Università Ca'Foscari Venezia

Master's Degree Programme

in

International Management

Final Thesis

How Space contributes and benefits the Global Economy: a review of the industry through a risk profile analysis of the Italian Leonardo SpA

Supervisor
Prof. Silvia Avi

Graduand
Edoardo Didonè

Matriculation number
867182

Academic Year
2021 / 2022

INDEX

1. Introduction

The Space Economy in the last years has been at the center of numerous national and international debates. The programs of the most important International Space Agencies, combined with the increasing investments of private individuals and companies, are changing the way through which the society perceive the space: not anymore as an unknown field still to be discovered, but as a new market for commercial operations, with huge potential benefits in multiple sectors.

The interest of man in space is a phenomenon that has always been inherent in human nature. It is only from the second half of the 1900s that man began to explore and observe space with a different perspective: if before the interest resided only in the observation of the sky and of the phenomena that occur in it, after the World War II, humans began to take an interest in space with the aim of achieving other goals. The competition between the USA and the USSR after the WWII, in fact, proved to be very active also in terms of space objectives, with various goals that were achieved alternately first by one nation and then by the other and culminating with the landing of the American Apollo 11 mission on the lunar ground in 1969. Between the beginning of the 1950s and the end of the 1980s, the so-called "Rush to Space", in addition to fueling this silent conflict (the Cold War), gave a strong boost to space research, with the introduction of the first launch mechanisms, the first space shuttles, the first satellites and the first exploration probes.

After the fall of the Berlin’s wall, the 90s marked the beginning of a consistent and extended international collaboration, bringing great benefits from the point of view of scientific research: the creation of the International Space Station (ISS) in 1998 is the biggest representation of collaboration between countries so far, which through the years combines not only investments, but also various skills and abilities for common goals of great interest for all humanity.

However, over the past 10 years, the space sector has been undergoing a major transformation under various aspects. First of all, the subjects involved in the value-creation network of the industry have increased and above all they are no longer the same as in previous decades: many private companies and private investors are entering the business, realizing that in addition to simple observation and scientific research, space can create great benefits in other fields as well.

This change in the characteristics of the industry is the consequence of various components. The most important driver of this mutation of the industry is the incredible progress made in the technological field for the support of space devices. Since the early 2000s, for example, technological advances have made it possible to more than halve the weight of artificial satellites, increasing their performance and accuracy of measurements, while making their work more efficient and at the same time the costs of launching and maintenance lower.

The combination of these two great forces: the greater investments of private companies and the technological advances (which often and willingly are at the same time both cause and effect of the other), has ensured that the fields in which the direct and indirect support of space technologies have increased dramatically. It is just necessary to think that every email, internet research, every bank transaction or GPS navigation occurs just through the support of a satellite. If all the satellites in orbit on Earth stop working all of a sudden, humanity will go back more than 50 years. The benefits, however, do not stop at the simple transmission of data and extend to many other fields, such as the monitoring of climatic conditions, the level of the oceans and of Earth's temperature, weather forecasts, the management of emergency health situations and wars and many others. It is not a coincidence in fact that one of the most recent great supports coming from space was the provision of internet with free access during the conflict between Ukraine and Russia by Starlink, a private company managed by the visionary entrepreneur Elon Musk.

The space industry is therefore moving towards a synergy between national agencies and private companies. On the one hand, the budget reserved for space investments by countries remains limited each year, leading national agencies to focus much more on targeted and long-term research projects. The James Webb telescope (also called NGST, Next Generation Space Telescope) for example, launched into orbit on the 25th of December 2021, was born from the collaboration between three of the most important space agencies in the world: the American NASA (National Areonautics and Space Administration), ESA (European Space Agency) and CSA (Canadian Space Agency). The telescope aims to be the successor to the Hubble telescope, the most powerful and successful orbiting telescope in terms of space observation before the Webb telescope. Furthermore, the Webb telescope is a great example of synergy between the private and public sectors. In fact, more than 300 actors between state agencies, universities and private companies collaborated for the design, implementation, maintenance and study of the project. In particular, the latter have made a strong contribution to the creation of launch and support infrastructures, as well as to the creation of highly technological devices in collaboration with the three space agencies. Among the others, the name of Thales Alenia Space stands out. The company is part of the group headed by the Italian Leonardo SpA, a multinational that has been active in the space sector for years.

It is thanks to the know-how and skills that are shared within this network that missions and investments of this type are possible, creating benefits both from the point of view of scientific knowledge and from the economic point of view.

