost a company to switch to another supplier.

  In the case studied, companies aiming to produce and manufacture their own satellites as well as settling their own ground stations, will only depend on raw material providers and communication equipment manufacturers. Currently, there already exists a plenty of suppliers of both assets: on one hand, primal resources such as titanium, aluminium, composites, etc., are easily found; on the other hand, there are a wide list of companies such as Samsung, Qualcomm, Cisco, etc, that provide telecom equipment. [32] [33]

  Hence, the resources needed to settle-down satellite internet services are widely found. Furthermore, the risks of changing or monopolizing prices are considerably low.

- **Bargaining power of buyers**

  The force of bargaining power of buyers, also defined as the market of outputs, is the ability of the customer segment to put the firm under pressure by driving the prices down. This force can be measured by analysing the quantity of customers, how significant are they for the company and how much would it cost to find new customers.

  As commented before, the major part of the customer segment of satellite internet is based on remote areas, who lack from terrestrial connectivity. Hence, the only viable way to connect to internet they have is through satellite internet. Therefore, taking into account that VLEO has better performance and very few competitors, the buyers have a really low influence on prices and very low availability to switch to other companies offering similar services.

- **Threat of substitution**

  This force refers to the likelihood of the customers finding different alternatives for the same service. The threat of substitution is low when the enterprise offers an attractive price-performance value and the buyer's cost of switching to the substitute is high.

  Therefore, since there already exists many ways to connect to the internet, it gives to internet users a great variety to get internet service from lots of companies. Thus, the risks of losing customers due to other technologies is significantly high. However, some aspects such as the service quality or the price will not be the same for each alternative.

- **Threat of new entry**

  This force analyses the risk of new entrants into the industry which can interfere with the strategies of current players. This threat depends on the size of a series of barriers that new organizations have to face, which include the costs of building brand awareness, initial investment, legal restriction, etc.

  Considering the satellite internet sector, the main barrier for new players are the extremely high costs when settling down the service. Furthermore, not only a big investment is the main problem, but also a correct business strategy has to be done, since the company does not start receiving inputs until the constellation does not covers a certain region. Thus, all this process requires a considerable amount of time and a correct planning, because, as previously saw in the market study, from the companies who tried entering in the industry, only few have succeeded.

- **Threat of rivalry**

  The last force measures the intensity of competitive rivalry in the market. Basically, it analyses how many competitors are in the sector, how strong are them strategically and their ability to undercut other companies. When rivalry is intense, companies tend to attract customers with aggressive price cuts and high-impact marketing campaigns; whereas, when rivalry is minimal, companies have significant strength in the industry and healthy profits.

  The premature age of LEO and VLEO market, where there are not many competitors, new projects have not to struggle to face big established organizations as in other sectors. Although some companies have begun with LEO and VLEO projects to provide global broadband, they are still on the first stages. More precisely, only the SpaceX has started deploying satellites on VELO, the rest are on higher altitudes or have not deployed yet. Therefore, the intensity of competitive rivalry in the LEO and VLEO satellite internet industry is minimal.

The Porter Forces analysis has been summarized in the following image:

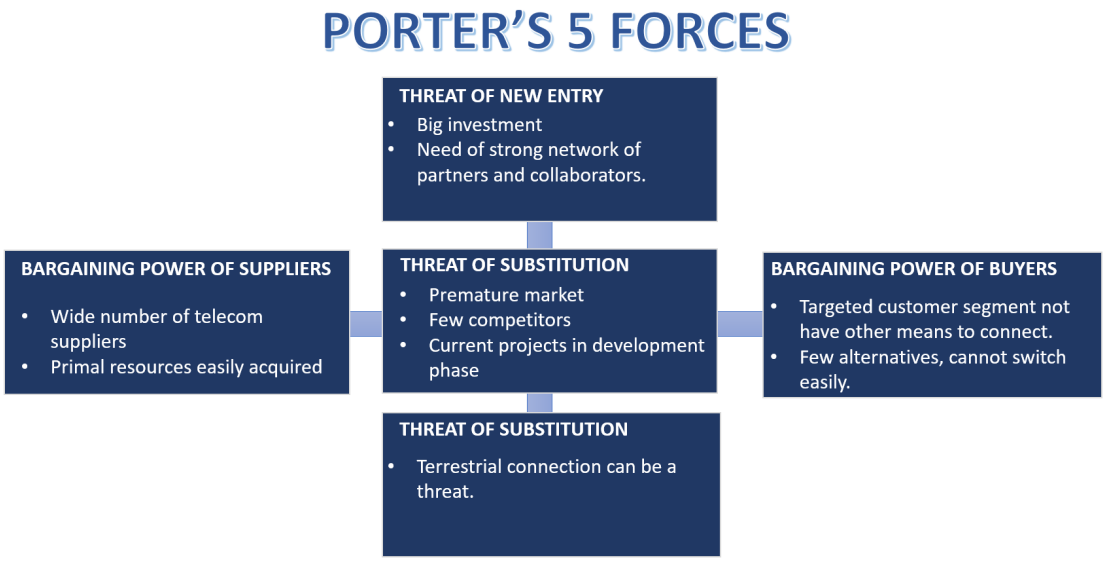


Figure 3.3: Porter's Five Forces analysis. Source: own elaboration

Finally, the conclusions obtained from the external analysis can be summarized in the following statements:

- The demand of internet service is increasing with high growth rates.
- Currently, companies working on similar projects, are not facing much restrictions to deploy satellites on the LEO and VLEO segment.
- Governments are funding similar projects since fast satellite internet allows to offer service to rural areas and countrysides.
- There are very few competitors in LEO and VLEO satellite internet industry.
- Terrestrial internet can be a threat since it offers faster service.
- The development of mega-constellations to provide satellite internet involves large amounts of investment. Companies working on similar projects have invested billions of dollars.

3.1.2 Internal analysis

To complete the other side of the picture and provide a general view of the business idea proposed it is necessary the internal analysis. This study will lead to identify which qualities differentiate the new proposition from the opposition and also will help to identify the delicate aspects.

3.1.2.1 Strengths

Starting with the key factor that can significantly distinguish the company among the market, VLEO satellites; the service provided through this method will allow the following attributes:

- Low latency, high broadband and high speed internet service.
- Low energy levels required to position satellites, which will lead to lighter weights and low manufacturing costs.
- Shorter distances between ground equipment and satellites will reduce transmitting system efficiency requirements. Hence, costs in ground and satellite equipment will decrease.

Apart from that, satellite internet in general are more practical than terrestrial providers in terms of installing the ground equipment to users. Whether the terrestrial depends on the wiring connection, which depending on the location can be a complex task, to provide satellite internet it is only required the communication window between the ODU and the satellite.

3.1.2.2 Weakness

Taking into account that to start charging the service at least a number of satellites will be needed to provide a constant connectivity for a specific zone. Therefore, the initial investment required to launch a minimum quantity of satellites and install the sufficient gateways will be considerably high.

As well as that, satellites operating at VLEO will have to face the side effects produced by the atmosphere such as the atomic oxygen damage or the effects of aerodynamic forces.

Having to start from zero is another drawback since the company lacks of brand reputation. This makes hard to get collaborators or partnerships with other organizations and also the investments.

3.2 SWOT

Once stated the situation analysis and the different aspects of the environment where the business idea is going to settle-down, a SWOT matrix can be developed. This analysis is a strategic planning technique used to identify strengths, weakness, opportunities and threats related to business competition or project planning.

The SWOT study assumes that strengths and weakness are internal, whereas opportunities and threats are the external aspects of the environment. Furthermore, these factors are also classified according to favourable and unfavourable features for the business idea. Finally, all these concepts are shown in the following figure 3.4

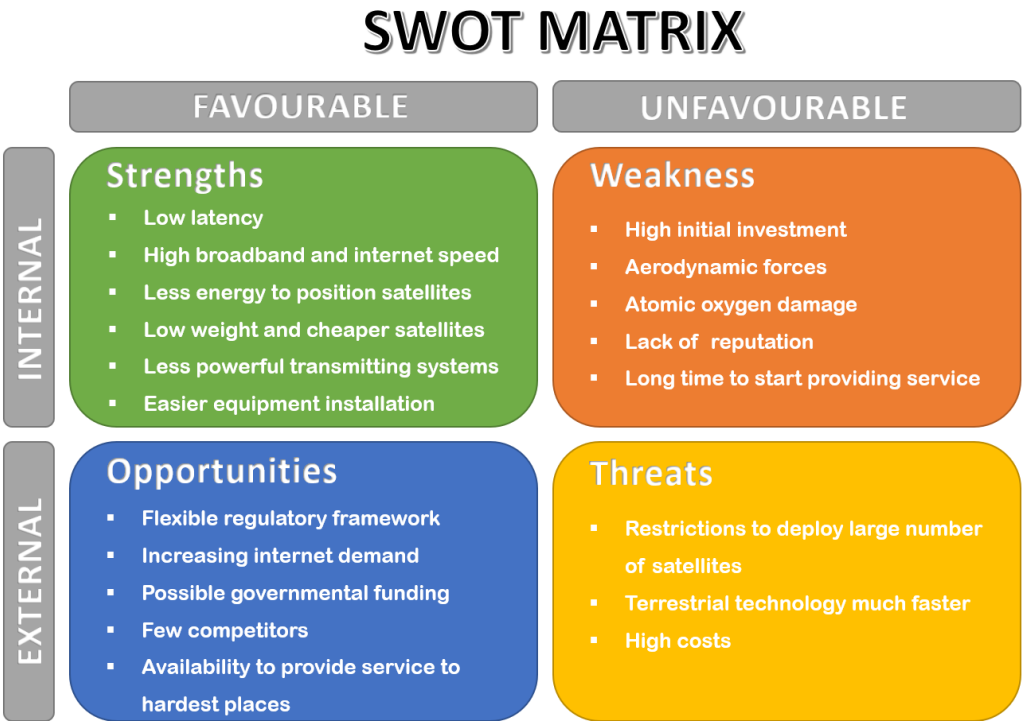


Figure 3.4: Swot matrix. Source: own elaboration

The information that can be extracted from the SWOT analysis is that the business idea has more positive aspects than negatives. The internal strengths offer a big potential to explode in the satellite internet industry. Moreover, the opportunities that are presented in the market, add more value to the business idea. Although there are some threats and weaknesses, their impact to the business is very low and most of them can be resolved. For instance, with a correct planning the time required to provide internet can be reduced, negotiating agreements with space agencies to achieve permissions to deploy large amount of satellites or improving satellites to reduce the VLEO atmosphere effects.