Another important example is the Artemis mission, launched by NASA with the collaboration once again of ESA, CSA and JAXA (Japan Aerospace Exploration Agency). The mission has as its first goal the that of landing a man and a woman on Lunar ground by 2024. Furthermore, NASA sees Artemis as a step towards the challenging long-term goal of establishing a self-sufficient presence on the Moon, laying the foundations to allow private companies to build a Lunar economy and ultimately send humans to Mars. Also in this project there is a strong collaboration of private companies, that have supported both in the study phase for the realization of the devices necessary for the mission and in the realization phase of the main technologies. Among the various companies that collaborated in the project it is important to mention Boeing, which collaborated in the study and construction of the transfer vehicles in the lunar soil, Blue Origin (company controlled by Jeff Bezos, founder and owner of Amazon) which supported and provided competences for the realization of the descent vehicles and SpaceX, which through Falcon 9, an innovative reusable rocket, provided an important resource for the launch of space modules. Only for the study and construction of prototypes, transfer and descent technologies in 2019, NASA announced collaborations for about 45,5 million dollars.

It is therefore clear how this new type of synergies is profoundly changing a sector that is experiencing a strong growth, generating a network between different subjects for the creation of both scientific and economic value. Space therefore in the last decades assumes a totally different meaning compared to the last decades of the twentieth century. The actors are different and the synergies that are established between them have different objectives. Luca Dal Monte, Head of the Industrial Policy and SME Division of the European Space Agency defines the historical moment as a consequence of the shift of interests towards private investors. According to Del Vecchio, the parameters on which international agencies were based to invest in projects in the Space Economy were essentially based on maximizing the performance of space devices against a minimization of risk, which represented a cost (especially in the event of missions failing) for national bodies. Indeed, projects funded by national and international space agencies are funded by public taxpayers, which by definition are risk averse. Del Vecchio argues that in the last twenty years there has been a convergence between the space industry and the digital economy, fueled by large private investors (such as Elon Musk and Jeff Bezos) who primarily financed the projects with their own money, and not with those of taxpayers, but above all who have given a totally different approach to investing in this sector. First, the propensity for risk and possible failure has increased, making the trial-and-error process more effective, creating increasingly suitable, updated and customized solutions for space economy customers. In this way, competition has increased and consequently also the offer in terms of space solutions, increasingly updated and in step with new technologies. Secondly, all these investments are aimed at creating an economic return for the investor, an objective initially far from those of the space agencies.

This logic is therefore completely different from the previous one which aimed to maximize performance and minimize risk. The objectives have therefore become: time-to-market, that is the possibility of offering new solutions in a short time, satisfying the customer's expectations, and secondly offering an economic return to those who invest in this type of sector.

This approach gives rise to a completely new field which is defined as: New Space Economy.

This thesis aims at analyzing the space industry, focusing on its mutation in recent years and above all on the economic benefits that the industry brings directly and indirectly to various sectors of the global economy.

First, the history and birth of the space industry will be analyzed, starting from the first observations, passing through the main discoveries and milestones that have marked the creation of a network of scientific knowledge that led to the formation of the first national space agencies. In this part, the passage from simple space "observation" to real physical "exploration" of space will be analyzed in depth. Furthermore, a particular focus is given to the main discoveries and innovations that have made possible the progress of the industry, passing through the "Rush to Space" and the landing of man on the Moon in 1969, up to the early 2000s.

Subsequently, the New Space Economy will be analyzed, discussing the main investments and above all the benefits that the industry brings to other sectors of the global economy. In this section, the main actors and drivers that have led to this new and innovative conception of the space sector will be defined. The areas in which the space economy mainly operates will then be defined, analyzing in each case the benefits and contributions in various activities that very often concern us as individuals on a daily basis. Finally, a paragraph is dedicated to the latest innovations and to the areas of greatest development in which mainly private investors have been investing in recent years.

The third part of this thesis is dedicated to the actors who have formed and are shaping the sector. Starting from the main international agencies, the focus will be shifted to private entities, bringing some examples of pioneering companies in the sector such as Space X, Virgin Galactic and Blue Origin. The purpose of the chapter is to define the links that in the last twenty years have been created in this brand new industry network, understanding the benefits that each party brings to objective and research that the most of the times are shared.

An example of an Italian company operating in the space sector is provided in chapter five. The Italian Leonardo SpA, with its subordinate Thales Alenia Space, is in fact one of the pioneering companies in the Italian and European market as regards private investments in the sector. The thesis will be confirmed by analyzing the financial profile of the company by analyzing: the risk profile, its capital structure and its dividend policy in the most recent years of activity. Although the analysis focuses on the whole company (which includes different sectors of operation and not just the space one), given the impossibility of separating the returns and the main indices only for the branch dedicated to the space economy, the aim of the analysis will be the one of demonstrating the state of health of a company that actively contributes to the sector, bringing innovation, knowledge and experience, that are the result of years of activity in the space economy, to the sector.

2. Building up the Space Economy: the history

2.1. History of space exploration: from observation to exploration

Space exploration, intended as the act of investigating the space outside the atmosphere of the Earth, comes from a desire gained and growth by humanity for thousands of years. The curiosity that the humankind has always had for the unknown and the necessity of finding a connection between what is “terrestrial” and what is not, has stimulated it to observe the sky while being fascinated by its mysterious purpose. While the exploration of the space is a subject that the mankind studies from millenniums especially through its observation, the “physical” discovery of the space is still a new-born activity and it represents the tip of an iceberg that is the whole space industry. To understand how and in how much time men managed to explore outside Earth’s atmosphere, it is useful to identify what steps and what sciences have been developed through the years to allow this industry to start and grow.

This paragraph wants to review the main historical facts that pose the basis of space exploration, starting from the first archeological records regarding space observation and arriving to the development of the technologies that allowed the creation of the first satellites and space shuttles in the last century. A particular focus is given to astronomy and astrometric, that are the two sciences that create the foundation of space observation and of space exploration. Thereafter, the discussion will be moved to the description of the main space achievements gained from the second post-war period to the present times.

Humankind, since the prehistoric times, has always been attracted by the sky and its components. Early civilizations observed with admiration the firmament, trying to interpret the complex phenomenon behind the movement of celestial bodies, searching for correlations with terrestrial events. Archeological records dating back to the Assyro-

Babylonians epoque (around 1000 BCE), revealed that humankind had already invented some rudimental gizmos used for observing the movement of stars and for tracking their position[1]. In fact, Mesopotamian civilizations were among the first to build knowledge on astrometry[2] and, in general, on astronomy[3] because they understood their importance for tracking time, for navigation and for monitoring and exploiting agriculture. However, even if they managed to track the position and movement of the stars, they were not able to measure their distance from the earth. It required a couple of centuries to have the first measures of space distances: around 300 years BCE astronomers from the ancient Greece, although they had a geocentric view of the cosmos, managed to roughly measure the distance between the Sun and the Earth and between the Moon and the Earth[4] in Alexandria, a Greek colony in Egypt, considered the center of the astronomic culture during the classic Greek epoque. For these reasons, 100 years later, Greeks had been able to frame the first stellar catalogue using an ancient Babylonian technique and few instruments available at the time. The technique consisted in drawing a circle, dividing it into 360 degrees and dividing again each degree into 60 arc minutes. Using this system Hipparchus of Nicaea, an ancient Greek astronomer, managed to map the sky with more than 850 stars with a precision of 1 degree. Furthermore, in the same period, he created the first magnitude system, which is the first recorded classification for the brightness of the stars.

During the dark ages, while the astronomic scenario had a sharp slowdown in Europe, it had a significant growth in the Asian and Islamic world. In this context, the observation and further investigation of the sky had been combined with the translation and the

[1] (ESA - European Space Agency, 2019)

[2] It is one of the oldest branches of astronomy and it consists in observing the sky and charting the position of the celestial bodies. According to the ESA, astrometry has two fundamental objectives. The first one is to produce a non-moving and non-rotating framework of the objects in the Solar System and of the stars in the Galaxy, which can be used as a model for space observation. The second objective is of providing basic observational data for the studying of spatial distribution (distance) and properties (mass, luminosities) of the stars in the Galaxy (ESA - European Space Agency, 2022). ESA's Hipparcos (1980-1993) had been the first mission of the European Space Agency in collaboration with the NASA entirely dedicated to astrometry. It had been followed by Gaia, a fully European space mission landed in 2013 which has the purpose of creating the most accurate and the largest three-dimensional map of the Milky Way Galaxy.

[3] The science that deals with the observation, study and explanation of celestial events. It investigates on the origins, development, movement of space trying to identify its chemical and physical properties.