CHAPTER 4

Business Model

Now that the business idea is well defined and the situation analysis has been done, a more detailed design of the proposal can be done trough a business model. This concept is a tool used to make a pilot-study considering all the aspects related to setting-down a new business project.

Currently, there is not any general definition about what a business model is. This is because the interpretation varies on lots of aspects such as on which sector is applied (marketing, science...), or when is applied. As the society grows, new companies are born every year; thus, the market gets bigger and the contents of a business model fluctuate.

Nevertheless, in the context of this study, it can be defined as a tool to describe or represent how an organization creates, delivers and captures value in economic, social, cultural or other contexts. Although it exists an extensive variety of models, there are some concepts that remain the same for everyone. Every method's final purpose is to represent the core aspects of a business, define the value proposition, build an operational process, target the customer segment and determine the strategies, resources and the infrastructure.

Hence, in order to answer some questions, related to defining the business idea, such as what is the company going to offer, how is going to do so, what will be the benefits and how they will achieve them, the Business Model Canvas will help to define them.

4.1 Business model canvas methodology

The Business Model Canvas is a strategic management template used for developing new business models or documenting the already existing ones. Alexander Osterwalder, the author, describes his methodology as a:

"A shared language for describing, visualizing, assessing and changing business models." (page 12 [34])

Basically, it gives a visual perspective of how an enterprise is organized to create, deliver and capture value in the market through nine building blocks. These systematic blocks, which cover the main four areas of a business: customers, offer, infrastructure and financial viability, are shown in the following template:

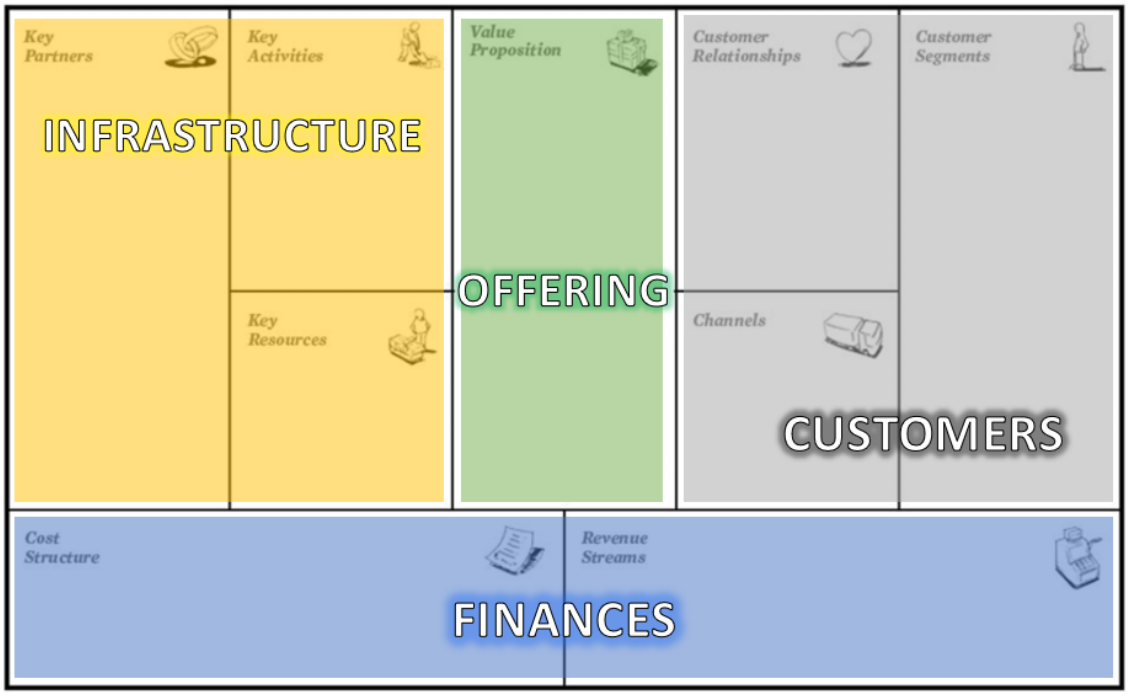


Figure 4.1: Business model Canvas with the four areas. Source: own elaboration [34]

In order to get more in depth, the business model can be understand through the description of the nine building blocks:

Infrastructure

- Key Partners: In order to optimize operations, reduce risks, and acquire resources, organizations usually create supplier-buyer relationships with other corporations so they can focus on their core activity. Thus, this block describes the network of suppliers and alliances which allow the business model work.
- Key Activities: It describes the main actions that an enterprise must do to operate successfully. For instance, for Bic company, one of the key activity is creating an efficient supply chain to drive down costs.
- Key Resources: This block describes the most important assets that a firm needs to create value for the customer. More precisely, these resources can be physical, financial, intellectual or human.

Offering

- Value Proposition: It describes the collection of products and services that the organization offers in order to create value for a specific customer segment. Basically, it defines the reasons of why the company stands out from the rest of the competitors. These values can be quantitative, such as the price and the efficiency, or qualitative, for instance the customer experience and outcome.

Customers

- Customer Segment: This block embraces the different groups of clients that the company aims to reach and serve. Therefore, the organization must identify which customers can they serve and classify them accordingly on their needs and attributes. This will lead to ensure an appropriate implementation of corporate strategies in order to meet successfully the demands of the different groups of customers. Thereby, the different types of customers segment include:
  - Mass market: Large group of customers with mainly similar demands and problems. This is situation is often found in the consumers of the electronics sector.
  - Niche market: Small group of clients based on specialized needs and characteristics that have a particular solution.
  - Segmented: Corporations create additional segmentation within existing customer segment accordingly their slightly different needs.

For instance, the services provided by the firm can vary on the gender, age or income, of the customers.

- Diversified: Segmentation of more than one group of clients that are completely different, but the enterprise finds them suitable for its activities.
- Multi-sided platforms/markets: Group of interdependent clients that mutually depend on a common customer. For example the newspaper and the advertisers have in common the readers.

- Channels: It describes the methods throughout the company reaches the customer segment. These channels cover five distinct phases: rise awareness, evaluate the value proposition, how to purchase it, how it is delivered and after sales support. Furthermore, they can be direct, such as the web sales, or indirect, for example stores.
- Customer Relationship: This division defines the type of relationship that the company establishes with each customer segment. In other words, it describes the way that the Channels block is carried out.

Finances

- Cost Structure: This block includes all the monetary consequences of operating under the business model. There are two type of business structures: while the Cost-driven model focuses on minimizing costs wherever possible, the Value-driven model aims on creating value for products and services.
- Revenue Streams: This division defines the income that the organization generates from each customer segment, which can be a one-time transaction or a recurring payment system. There are many types of revenue streams: asset sale, usage fee, subscription fee, renting and licensing.

4.2 Business Model Canvas design

Once the Osterwalder's theory has been analysed, the Business Model Canvas for a VLEO satellite internet service provider can be designed.

4.2.1 Customer Segment

Although the service provided by the company would be able globally, there would be some segments where other alternatives will be better in terms of quality, speed and costs. This customer segment corresponds to urban areas with dense populations, already wired with cable and fibre, where the costs of installing fibre-internet per customer results cheaper for terrestrial ISP's. Furthermore, considering that the corporation is being designed from zero, aiming to these segments would lead to huge economic efforts with high risks of not having profitable results, since the competition would be tough.

However, running optic-fibre or cable lines all around the globe is non-profitable as well, since the benefits per customer does not compensate the installation and maintenance costs of such infrastructure. Yet the demand of internet in the countryside, rural areas, less dense and distanced urbanization, is the same as the rest of the locations.

Thus, in this field is where satellite internet comes in. Unlike other means, satellite internet does not require any land-based infrastructure running out to buildings. Instead, a home satellite dish is enough to communicate with satellites and establish full broadband service.

Going more in depth, from recent studies have been found that the global rural population in 2019 was close to 3.4 billion, around 44 % of the total. Africa and Asia are home to nearly 90 % of world's rural residents, with countries such as India (893 million), China (578 million) and Nigeria (97 million). [35] [36]

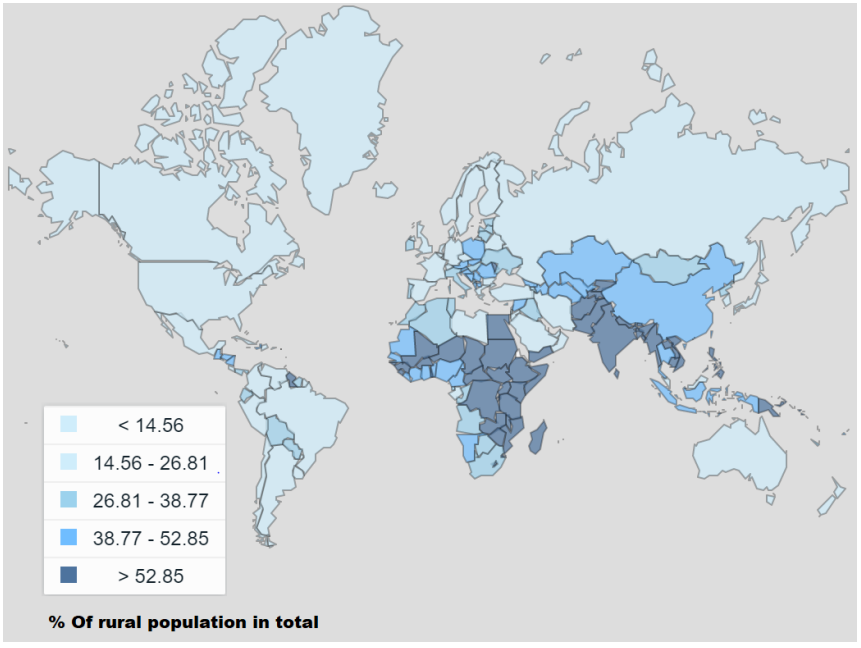


Figure 4.2: Percentage of rural population across the world. Source: [35]

Furthermore, during last decades, trends show that the rural population is migrating towards urban cities due to lack of job opportunities and facilities. However, during the COVID-19 pandemic, many jobs have evolved towards work from home direction throughout internet. Consequently, people's residential habits have also changed towards less dense regions avoiding overcrowded areas. Therefore, fast speed internet through VLEO and LEO satellite constellations would have great impact into people when considering their residence. [37]

Finally, for the first stage of the company and until a minimum service is not established and a considerable revenue are not achieved, the customer focus will be the remote, rural, countryside and distanced areas. Hence, this type of customer segment could be included inside the niche market.

Afterwards, in the second stage, the benefits and market reputation obtained from the first stage could be reinvested to improve the density of the constellation, to cover larger zones, and run a more competitive campaign against the rest of technologies aiming to provide internet to every customer segment.

To conclude this subsection, two profiles that would represent the major part of the demand, are represented in a form of Buyer-Persona roles taking into account all the information analysed during the previous and recent chapters:

Figure 4.3: Buyer-Persona example 1. Source: Own elaboration

Figure 4.4: Buyer-Persona example 2. Source: Own elaboration

4.2.2 Value Proposition

Starting filling the customer segment block helps to understand better the personality and behaviour of the consumers in that particular field and recognise what are their main needs. This way, the value proposition of the company is formulated taking into account all the aspects of the demand which makes it more attractive in the eyes of the customers.

Hence, as a satellite internet company, the main features that will generate value to the organization will be:

- **Newness**

  The most important value of the company will be settling-down the satellite constellation on very low earth orbit. Providing connectivity from the lowest altitudes will enable to offer the lowest latency and the highest-speed in the whole space internet segment. This service will allow to do online gaming, have high quality video calls, watch live streams, etc.

- **Flexibility and Customization**

  The company will offer a wide variety of internet plans with their respective internet speeds, which will give a certain flexibility when hiring the service. This way, customers will be able to contract and pay for the service they want according to their specific needs.

- **Accessibility**

  Planning a good strategy, of both launching and placing ground stations, to progressively cover the earth's surface, will enable to start providing high-speed internet service to places where access through ground infrastructure was unreliable or completely unavailable. Furthermore, the service will ensure 24/7 connectivity to every customer.

- **Affordable and Quality**

  As a start-up, the company should attract the attention in the industry and give them some important reasons to justify why they should choose our product. A very effective tool in these cases is the price. Creating affordable prices without losing the quality will make the product more attractive and reachable to bigger customer segments. Therefore, in order to guarantee these affordable prices, without losing the standard, the following features can be useful:

  - Since the satellites need to be position at VLEO, it requires less energy and less fuel to reach there. Thus, size optimized launch vehicles or carrier rockets can be sought to the reduce costs. Fur-

thermore, since the satellite launching will be a frequent activity, also reusable vehicles would improve the economic results. Another option would be the use of hot balloons complementing the launching.

- Lean Manufacturing process can be applied for both, satellite manufacturing and telecommunication assembly tasks.
- Since the distance between ground and space segment is lower, less powerful telecommunication equipment will be needed. Therefore, this will lead to reduce sizes and weights of antennas and other equipment, to finally reduce the costs.

- **Environmentally-Friendly**

  Another way to be differentiated from the competitors and adapt the new trends, to help the world grow toward a brighter future, Eco-friendly policies will be taken into account. This would be achieved with practices such as:

  - Use of renewable energies in the ground facilities.
  - Recycling telecommunication equipment from costumers once they unsubscribe the service.
  - Playing at VLEO will not contribute with space debris.
  - Non-reflective materials will be used in satellite manufacturing to eradicate the light pollution due to satellite reflection.

4.2.3 Channels

In order to maximize profits and reach the maximum of potential clients, the enterprise will have both direct and indirect channels. Within the business deign, the channel block will be split in 4 different parts:

- **Advertisement**

  First of all, to raise awareness inside the industry about the services that the company is offering, the publicity campaign will follow two types of strategies:

  - General Advertisement: This type of publicity will be carried out through Social Media platforms or influencers, TV and website adverts and signing sponsorships in the fields where internet plays a key role, for instance EA Sports. Therefore, it will be addressed to anyone consuming the kind of channels just mentioned.

  - Focused Advertisement: This promotion strategy will be addressed to the specific customer segment defined in the previous block. Since they are on specific areas, channels such as posters, commercial phone calls and advertising brochures are the appropriate to reach them.

- **Website mobile app**

  Once the customer gets interested in the service that the company is offering, they would be able to get a detailed information from a website about the following aspects:

  - The plans and prices of the service available.
  - How to purchase the service and the equipment.
  - Information about company's policies, contact details and other important data.

  Furthermore, once they purchase the service, customers will be able to download an mobile app, from which they can consult their internet, interact with the customer care team, etc.

- **Commercial and sales team**

  The commercial and sales team will carry out the whole process of contracting the service by the client, give any extra information that the clients demand or any personal assistance. As well as that, they will take the feedback of the evaluation made by the customers and support the post-purchase procedures.

- **Call Center**

  Finally the call center will make possible to bring the service to every customer's house. They will manage the technical teams to develop tasks such as ground equipment installing, assistance to break-downs and failures or other required maintenance.

4.2.4 Customer Relationship

The relationships between customers will be planned in relation with the different types of distribution channels. Thus, two types of relations can be differentiated:

- **Personal assistance**: The customers will be able to interact with human teams in order to purchase services, consult plans and prices or have any inquiry. The commercial and sales team as well as the technical team will compound this part.

- **Automated services**: Customers will have the possibility to maintain no direct relationships with the firm throughout the website interface or an app. This way they could help themselves if they have any issue or consult the data or other features provided by the app.

4.2.5 Revenue Streams

The inputs that the company is going to have in exchange of providing the service will be both one-time transaction and recurring revenues, similarly as the rest of ISP companies. Besides, the pricing mechanism of the product will be a fixed price, based on the costs and specifications. More precisely the revenues streams will be:

- **Subscription fees**: The main income of the company will be the subscription payment that the customer will pay each month for the internet service. The company will provide several internet plans that will depend on data threshold. This data threshold consumes more or less resources since it carries the amount of information towards the space and back. Thus, the company will provide several plans of data speed each month with their respective prices, and if the customer consumes the whole plan before the end of the month, they will have a minimum service speed until the next month.
- **Leasing fees**: Customers will have to pay a temporary granting fee for the ground equipment installed on their buildings. This cost will be charged at the beginning of the booking and returned to the customers at the end of the service as long as there is not any problem with the equipment.

4.2.6 Key Resources

The key resources that the company will need in order to create and deliver the value proposition, cam be differentiated as:

- **Physical Resources**: As a satellite internet provider, physical assets such as the ground stations and satellites will constitute the main resources of the firm. Thus, ground facilities to manufacture and assemble the satellites with the telecommunication equipment will also be required. Besides, the organization will also need some headquarters where the management team and other executives will operate.
- **Human Resources**: To create, develop, manage and run the company, a great amount of human resource is necessary. Thus, the organization will have highly qualified staff in all its departments:
  - Engineers and technicians to manufacture satellites, operate on ground stations and supervise the constellation.

  - Administration team to carry out management and planning roles.
  - Commercial profiles to do promotions marketing and sales tasks.
  - Technical team to develop activities such as ground equipment installing and maintenance.

- **Financial Resources**: As observed in the market study, establishing a company in the satellite internet industry it is not an easy or cheap task. The creation of the value propositions requires highly qualified team, abundant manufacturing resources and expensive technology. Hence, to supply all these assets, the enterprise will need an important investment of capital to start providing internet from the space and succeed in the industry.

4.2.7 Key Activities

In the case of the satellite internet provider, the actions that the company should carry out in a regular basis in order to operate successfully are the following ones:

- Within the production activities, since the core activity of the company is to provide internet service via satellites; the manufacturing, including the proper assembly of the telecommunication equipment required, will figure one of the key activities. As well as that, from configuring a minimum network of satellites to establishing the mega-constellation; another recurring activity will be the progressive launching of the satellites.
- In relation to the ground segment, the construction and operation of the ground stations. In parallel with satellite launching, another activity will be the opening of new gateways with their respective antennas.
- Supervision and maintenance of the space and ground connection to maintain the internet service active. This activity also includes the monitoring to avoid possible collisions or other interference.
- Continuous branding and marketing campaigns to spread the value proposition of the company, be known in the industry and attract as much customers as possible.
- Within the Customer management, every process of administration and interaction with the customers will suppose a recurring activity.

4.2.8 Key Partners

To develop such kind of project, the organization will need a set of indispensable allies which will play a key role to optimize the business model, reduce risks and bring lots of trust and brand value to the company. Therefore, the key activities that the organization wants to perform in order to create the value proposition, will require alliances with the following entities:

- **Data Centres**: At first, internet data centres will spouse one of the most important partners to bear in mind, since they enable the internet traffic demand. The ground stations, which are connected to them via fibre optics, should be in close proximity to these infrastructure for optimum operability. Therefore, it's a must to create cooperation relationships with these data centres.
- **Material suppliers and ground equipment manufacturers**: Strategical relationships with material suppliers will be needed to get physical resources needed to manufacture and assemble the satellites. Besides, partnerships with ground equipment providers to get telecommunication devices such as antennas, dishes and transmitting systems, will also be needed.
- **Launchers and deployers**: In order to deploy the fleet of satellites progressively, the company will have to negotiate with rocket launchers and satellite deployers. Assigning this task to a key partner will help to reduce planning and economic efforts.
- **Space Agencies**: The corporation will also require to make agreements with space agencies to get licenses and permissions to launch and establish the satellite constellation and provide internet from space.
- **Governments**: Cooperative relationships will be sought with governments of the countries where the service would be able, in order to receive subsidies and funding in exchange of offering connectivity to territories where other means cannot arrive. Besides, other local permissions and rights will be needed to start operating in each country or placing ground stations.
- **Investors**: As per the enormous dimensions of the project, the initial investment needed is considerably high. As seen in the state of the art, the companies in the industry have already invested millions of dollars in similar projects and there are some that went bankrupt due to lack of capital. Thus, for the correct implementation of each key activity and obtain the required key resources, the enterprise will need some potential investors.

4.2.9 Cost Structures

The cost structure of organization will be cost-driven as it will focus on minimizing costs wherever possible, without losing quality, in order to offer affordable prices. The main costs that the company will have are the following ones:

- **Facilities & Equipment**: This element includes all the expenses of purchasing and maintaining the centres needed, with their required equipment, to manufacture and assemble satellites and from where the staff will operate.
- **Material Purchase**: This block describes all the costs associated to purchasing the necessary material to manufacture and assemble the satellites and the telecommunication equipment required for ground stations, ground segment and satellites.
- **Launching & deployment**: These expenses will represent all the costs related to satellite launching and its deployment on the very low earth orbit.
- **Ground structure**: Within this block, it will be represented all the economic resources needed to settle the ground stations and establish the connectivity with the data centres.
- **Human resources**: This element describes the costs associated to the salaries of every person working in the company.
- **Marketing**: This includes all the costs due to advertisement, promotion and branding activities that the company does in order to reach the customer segment.