[4] Aristarchus of Samus, one of the few supporters of the heliocentric system, supposed that the Earth travelled around the Sun and not the other way around. He also approximately determined that the Earth-Sun distance was 18 to 20 times greater than the Earth-Moon distance. Current data prove that the real distance is 400 times greater, but with the tools and knowledge of the time it can be considered a good approximation of the first cosmic scale.

enlargement of the ancient Greeks' texts and catalogues. Furthermore, in both areas, scholars and technicians developed and invented new tools and more advanced astronomical instruments to measure angles and distances in the sky, managing to improve the precision of the previous measures taken by the Greeks, while broadening the existing stellar catalogues. In the 15th Century in Central Asia Ulugh Beg, a famous scholar, astronomer and mathematician of the Timurid dynasty managed to map 994 stars in a new catalogue through the creation of a cutting-edge sextant in Uzbekistan. Ulugh Beg is considered as a common thread to the modern era and he has the merit of maintaining the practice of astronomy and astrometry alive during the Middle Ages.

During Renaissance in Europe there had been an important revival of classical sciences, including astronomy. For this reason, combined with the rediscovery of the ancient texts of the Greek and Islamic scholars, such as the Ptolemy's[5] original text on geocentrism, some astronomist started investigating on these theories and on their feasibility. In 1543 Nicolaus Copernicus[6], a Polish astronomer, revolutionized the whole vision of the cosmos by defining the heliocentric system, which poses the Sun at the center of the Universe and not the Earth, as Ptolemy pretended. Although the theory was simpler and described the movement of the planets around the Sun in a plainer way, the intuition behind the Sun at the center of the system was correct. Despite this, especially because of the opposite belief of the Cristian church which supported the idea of the Earth at the center of the Universe, the model required more than a century to become accepted by both within and beyond the scientific community.

Approximately in the same period Tycho Brahe[7], a Danish astronomer, completed and published (in 1627) an advanced catalogue of the stars by building "Uraniborg", the greatest astronomical observatory before the invention of the telescope. The catalogue, which included and mapped more than 1000 stars, gave a strong impact to research in

[5] Claudius Ptolemy (≈ 100-170 AD), the Roman mathematician, astronomer and theorist who developed the geocentric theory which poses the Earth as a static object in the Universe, with all the other planets and celestial objects gravitating around it (Jones, 2021).

[6] Nicolaus Copernicus (1473-1543) had been one of the most important astronomers in history. He revolutionized the vision of the cosmos by introducing the heliocentric system, which poses the Sun at the center of the Universe, with the other planets, including Earth, orbiting around it. He also defined the concept of the axis around which the Earth turns daily and the annually motion of the Earth around the Sun. This revolution, published in "*De revolutionibus orbium coelestium libri vi*" in 1543 generated important consequences for the following studies of scholars such as Galileo, Kepler, Descartes, Newton and gave a strong impulse to the Scientific Revolution (Westman, 2022).

[7] (Eggen, 2021)

the field of astrometry and constituted the more advanced astronomical catalogue before the invention, diffusion and use of the telescope.

The seventeenth century represented a period of great revolutions in astronomy. In particular, the acknowledgment on the heliocentric system and the invention of the telescope encouraged the interest in sky observation and boosted studies on the orbital mechanic and on astrometry[8].
Galileo Galilei[9] in 1609 built his own telescope and had been the first to take an "*augmented*" view of the sky. His observations with the telescope revolutionized astronomy and reinforced the theory of heliocentrism, while giving a profound impact to the Scientific Revolution of the years: he had been among the firsts to support scientific discoveries with empirical, mathematical and physical data boosting the importance of sciences over the anachronistic theories powered by the catholic church (such as the geocentric system theory). Finally, Galileo's discoveries opened the way for other fundamental scientific discoveries, such as Isaac Newton's Theory of Gravity and Johannes Kepler's theories on Universal Gravitation.