4.3 Business model canvas overview

Once all the different components of the business models have been defined, a visual overview of with each block together can be represented according to Osterwalder's model:

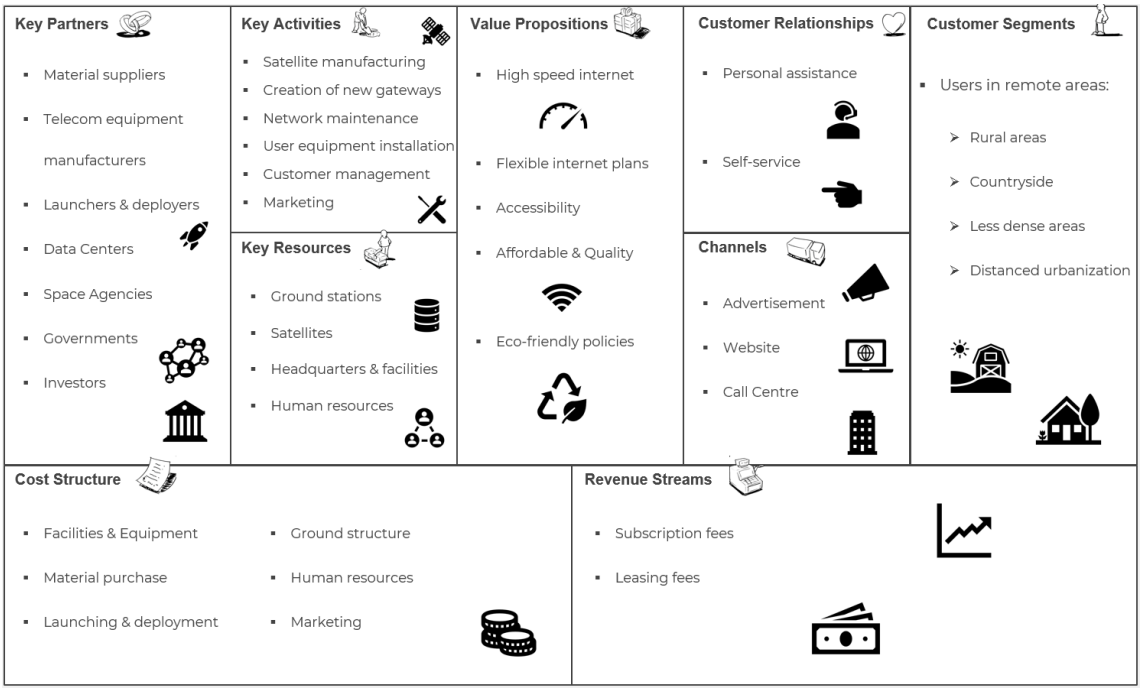


Figure 4.5: Business Model Canvas Overview. Source: Own elaboration

CHAPTER 5

Marketing Plan

Marketing is known as the set of activities to promote and make known the service or product of a firm, in order to reach the economic objectives. Therefore, marketing is considered one of the crucial activities that the company must carry out in order to succeed. Besides, the marketing plan is a tool that businesses use to organize, execute and track their marketing tactics and strategies to achieve their final goals.

Hence, in this section, a preliminary marketing analysis has been developed which goes from defining the core values of the company, the development of the mix marketing study and the estimation of financial assets needed to implement the marketing plan.

5.1 Company's core values

- **Mission**

  The main purpose of the company is to remove the barriers to connectivity on Earth and make high-speed internet available in any part of the world through satellite communication.

- **Vision**

  Develop a solid position in the satellite communication industry and be the reference of the fastest satellite internet in the space segment.

- **Objectives**

  - Offer the lowest latencies in satellite communication technologies.
  - Offer competitive prices in order to make the service affordable as much people as possible.
  - Make the value proposition attractive establishing good relationships with the customers.

  - Set-up strong associations with partners in order to maintain a healthy growth with strong roots.

5.2 Marketing mix

The marketing mix or also known as "The Four Ps of Marketing" it is a marketing scheme, proposed by Jerome McCarthy, which conducts marketing plans through four variables:

- **Product**: In the case of which the current company is being designed, it is a service what is being offered, rather than a product. More in detail, as explained in previous chapters, the company will offer internet connectivity through several data plans and downloading and uploading speeds, which customers could choose according to their needs.
  - **Attributes and features**: The most characteristic features which will highlight the service are due to playing at VLEO such as the high internet speeds due to lower latencies.

    Besides, the closer distance between the space and ground segment will lead to use smaller size user terminals, since there will be less transmitting power requirements. This fact will provide convenience when installing and allocating the equipment on user's locations.

    Finally, as a feature of satellite communication technology, the service would be available anywhere around the globe. It is true that there are other companies in the industry that already provide this service from space. However, they are not able to provide high speeds and low latencies such as the VLEO networks.
  - **Branding**: The branding of the company is another important activity because it represents the image of the organizations and differentiates them from other firms. Thus, to establish the brand of the enterprise it is required a name and a logo or symbol, which has to be directly meaningful to the value proposition of the company. Taking into account all these aspects, it has been decided to use the name of VleoNet for the company and the following logo:

Figure 5.1: Caption

The name has been created combining two of the main concepts of the company: the Very Low Earth Orbit and the Internet, which results in an easy to remember and a meaningful name.

- **Support services**: As planned in the business design of VleoNet, there will be several methods to assist and support the customers and other people interested in the service. From personal assistance through telephones and emails to automated platforms such the website and the mobile app. Therefore, throughout these channels, a good relationship with customers will be built, which will guarantee a good confidence and comfort to customers towards the company.

- **Price**: The company will offer several prices for different internet plans, which customers will have the possibility to subscribe one that fits their necessities.

  One way to decide a price of the service could be calculating the costs of the offered service with an extra added profit margin. However, it cannot be applied in this situation, since the costs of establishing the whole network requires billions of dollars, so the price that would result from that speculation, would be unaffordable to people. The pricing of the service in these cases, has to be a reasonable amount, which usually will cause a negative cash flow during the first years, until there is not a solid base of customers, but at long term it will generate the desired benefits.

  Therefore, the estimation of the charging fees for the service, will be given in further chapters, after computing the costs and speculating the customer demand. However, for a general approach, currently, satellite internet companies offer internet plans at prices that go from $50 to $150 per month, with an extra charge fee for the equipment. [38] [39]

- **Place**: As described in the business design, there will be several methods to purchase the service. The people interested in the service would be able to contract the service from the website or calling to the commercial team. Furthermore, there will be a public presence trough social media, from where important information will be shared, for instance upgrades in the service, advertising, etc.

- **Promotion**:

  In order to make known the service and spread the brand into the potential customer segment, as mentioned in the channel block of the business model, VleoNet will promote its service through two types of strategy: General advertisement and focused advertisement. This promotion will be carried out through social media platforms, TV, web adverts, advertising brochures and posters.

5.3 Marketing budget

Providing internet from space involves huge amount of investment, for instance millions and billions of dollars have been invested in projects such as Kuiper and Starlink. The current business model, that has been stated to be affordable, highly needs a big customer base to amortize the investment and its running costs. Therefore, to keep the demand high and reach larger amounts of customers, there would be needed a considerable marketing budget. As mentioned before, the advertisement will be carried out through traditional media (Tv, advertising brochures and posters), modern media (social media, web adverts, streaming platforms) and the commercial department.

Besides, analysing the annual report of Viasat, another satellite communication company, it has been obtained that the company has been investing 5-10 million dollars in marketing. The expenditure was higher in the earlier years, which has been decreasing over the years.

Finally, taking into account all these aspects, it has been decided an initial marketing budget of 10 million dollars, which will decrease by 10% each year.

Table 5.1: Marketing budget

	Marketing Budget									
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Millions of dollars	10,00	9,00	8,10	7,29	6,56	5,90	5,31	4,78	4,30	3,87

CHAPTER 6

Economic Plan

6.1 General considerations

When it comes to study and design an economic plan for a company that aims to establish a constellation of satellites to provide broadband services, there are required some important figures which strongly influence the final results. For instance, the quantity of satellites that will form the constellation, the number of ground stations and the type of satellites used in the mission, are that type of inputs required. However, these values cannot be determined easily, since defining the whole constellation requires exhaustive engineering work with complex optimizing algorithms.

First of all, the number of satellites required in a constellation is governed by the type of coverage that is intended to provide. For a global coverage, the lower the altitude is, the fewer the number of satellites is required. For instance, at GEO are needed 3 satellites and at MEO from 5 to 30 (depending on the altitude). Furthermore, observing the data from the following figure, 50 to 200 is the minimum amount of satellites needed to span the globe, depending on the type of orbit:

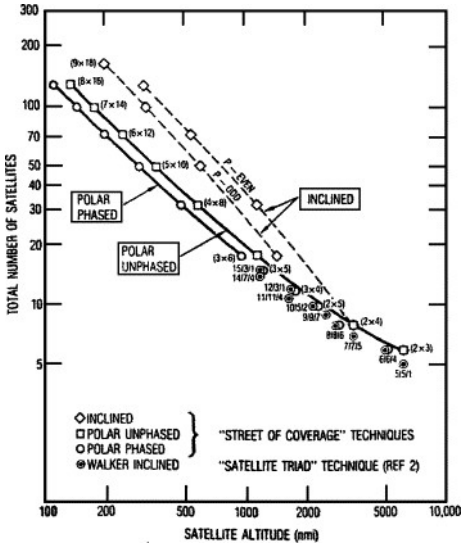


Figure 6.1: Number of satellites for full Earth coverage as a function of altitude. Source: [40]

Secondly, another fact to bear in mind is the bandwidth capacity of the constellation. Each satellite has a limited throughput capacity, that represents the spectrum beam that carry out the data on each interaction, which varies from 15-35 Gbps depending on the model and type of satellite (taking into account existing LEO satellites). This total capacity is divided among the clients covered by the satellite depending on the plan they have contracted. Therefore, depending on the demand that is desired to supply, the number of satellites forming the constellation will vary accordingly to it.

Finally, these two variables would suppose the main inputs, among others, of a complex algorithm in order to determine the proportions of the constellation. Without doubt, this could be another thesis project in according to its complexity. For this reason and due to lack of time, this study will not be conducted; however, a general approach considering several scenarios will be done in order to achieve some economical results.

Actually, studying current projects that have been proposed on LEO and VLEO during the last few years, some figures can be estimated. Therefore, analysing these constellations in depth the following table has been done to summarize them:

Table 6.1: Comparison between LEO and VLEO satellite internet constellations [20] [22] [25] [27]

	Starlink	OneWeb	LightSpeed	Kuiper
Initial constellation size	4425	648	298	3236
Expansion	12.000 (30.000)	6.372	1.600	-
Orbit	350-560 km	1.200 km	1.000 km	590-630 km
Frequency	Ku-band	Ku-band	Ka-band	Ka-band
Total bandwidth throughput	25 Tbps	1.56 Tbps	15 Tbps	unknown
Latency	20-40 ms	<50 ms	30-50 ms	<50 ms
Satellite mass	227-260 kg	150 kg	800 kg	unknown
Satellite life	5-7 years	~5 years	10-12 years	~7 years
Num. ground stations	123	71	42	unknown
Num. gateway antennas	3500	725	221	unknown
Reported capital expenditure	$10 B	$2.4 B	$5 B	$10 B

As it can be seen, constellations at higher altitudes on LEO such as OneWeb or LightSpeed can offer services with hundreds of satellites; while, Starlink and Kuiper, need thousands of them. Besides, with less satellites, the bandwidth throughput can be achieved through more powerful telecommunication systems which lead to bigger and heavier satellites. Thus, there is a direct relationship with the number of satellites with their individual weight if it is desired to maintain the throughput.

Finally, since the business model that is being designed is focused on VLEO, presents similarities with Starlink and Kuiper constellations. Therefore, analysing both constellations, the total amount of satellites would be between 3,200 to 4,450 satellites. However, it should be considered, that both projects are owned by well-known and established firms such as SpaceX and Amazon, which already have a considerable reputation inside the customer segment. Consequently, their sales forecast will be higher than any new-born company.

6.1.1 Starlink constellation framework

To start planning how the entire network will be established, the Starlink project will be taken into account as a reference, since it is on advanced stages and there is more data available to everyone rather than the project Kuiper. Thus, after having a deep study of the entire project the following statements about the deployment strategy have been obtained:

- Although they started doing launch tests by 2017, it was not until 2019 that they began deploying satellites exhaustively to start establishing the network. [20]
- By the date of May 2021, they have already deployed 1.737 satellites and aim to finish the first stage of the project, which was set to have 4.425 satellites by 2023, using batches of 60 satellites through Falcon 9. [20]
- The second stage which aims to establish 12.000 and the third stage, which was filed to FCC in 2019, to arrange spectrum for additional 30.000 satellites, will be deployed with new Falcon family vehicles and the Starship. These two vehicles will have bigger payload capacities, with the possibility to carry large batches, reducing the launching costs. [41] [42]
- Starlink has been building and deploying V0.9 and V1.0 satellites which have 5 years of durability in LEO. Currently they are building the next generation satellites V1.5 and V2.0 which have better performance and efficiency. As well as that, they will include intersatellite laser connection. [43] [44]
- For the first stage, there will be operating 123 ground stations to support the 4.425 satellites. The number of ground stations will not grow with the same intensity as the satellites, since the intersatellite linking will upgrade

the efficiency of the network. [45]

- SpaceX aims to use part of the remaining payload of its rockets for customers payload in order to reduce launching costs. [46]
- Around 10.000 people have been trying the beta version of the service and Elon Musk announced that over 500.000 people ordered for the final version. Furthermore, by the end of the first stage, Starlink aims to provide the service to over 2.1 million users. [47]

Taking into account these statements, a hypothetical launching framework has been estimated, which is shown in the following table:

Table 6.2: Starlink constellation deployment

Stage	1	2	3
Years	2019-2023	2024-2027	2027-2032
Launches	70	25-30	60-90
Satellites per launch	60	165	400-450
Launcher	Falcon 9	Falcon heavy	Starship
Ground stations	123	300	450-600
Satellite constellation	4.425	12.000	30
Users	2,4 million	5 million	+10 million

6.1.2 Deployment strategy

Finally, once analysed the Starlink project in depth and taking in mind every consideration that have been made during this chapter, the master plan of the constellation deployment has been made and is represented in the following table. It should be noted, that Starlink aims to higher figures and very optimistic scenarios since its backed by big firms. However, the master plan has been made taking into account conservative predictions.

Table 6.3: VleoNet constellation deployment strategy

	STAGE 1							STAGE 2			
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
Launches		4	2	3	4	11	12	1	3	9	12
Sats. per launch		165	165	165	165	165	165	420	420	420	420
Total sats.		660	330	495	660	1.815	1.980	420	1.260	3.780	5.040
De-orbited sats.		0	0	0	0	693	347	520	693	1.906	2.079
Constellation		660	990	1.485	2.145	3.267	4.900	4.800	5.367	7.241	10.202
New G.S.		20	18	18	14	14	14	12	12	12	12
Total G.S		20	38	56	70	84	98	110	122	134	146
User capacity		231.000	346.500	519.750	750.750	1.143.450	1.715.000	3.360.000	3.756.900	5.068.700	7.141.400

The master plan consists in a 10 years period where 2 stages can be distinguished:

- **Stage 1 (2025-2030)**: The first stage, which will be the seed phase of the company will constitute a period of 6 years.

  The initial aim of the company will be establishing a constellation of 3.000-5.000 satellites, as agreed in the previous section, using a similar launch vehicle as Starlink plans to use in the second stage, with batches of 165 satellites.

  Since the first stage will start when Starlink already had begun with the second stage, the satellites considered in the current planning, will be similar to the next generation satellites of Starlink. Thus, it is considered that each satellite will be able to support from 300 to 400 users and will be equipped with inter-satellite linking systems so there would be required less ground stations. As well as that, it has been considered 4 years of lifespan of each satellite, one year less than Starlink. Further details have been stated in the next sections.

- **Stage 2 (2031-3034)**: The second stage, which will be the consolidation phase, will constitute a period of 3 years; however, it can be longer or different taking into account the results obtained during the seed phase.

  This stage will be characterised due to massive satellite launching through large payload space vehicle carriers. This will lead to reduce costs on launching and increase the capacity of the network. As well as that, the next generation of satellites with better performance and efficiency would be able to deploy.

NOTE: It has been taken an extra 5% of de-orbited satellites in each year, taking into account on the possible failure in satellites during their operability. This percentage has been figured taking as a reference the 3% of failure that Starlink has had with their satellites. Besides, the launching program has been considered by 2025, since previously, it will be required some activities such as the acquisition of the facilities and licenses, the manufacturing of satellites, dealings with partners,

etc. [48]

6.2 Costs

The costs of every element needed to develop the mega-constellation has been justified in this subsection.

6.2.1 Launching

Analysing the launching strategy of SpaceX, they are currently using a Falcon 9, which carries 60 satellites. This rocket costs to SpaceX around $50 Million, which includes range services, standard payload integration and third-party liability insurance. For an external company, they charge a launching price of $62 million. However, rocket re-use plays a major role in the business model since the first-stage booster of the space vehicle is capable to perform 10 to 100 flights, dropping down the costs to $28 million, as said by the director of SpaceX Christopher Couluris. [46]

Regarding the Falcon Heavy, which is supposed to start launching batches, of between 140 to 180 satellites by 2023-2024, will cost around $74 million to SpaceX, while the commercial price is settled at $90 million. Taking as a reference the reusable price of Falcon 9 and doing a extrapolation of the prices, the Falcon Heavy re-used launch cost can be estimated as $42 million.

Starship is stated to be the cheapest rocket ever considering the amount of payload that can withstand. Starship is said to cost $216 million dollars and Musk claims that its full reusability would drive the costs per launch as low as $2 million. But the actual number is closer to $5 million. [49]

Taking as a reference these space vehicles of SpaceX, the only way to afford the launching costs is by operating with re-usable vehicles. There are a few of them, planned for the next few years, that will give a tough competition to Elon Musk's company: New Glenn by Blue origin, Electron and Neutron by Rocket Lab and Vulcan Centaur by United Launch Alliance (ULA). [50]

For the first stage, a clear candidate can be the New Glenn rocket, since presents several similarities with the Falcon Heavy and would be able to carry out batches of 165 satellites just as SpaceX vehicle [51]. Since Blue Origin has not published any cost value of the rocket, it has to be estimated taking as a reference the Falcon Heavy. Therefore, adding a considerable margin to the $42 million, a reasonable price of New Glenn per launch, considering its reusability, can be of $52 million dollars.

For the second stage, which will begin in 2031, there is not any clear candidate since the SpaceX competitors have not published any data yet. However, by the

end of these decade there will be several launches of heavy payload space vehicles such as the Chinese LM9, Nasa's SLS and the Russian Yenisei. Furthermore, China is working on a Starship's clone, which recently was shown in a promotional video. [52] [53]

Finally, to compute the launching costs of the second phase, the price of Starship with a considerable margin will be taken into account, resulting in the final amount of $20 million per launch.

6.2.2 Satellites

Taking as a reference the first-generation satellites V0.9 and V1.0 used by Starllink, Gwynne Shotwell, the president of SpaceX, said that the manufacturing price of the 60 satellites aboard the Falcon 9 was cheaper than the launching costs. The costs of each SpaceX satellite could be between 250 to 300 thousand satellites. Furthermore, it should be taken into account that the next generation satellites, which are supposed to be more efficient, will be economically more competitive. [54]

Therefore, to compute the satellite manufacturing costs, a reasonable price taking into account a considerable margin, can be estimated as 350.000 dollars per satellite.

6.2.3 Ground Station

Current gateways for GEO satellite communications are quite expensive. However, they are not directly comparable to LEO ground stations, since they are smaller and have lower power requirements. Traditionally, satellites have been tracked through big parabolic antennas, but LEO and VLEO have allowed to incorporate a new technology into the antennas called Electronically Scanned Apertures (ESAs). This feature allows to shift beams, track and access large number of satellites, without physical movement. ESAs can be designed for modular assembly, which drives down the manufacturing costs since it allows to produce large number of basic parts. [55]

Currently, there is not any public data of Starlink about the ground station costs. However, it has been taken as a reference a paper about the costs of design of a semi-automated ground station which tracks and commands LEO satellites. The costs estimated in this paper are $280.000 per ground station [56] . Therefore, taking into account an extra margin, due to placing and other costs, a conservative price per ground station can be assumed as $350.000 per location. Furthermore, it will be considered another $30.000 per year of each station's operational costs.