The advancement in the technology of the objects and tools used for space observation let the astronomers to determine the basis of the stellar parallax theory, one of the most important disclosures for what concerns astronomy and astrometry. A parallax, according to the definition given by the ESA is "an apparent movement of a foreground object with respect to its background owing to a change in the observer's position"[10]. The argument of stellar parallax had been in the center of the astronomical debate for both the Seventeenth and the Eighteenth centuries, with the contribution of a lot of scholars[11], mathematicians and astronomers that tried to approach the right result that was considered a fundamental point in astrometry, since it would have allowed astronomers

[8] (ESA - European Space Agency, 2019)
[9] Galileo Galilei (1564-1642) has been an Italian astronomer, philosopher and mathematician that contributed to the development of the scientific method during the end of the Sixteenth and the beginning of the Seventeenth century. For what concerns astronomy, he is identified as the first user of the telescope for sky observations and one of the first innovators of its technology: he managed to build his own telescope and to amplify its power using a trial-and-error process. Some of his astronomic discoveries comprehend Jupiter's moon, Saturn's rings, the nature of the sunspots and the first observance of the Moon's phases and surface. These discoveries were earthshaking for the period and combined, they fueled the Copernican hypothesis of a heliocentric system.
[10] (ESA - European Space Agency, 2019)
[11] Such as Giovanni Cassini, Edmond Halley and Wilhelm Struve (ESA - European Space Agency, 2019).

to determine the exact position of the celestial objects in the sky. Finally, in 1838, Friedrich Bessel, a German astronomer and mathematician, managed to publish the first reliable calculation of the parallax of a star. This is considered as a crucial point in the history of astronomy and in particular in that of astrometry.
Furthermore, in the same period, more advanced maps and catalogues of the stars had proven to be really helpful during the years for maritime and non-maritime navigation, yet showing the wide range of possibilities that the space can create, even for non-scientific and not space-related activities.

During the Nineteenth century, another milestone of space astrometry had been reached. In the 1840s, after the invention of photography, the first pictures of the Sun and Moon had been taken. Thereafter, the use of photography spreads in different fields of research in astronomy and allowed scholars to increase the exactness of their research. Furthermore, in the late years of the century, spectroscopy had been introduced in the study of celestial objects. This was a game changer because this technology enables astronomers to analyze the chemical composition of distant and thus inaccessible stars, revealing fundamental aspects of the matter that would not have been revealed through observation or through telescope photography.
Photography and spectroscopy opened the way to the discovery of important findings such as the main-sequence fitting method, that allows astronomers to collocate stars and their distance to stellar clusters according to their magnitude and following predictions from the stellar evolution model. Furthermore, during the first half of the Twentieth these methods allowed researchers to discover and explore galaxies even beyond the Milky Way[12].

This ability to explore the distance to faraway sources, facilitated and boosted by the advancement in technologies and by the developments in theoretical physics of the 20th Century, led to breakthrough after breakthrough in the 1920s and 1930s.

[12] (ESA - European Space Agency, 2019)

2.2. History of space exploration: space exploration in the XX and XXI Century

Even though the study of space has always occupied a central place in human thoughts, it is only from the 20th Century that, thanks to the evolution of the aerospace technologies worldwide, humankind started firstly in an indirect way and secondly in a physical way to move away from the terrestrial ground for studying those celestial objects that have been observed for millennia.

In terms of space observation, that as specified in the previous section had reached during the 1940s a great level of specificity and of technological development, the advancement on the precision of the measurements and thus of the discoveries had been slowed down by some barriers such as Earth's turbulent atmosphere[13]. For these reasons, astronomers started considering the many advantages of observations with space-based telescopes: powerful magnifying lenses able to collect better measurements and images from a favored position on an orbit around Earth, enjoying less interference from Earth's atmosphere. The main barrier for this type of missions was the ability of sending objects into space. During the latter half of the 20th Century, also because of the worldwide expenditures and research in war and in war-related devices, some countries had been able to develop rockets capable of covering long distances.
Studies on propellants and on materials continued until the 50s, creating an actual rush to space and increasing the political hostilities between the two major powers of the second post war, the United States and the Soviet Union. It was Russia, in fact, on the 4th of October 1957 that managed to send the first artificial satellite into space[14]. The *Sputnik-I,* that is the name of the first Russian artificial satellite, had been followed a month later by the *Sputnik-II*, the second Russian artificial satellite with the primate of the first living creature on board (a dog named Laika, that unfortunately died a few hours after the

[13] In fact, Earth's atmosphere affects and alters the precision on the measures of distance and it degrades the quality of astronomical images (ESA - European Space Agency, 2019)
[14] (Wilkinson, 2020)

arrival in the Earth's orbit[15]).

The mission had two main outcomes. On one hand it boosted the competition in the Cold War between the US and the URSS (Union of Soviet Socialist Republics), bringing the pression on the conflict into another level[16]. On the other hand, it proved that the actual rockets were powerful enough to send a "craft" into space and, especially, to send in the space a human being.