6.2.4 User terminal

The manufacturing price of a user terminal, which also incorporate ESAs technology, are between $ 300 to $500 range. Amazon's Project Kuiper has developed a low-

cost flat-panel antenna which with the reduced size can drive down considerably the manufacturing costs. Bearing in mind all these aspects and taking into account that this equipment would be purchased from a third party as planned in the business model design, it can be assumed to cost $700 per unit. [55] [57]

6.2.5 Human Resources

Within Starlink project, the employees working there are part from SpaceX, which has in total around 10,000 people [58]; but there is not any exact figure about the employees working precisely in the Starlink project. Besides, it should be taken into account that SpaceX, apart from the Starlink project, has other key activities such as rocket launching and manufacturing which also requires high amount of manpower. Regarding to Amazon, it has assigned around 500 people to the project Kuiper. [59]

Bearing in mind all these aspects, it is evident that there are required many departments which have to work along in order to develop the project, from engineers and technicians to management and sales teams. Therefore, to calculate the costs of the employees working in the company, a fair number of workers will be distributed along three different groups:

- **Engineers and technicians**: This group will be formed initially by 800 members, which will gradually increase by 10% each year. An average annual salary of an Aerospace engineer in Europe is between 30.000 to 40.000 euros. Since, this type of project requires highly qualified people it will be increased and rounded to $50.000. [60]
- **Management and sales teams**: This group will be formed initially by 200 people and also will increase by 10% each year. Applying the similar criteria, an average salary for this group will be of 30.000 dollars per year.
- **Directors and executives**: This group will be formed by 10 persons (similar to SpaceX). The average salary for this group will be of 90.000 per year.

6.2.6 Facilities

To compute the costs of the headquarters and manufacturing infrastructure, it will be taken into account the SpaceX space force base Vandenberg, which costs between $10-30 million and its operational costs are between $1-3 million per year. However, these costs include the expenses of testing and manufacturing of launchers. Thus, since the new company will only manufacture satellites, the facilities costs can be estimated as $20 million of the infrastructure construction and $3 million its operability. [61]

6.2.7 Marketing

Marketing costs, which have been determined in section 5.3 during Marketing study chapter, will be 10 million dollars for the initial year and will decrease by 10%.

6.2.8 Total Costs

Finally, the costs of the project explained above has been summarized in the following table:

Table 6.4: Project costs broken-down

COSTS	
Fixed	
Item	**Price in USD**
Launching	
Launcher 1	52.000.000/launch
Launcher 2	20.000.000/launch
Satellite manufacturing	
Satellite	350.000/u
Ground Station	
New G.S.	350.000/u
G.S. Operation	30.000/u
Human resources	
Group 1	50.000/person
Group 2	30.000/person
Group 3	90.000/person
Others	
Facilities	20.000.000
Operability	3.000.000/year
Marketing	10.000.000/year
Variable	
User Terminal	700/unit

6.3 Sales Forecast

During previous chapters, it has been seen the increasing figures of the internet users and the demand of high-speed internet during the last decades, as well as that, it has been analysed the extremely high growth ratios of the internet industry. But to define the penetration rate and estimate the potential customers, It has been studied the demand by regions.

- **North-America**: In USA there were around 400 million users by 2020 and, from 35 million people who were not connected to the internet, there were around 21.3 million people who did not have any broadband access according to the FCC report. All these, without taking into account the millions of people who don not have adequate internet speed. [62]
- **Europe**: In Europe there are about 600 million internet users and around 88 million people who are still unconnected. According to the Digital Economy and Society Index (DESI) report made by the European commission, fast internet was only available on 60% of European homes. [63]
- **Oceania**: Australia has around 15 million users, from which already 100.000 are satellite internet users. In the entire continent are already 27 million internet users and 12 million who are not connected. [64]
- **Asia, Africa and South-America**: The major part of unattended internet coverage is concentrated in Asia, Africa and South-America, which has over 3.2 billion people who don not uses internet. However, it should be taken into account, that these continents include the major part of developing countries with weak economies who simply cannot afford the internet prices. Nevertheless, as a first approach, it can be estimated that a 20%, around 640 million, could be potential users who can afford satellite internet. [65] [66] [67]

Among them, the potential number of internet users is approximately 770 million users. Thus, taking as a reference this value and the forecast that Starlink estimates for the next years, it has been developed the following situations for the new company:

- **Optimistic Scenario**: Assuming an optimistic penetration of 0.03% from the 770 million for the first year, results in approximately 220.000 customers in the first year. Then, taking into account an optimistic growth of 50% each year during the seed phase and after that a 40% due to product maturity. At the end of the first stage, there will be over 2.4 million users, just like Starlink aims to have it, but by the end of its first stage (2024).

Table 6.5: Client distribution for the optimistic scenario through the 10 years studied

	OPTIMISTIC SCENARIO										
	STAGE 1							STAGE 2			
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
New Users		220.000	110.000	165.000	247.500	371.250	556.880	835.320	1.002.380	1.403.330	1.964.660
Total Users		220.000	330.000	495.000	742.500	1.113.750	1.670.630	2.505.950	3.508.330	4.911.660	6.876.320

- **Neutral Scenario**: Applying similar criteria, with a penetration of 0.025%

and a conservative growth of 45% for the first stage and 35% for the second, we have the following distribution:

Table 6.6: Client distribution for the neutral scenario through the 10 years studied

	NEUTRAL SCENARIO										
	STAGE 1							STAGE 2			
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
New Users		195.000	87.750	127.240	184.500	267.520	387.900	562.460	634.330	856.350	1.156.070
Total Users		195.000	282.750	409.990	594.490	862.010	1.249.910	1.812.370	2.446.700	3.303.050	4.459.120

- **Pessimistic Scenario**: The negative scenario would be a penetration rate of 0.02% with a growth rate of 40% during the first stage and 30% for the second. In this case, it results in 154.000 customers in the first year, and the line of 2.4 million would not be passed until the year 10.

Table 6.7: Client distribution for the pessimistic scenario through the 10 years studied

	PESSIMISTIC SCENARIO										
	STAGE 1							STAGE 2			
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
New Users		154.000	61.600	86.240	120.740	169.030	236.640	331.300	347.870	452.230	587.900
Total Users		154.000	215.600	301.840	422.580	591.610	828.250	1.159.550	1.507.420	1.959.650	2.547.550

Current satellite internet service providers such as Viasat and HughesNet offer internet plans which vary from $30 to $150 per month. As well as that, they charge an initial fee for the equipment installation, which depends on the location of the customer, and then another monthly equipment leasing fees which varies between $12 to $15 month. Taking as a reference these numbers, the prices for the new company can be established as: [38] [39]

- Internet service fee: $99 per month
- Equipment installation fee: one single payment $499

It should be noted that these prices may change after the seed phase. If the company achieves positive results these charges can reduce in order to make the service affordable in more places. Besides these prices are similar to what Starlink pretends to charge to its customers.

6.4 Economic Balance

After establishing the inputs and outputs of the company, in the following tables it has been represented the costs and the revenues broken-down for the upcoming 10 years.

Table 6.8: Costs broken-down through the 10 years studied

	STAGE 1							STAGE 2			
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
FIXED COSTS (Millions of dollars)											
Launching		220,00	110,00	165,00	220,00	605,00	660,00	55,00	60,00	180,00	240,00
Satellite		231,00	115,50	173,25	231,00	635,25	693,00	147,00	441,00	1.323,00	1.764,00
New G.S.		7,00	6,30	6,30	4,90	4,90	4,90	4,20	4,20	4,20	4,20
G.S. Operation		0,60	1,14	1,68	2,10	2,52	2,94	3,30	3,66	4,02	4,38
Engineers & Technicians		40,00	44,00	48,40	53,24	58,56	64,42	70,86	77,95	85,74	94,32
Management & Sales		6,00	6,60	7,26	7,99	8,78	9,66	10,63	11,69	12,86	14,15
Directors & Executives		3,00	3,00	3,00	3,00	3,00	3,00	3,00	3,00	3,00	3,00
Facility operability		0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90
Marketing		10,00	9,00	8,10	7,29	6,56	5,90	5,31	4,78	4,30	3,87
TOTAL		506,50	290,44	404,89	518,42	1.292,48	1.408,73	265,21	607,18	1.618,03	2.128,82
VARIABLE COSTS (Millions of dollars)											
Optimistic Scenario											
User terminal		154,00	77,00	115,50	173,25	259,88	389,82	584,72	701,67	982,33	1.375,26
Neutral Scenario											
User terminal		136,50	61,43	89,07	129,15	187,26	271,53	393,72	444,03	599,45	809,25
Pessimistic Scenario											
User terminal		107,80	43,12	60,37	84,52	118,32	165,65	231,91	243,51	316,56	411,53
TOTAL COSTS (Millions of dollars)											
Optimistic Scenario		672,50	373,44	529,39	703,67	1.585,35	1.834,54	884,93	1.308,85	2.600,36	3.504,08
Neutral Scenario		655,00	357,87	502,96	659,57	1.512,74	1.716,26	693,93	1.051,21	2.217,47	2.938,07
Pessimistic Scenario		626,30	339,56	474,26	614,93	1.443,80	1.610,38	532,12	850,69	1.934,59	2.540,35

Table 6.9: Revenues broken-down through the 10 years studied

	STAGE 1							STAGE 2			
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
REVENUES (Millions of dollars)											
Optimistic Scenario											
User terminal		107,80	53,90	80,85	121,28	181,91	272,87	409,31	491,17	687,63	962,68
Internet service		261,36	392,04	588,06	882,09	1.323,14	1.984,71	2.977,07	4.167,90	5.835,05	8.169,07
Total revenue		369,16	445,94	668,91	1.003,37	1.505,05	2.257,58	3.386,38	4.659,06	6.522,68	9.131,75
Neutral Scenario											
User terminal		95,55	43,00	62,35	90,41	131,08	190,07	275,61	310,82	419,61	566,47
Internet service		231,66	335,91	487,07	706,25	1.024,07	1.484,89	2.153,10	2.906,68	3.924,02	5.297,43
Total revenue		327,21	378,90	549,42	796,66	1.155,15	1.674,96	2.428,70	3.217,50	4.343,63	5.863,91
Pessimistic Scenario											
User terminal		75,46	30,18	42,26	59,16	82,82	115,95	162,34	170,46	221,59	288,07
Internet service		182,95	256,13	358,59	502,03	702,83	983,96	1.377,55	1.790,81	2.328,06	3.026,49
Total revenue		258,41	286,32	400,84	561,19	785,66	1.099,91	1.539,88	1.961,27	2.549,66	3.314,56

The total amount of fixed costs during the seed phase rises up to $4.420 million. Therefore, it will be considered an initial investment of $4.500 million to compute the cash flows and obtain the viability indicators.

Table 6.10: Economic balance through the 10 years studied

	STAGE 1							STAGE 2			
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
Cash flow (Millions of dollars)											
Optimistic Scenario											
Initial investment	-4.500										
Cash flow		-291,34	78,50	148,52	311,70	-47,31	459,04	2.536,45	3.350,21	3.922,32	5.627,67
Cumulative cash flow		-4.791,34	-4.712,84	-4.564,32	-4.252,62	-4.299,93	-3.840,89	-1.304,45	2.045,76	5.968,09	11.595,76
Neutral Scenario											
Initial investment	-4.500										
Cash flow		-315,79	27,04	55,46	149,09	-324,59	-5,29	1.769,77	2.166,29	2.126,16	2.925,84
Cumulative cash flow		-4.815,79	-4.788,75	-4.733,29	-4.584,20	-4.908,79	-4.914,08	-3.144,31	-978,03	1.148,13	4.073,97
Pessimistic Scenario											
Initial investment	-4.500										
Cash flow		-355,89	-47,24	-64,41	-41,75	-625,14	-474,46	1.042,77	1.110,58	615,07	774,21
Cumulative cash flow		-4.855,89	-4.903,13	-4.967,55	-5.009,29	-5.634,44	-6.108,90	-5.066,13	-3.955,55	-3.340,49	-2.566,28

6.4.1 Results

The chosen indicators to evaluate the economic feasibility are listed below:

- **Pay Back Time (PBT)**: It refers to the time required to recover the funds expended in the investment of the project. In other words it is the time it takes to reach the break-even point.
- **Net Present Value (NPV)**: It refers to the net worth of the project at a given time. It is calculated by taking the difference between the present value of cash inflows and present value of cash outflows over a period of time. It gives an estimation about the profitability of a projected investment. Besides, a discount rate is applied to adjust the future cash to a present value; in this case it has been used a 6%. The following equation has been used to calculate it:

$$NPV = Investment + \sum_{to}^{t} \frac{CF}{(1+i)^n} \tag{6.1}$$

  where:

  - CF: Cash flow
  - i: discount rate
  - n: year
  - t: from the year 1 to last

- **Internal Rate of Return (IRR)**: It evaluates the Annual rate of growth an investment is expected to generate. It is calculated setting the NPV to zero and solved for the discount rate, which is the IRR.

- **Return on Investment (ROI)**: It measures the benefit an investor will receive in relation to their investment cost. It is calculated with the following equation:

$$ROI = \left(\frac{NPV}{Investment}\right) \cdot 100 \tag{6.2}$$

Hence, the indicators obtained from the economic balance of 10 years, are represented for each scenario in the following table:

Table 6.11: Feasibility indicators for the three scenarios

	PBT (years)	**NPV ($M)**	**IRR (%)**	**ROI (%)**
Optimistic Scenario	7,39	4.451,19	15,90%	98,92
Neutral Scenario	9,46	159,31	7,41%	3,54
Pessimistic Scenario	Not recovered	-3.696,30	-7,42%	-1,23

Analysing the results obtained, the indicators in each scenario differ considerably from each other. While in the pessimistic scenario the ratios obtained are highly negative, in neutral and optimistic scenarios are positives, but still different.

Regards to the optimistic scenario, the results are very positive and the benefits are really high. Furthermore, in general, a good project to invest implies a payback time between 7 to 9 years. However, in this situation, in less than 8 years the project results profitable. In case that the speculation becomes true, it can be considered reducing considerably the sale prices in order to make the service more affordable and competitive in the market.

Regarding to the neutral scenario, it still offers positive results but the benefits are lower with a higher payback time. The resultant NPV has decreased approximately 27 times and the IRR has decreased to half in relation to the optimistic scenario. However, the project it is still attractive because the figures show good profitability.

In relation to the pessimistic scenario, the results obtained are negative. The costs are so high, that the inputs cannot repay the losses. Although the cash flow recovers half of the initial investment, it remains negative during the entire period.

Finally, from the results obtained, it has been seen that, with a slight change in sales, the indicators vary remarkably. Thus, it has been proven the importance of the customer base, which directly influences the revenues to overcome the running costs.

6.5 Sensitivity analysis

To measure the susceptibility of the indicators due to the inputs of the economic study, a sensitivity study has been carried out. Taking as a reference the neutral scenario, it has been applied a variation of 10% on the following parameters:

- Initial investment
- Launching costs
- Satellite manufacturing costs
- User terminal costs
- The costs associated to establishing a new ground station and its operational costs
- The number of users in neutral scenario of each year
- The sale price for the service and for the equipment installation

These parameters represent the main variables of the economic balance, which can be distinguished as external or internal factors to the business. Within the internal, the initial investment, satellite manufacturing costs, ground station costs and the sale prices, represent the aspects that the company can directly control. The rest, cannot be controlled directly since they depend on third parties or on the demand.

The sensitivity study has been performed taking into account all these aspects and the impact on the PBT, NPV, IRR and ROI have been measured. For each indicator it has been registered the variation and magnifier factor. Then, to measure the sensibility, it has been obtained the mean value of the 4 magnifier factors.

The results have been represented in three different colours. Green colour shows that the selected variables are robust and practically don not influence the indicators, whereas the red colour shows that those parameters are highly sensitive. Yellow colour represents the mid-term between both extremes. The results are shown in the following table.

Table 6.12: Sensitivity study results

	PBT (years)	NPV ($M)	IRR (%)	ROI (%)	
Neutral case	9,46	159,31	7,41	3,54	
Investment	9,25	609,31	8,66	15,04	**Internal**
Variation (%)	-2,22	282,48	16,90	324,97	**Sensitivity**
Magnifier	0,22	28,25	1,69	32,50	15,66
Launching costs	9,37	325,52	7,84	7,23	**External**
Variation (%)	-0,95	104,34	5,78	104,34	**Sensitivity**
Magnifier	0,10	10,43	0,58	10,43	5,39
Sat. Costs	9,31	510,67	8,30	11,35	**Internal**
Variation (%)	-1,59	220,56	11,93	220,56	**Sensitivity**
Magnifier	0,16	22,06	1,19	22,06	11,37
User terminal costs	9,36	350,10	7,90	7,78	**External**
Variation (%)	-1,06	119,77	6,53	119,77	**Sensitivity**
Magnifier	0,11	11,98	0,65	11,98	6,18
G.S. costs	9,46	164,71	7,43	3,66	**Internal**
Variation (%)	0,00	3,39	0,19	3,39	**Sensitivity**
Magnifier	0,00	0,34	0,02	0,34	0,17
Users	10,04	-886,04	4,55	-19,69	**External**
Variation (%)	6,13	-656,19	-38,65	-656,19	**Sensitivity**
Magnifier	0,61	65,62	3,86	65,62	33,93
Sale price	10,14	-1.076,83	3,98	-23,93	**Internal**
Variation (%)	7,19	-775,96	-46,24	-775,96	**Sensitivity**
Magnifier	0,72	77,60	4,62	77,60	43,13

From the results obtained, the number of customers subscribed to the service will severely impact on the viability of the project. Besides, internally, the company will have to decide carefully the prices of the service. Which may be higher if the demand is low, or lower whether if the customer base increases. As well as that, if the organization drives down the satellite manufacturing costs, it will achieve higher profits. It also should be noted that, the launching and user terminal costs, which will depend on the partners, will stay robust if there is any change.

CHAPTER 7

Environmental study

This section is devoted to assess the impact on the environment of developing the business model designed in the present thesis. Establishing the entire VLEO network not only has negative impact, such as launching and light pollution, but also entails some positive aspects, for example no contribution to space debris and avoidance of large wire networks such as involved in fibre-optic infrastructure.

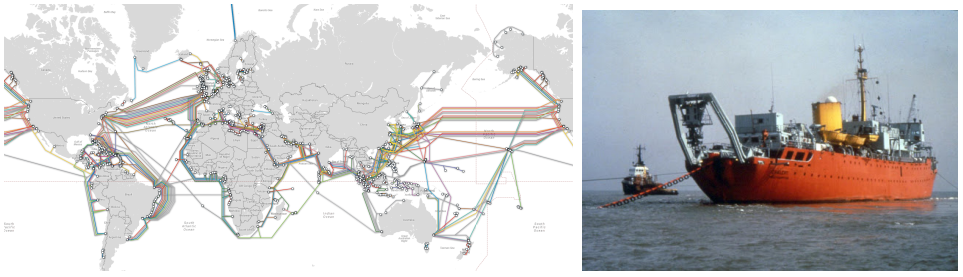
7.1 Fibre-optic infrastructure

Although it seems that currently we are living in a wireless era, there exists gigantic wired networks that extend around the globe and are not easily visible since most of them are under ground or under water. These networks are formed by millions of kilometres of cable which different companies have been installing during decades. The resources and manpower required to establish such infrastructure is considerably high and so is its maintenance.

(a) (b)

Figure 7.1: Terrestrial Fiber-optic network (a) and examples of infrastructure installation (b). Source: [68] [69]

Besides, there are more than 1.000 million meters of submarine networks which are used for intercontinental connections. To place them, there are used special ships, which travel along oceans and seas, unrolling the wire until the depths.



(a) (b)

Figure 7.2: Submarine cable map (a) and cable layer ship (b). Source: [70] [71]

The cables are typically about 25 millimetres in diameter and weigh between 1.4-2.2 tonnes per kilometre, depending on the depth. They are composed by 8 layers, seven of them, which protect the fibre optic, are formed by: polyethylene, Mylar tape, stranded steel wires, aluminium, polycarbonate, copper and petroleum jelly. [71]

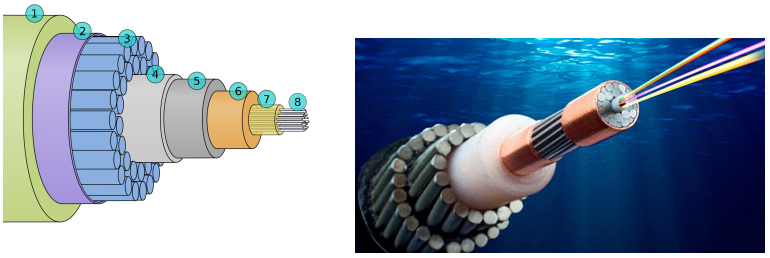


Figure 7.3: Fibre-optic cable layers. Source: [71]

Hence, the enormous infrastructure of the network involves huge amounts of materials and resources, for instance the usage of large amounts of copper, whose mining is extremely harmful to the environment. A part from that, the damages produced by accidents or natural disasters involve highly expensive repairs. Besides, the submarine fibre optic networks, which produce electromagnetic fields during the operational phases, also impacts to marine flora and fauna. Through satellite communication technology the environmental footprint, in aspects such as mentioned in this section, are reduced since the major part of the process relays on wireless transmission.

7.2 Launching pollution

Rocket launching has a strong carbon footprint due to the burning of solid rocket fuels. However, some rockets are propelled by liquid hydrogen fuel, which, when is burnt with oxygen, produces water vapor. Unfortunately, most hydrogen is produced from fossil fuels, for instance methane, coal gasification or natural gas, which are not sustainable sources.

Besides, rocket engines release trace gasses and particles of soot into the upper atmosphere, which directly contribute to ozone depletion. The release of black carbon into the stratosphere produces toxic chemicals that can enter surface waters and persist in the soil, damaging ecosystems and human health. [72]

Figure 7.4: Rocket launching. Source: [72]

7.3 Light pollution

The deployment of large number of satellites on LEO and VLEO has raised a concern in the astronomical observation community. They claim that the increasing number of satellites, referring to the Starlink project, will outnumber the visible stars. Not only that, they state that their brightness will severely impact scientific observation, since Starlink satellites can autonomously change their orbits, which unable scheduling observations to avoid them. Furthermore, satellites will appear as a streak in images tracked by telescopes, saturating the detectors and damaging large astronomical telescopes. [73]

The question is: How are these satellites so visible from the ground? Basically, during sunsets and sunrises, sun-rays reflected from satellites arrive before the ones that come directly from the sun. Moreover, Starlink satellites, which have two types of orientations (shark-fin and open book) that vary depending on their phase of flight, reflect more sun-rays during the open book. The following image shows graphically this phenomenon.

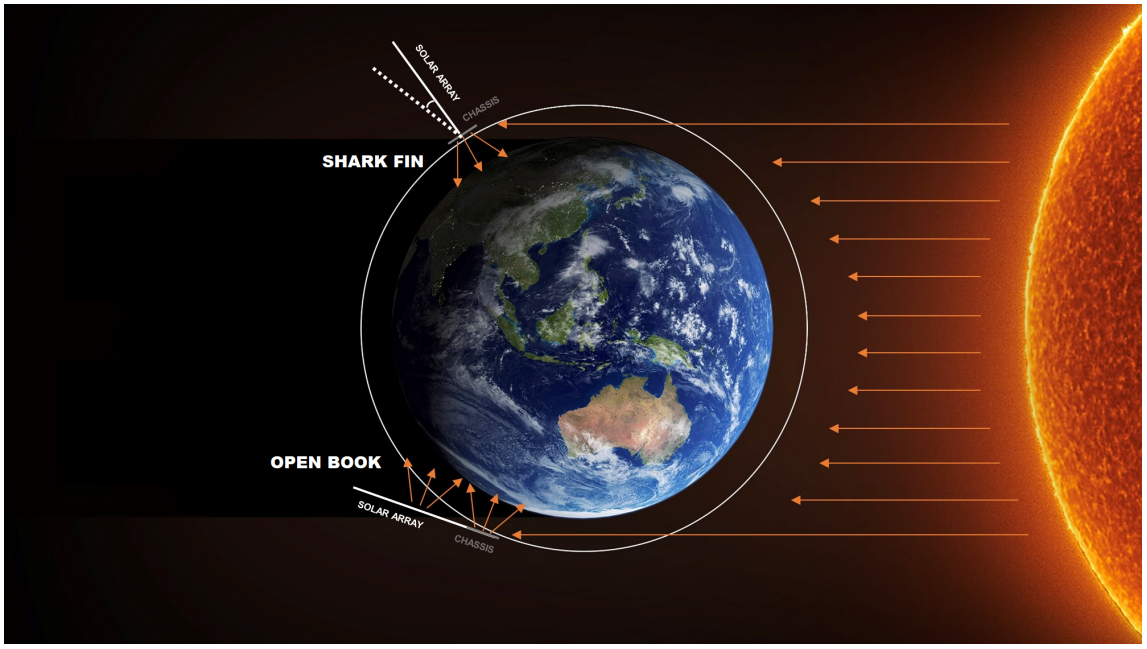


Figure 7.5: Satellite light reflection. Source:[74]

However, SpaceX has been working with astronomers to mitigate this problem and has proposed the following solutions to reduce the satellite brightness:

- Darkening of phased array and parabolic antennas of satellites.
- Rolling the satellite during the open book orientation to reduce the reflection.
- Implementation of a sun visor system to avoid thermal issues due to darkening the satellites and block even more sun-rays. [74]

7.4 Space debris

Space debris, also known as space junk, refers to any piece of machinery, from dead satellites or any other object that have failed or ended its mission, left by humans in space. US Space Surveillance network tracked around 20.000 artificial objects orbiting around the Earth. Within large objects, there are more than 2.000 active satellites and also 3.000 dead ones. Moreover, there have been estimated more than 34.000 pieces bigger than 10 cm orbiting at thousands of kilometres per hour. At that speeds, even tiny pieces can cause catastrophic damages and produce more debris. Thus, at some point there would be an endless cascade of collisions, which would make difficult any space activity. This phenomenon is also known as Kessler Syndrome. [75]

Nevertheless, at LEO and VLEO, the density is higher, which makes debris decay at higher rates. Furthermore, the existence of atmosphere at lower orbits produces drag, which burns the small pieces, and clears itself from debris than higher orbits. Therefore, it has been estimated that, VLEO will remain clean for many years and would play a key role in future space projects. [76]

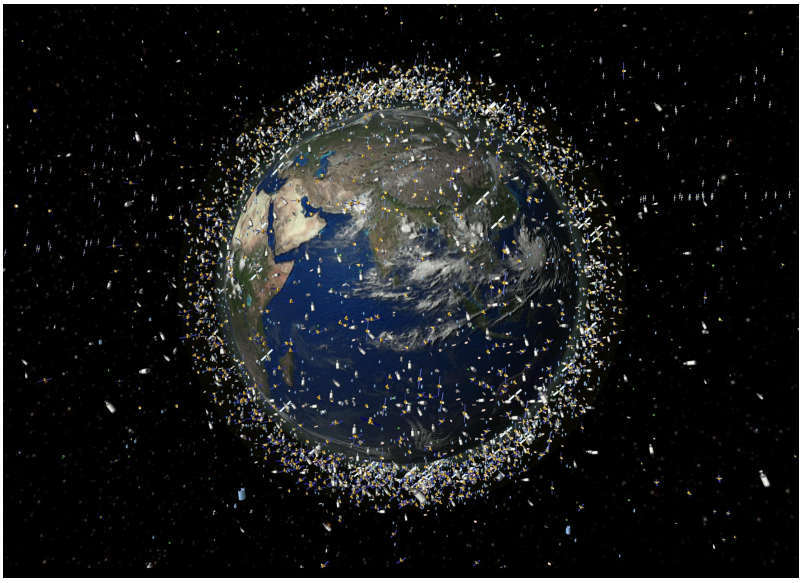


Figure 7.6: Space debris simulation. Source:[77]

CHAPTER 8

Conclusions

The present thesis, had as an objective to design a business model for an internet service provider company based on VLEO satellite communication technology. The completion of this study has served to draw the following conclusions:

In the past, internet satellite had faced several technological limitations, with not an optimal operational execution and a weak customer base. However, currently, the lack of users problem is being vanished due to the increasing demand of internet, which is happening worldwide due to the new technological era. The present study showed that, inside the emerge of this wave, there is an existing market where satellite internet has a key role to play. Remote areas, countryside, less dense urbanizations and rural areas are the places where satellite internet stands out among other technologies. Regarding to the technological limitations, new advancements in space industry has driven down the costs and opened doors to LEO and VLEO segment. Hence, big corporations, such as SpaceX and Amazon, has anticipated these potential factors and made their move towards this part of the internet industry.

For a new emergent company, it has been seen that, it is required to design a strong strategy and planning to operate successfully. As well as that, the organization needs to create strong relationships with their partners, particularly with satellite launchers, raw material providers and space agencies in order to create a healthy value proposition. Several projects in this field have failed for not being constant at launchings and deploying satellites on time or directly went bankrupt due to a bad planning.

Regarding to the economic plan, the study displayed positive results for neutral and optimistic scenario. Nevertheless, the pessimistic scenario presented negative results. Furthermore, it was driven a sensitivity study on the main parameters to analyse the variation on the feasibility indicators. The results showed that the customer base will affect considerably to the company's results. Mainly, the viability of the business will depend on the number of targeted subscribers achieved by the company. The most challenging problem for the company would be not achieving enough users in order to recover the costs associated to developing the project. But also, if the optimistic scenario occurs, it would give margin enough to reduce user

terminal installation and service prices, making them the lowest prices in the internet satellite industry. Apart from that, since the network requires developing large number of satellites, the costs associated to manufacturing has also a big impact on the economical results. Thus, to drive down these costs, the company would require to adopt highly efficient manufacturing practices such as Lean manufacturing and process optimization.

However, it should be considered that the feasibility study has been made taking as a reference a hypothetical network layout. Thus, results may vary into positive if it is designed an efficient network through optimizing algorithms, just as similar constellations, such as Starlink or the Project Kuiper.

The environmental impact of the mega-constellation is another fact to bear in mind. Deploying these many satellites entails light pollution which directly affects to space observation and astronomers. Therefore, before start launching satellites exhaustively, it would be a must to solve this issue, as in the future space agencies could rise restrictions which would result in unwanted economical losses.

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