In this period of turbulent political atmosphere, it did not take a long time for the American answer to arrive. One year later, in 1958, approximately concurrently with the creation of the American NASA (National Aeronautics and Space Agency) by the American president Dwight D. Eisenhower, the US sent the artificial satellite *Explorer 1* into space. The mission had been the first of a series of successful achievements that promotes the NASA as the most advanced space agency in the world for the following 50 years. Despite this, the primate of the first orbit flight with a man on board belongs to the Soviet Union that on the 12th of April 1961 sent the capsule Vostok I on orbit, with Yuri Gagarin, a Soviet cosmonaut and pilot, on board. Gagarin completed an entire Earth orbit before landing back on Earth.

The so-called Space Race[17] continued during the following decades with a sequence of new technological achievements for both the superpowers: the first spy-reconnaissance satellites for military use had been launched, followed by other satellites dedicated to meteorological uses and to telecommunications. Other spacecrafts had been sent in the direction of the Moon, Mars and Venus to explore these planets. Moreover, both the US and the URSS developed their first space programs, including their short and long-term objectives for space missions and research.

[15] (ESA - European Space Agency, 2017)

[16] Space artificial satellites are powered by rockets, that are based on the same technology of war missiles as the V2 or the Russian's R7 rocket (the so called ICBMs, intercontinental ballistic missiles). While boosting space exploration this technology had been used as a powerful weapon and during the Second World War it destroyed a lot of European cities, causing many deaths. In 1957 the Russian ability of sending an artificial satellite into space for few days had been perceived as a threat in the United States, augmenting the tension during the Cold War (Wilkinson, 2020).

[17] The competition on spaceflights capabilities between the United States and the Soviet Union during the Cold War period.

In particular, the primary orientation of the American space program developed and encouraged by all the American presidents succeeded during the 60s[18], was oriented toward the conquest of the Moon. After the first American-human spaceflight in 1961, just three weeks after Gagarin's one, the NASA launched the first man on a suborbital trajectory. After this success in fact, the American president John F. Kennedy deliberately and publicly declared the main US goal in terms of space exploration: "I believe that this nation should commit itself to achieving the goal, before the decade is out, of landing a man on the moon and returning him safely to Earth".

Kennedy's declaration was followed by the initiation of the Gemini program, followed by the famous Apollo program (1968-1972), a series of space flights and experiments that culminated in 1969, with the first man on the Moon. The 20th of July 1969 Neil Armstrong and Buzz Aldrin landed on the Moon on the Apollo 11 mission[19] and had been the first men to place their foot on the Moon's surface.

Before the 60s Russian's capabilities exceeded the majority of American's technological achievements, just consider that every primacy before the US landing on the Moon was Russian: the first artificial satellite (1957), the first man on Earth orbit (1961) and first man on orbit for 24 hours (1961), first spacewalk wich made also Valentina Tereshkova the first woman in space (1963) and the first human-made object on the Moon's surface with the Luna 2 and Luna 3 missions (1959)[20]. Nonetheless, the American conquest of the Moon in 1969 represented the end of the Rush to Space between the USRR and the US, ending their competition on the achievements in terms of space conquests and making the US the primary power for space exploration and research activities.

During the 70s more countries approached the space research with the creation of more national and international space agencies. In particular in 1975, mainly thanks to the French know-how the European Space Agency (ESA) had been created. For the creation of the ASI (Agenzia Spaziale Italiana, the Italian Space Agency) it is necessary to wait until

[18] In chronological order-succession: Dwight D. Eisenhower (1953-1961), John Fitzgerald Kennedy (1961-1963), Lyndon B. Johnson (1963-1969) and Richard Nixon (1969-1974).

[19] Apollo 11 had been the first space mission to bring the first men on the Moon. Neil Armstrong and Buzz Aldrin, supported by Michael Collins who remained in the spaceship on the lunar orbit, landed on the Moon's surface the 20th July 1969 on live television worldwide. The crew landed back on Earth four days later, on the 24th of July in the Pacific Ocean (Loff, 2022).

[20] (Wilkinson, 2020)

1988 and for the Canadian Space Agency (CSA) until 1990. Finally, in 2003 it had been created the JAXA, the Japanese Space Agency, composed by the merger of three other agencies[21]. Moreover, the 70s marked the beginning of the Space Stations era: in 1971 the RKA[22] launched the *Saljut*, the first orbiting laboratory. Russians had been followed by the NASA in 1973, with the launch of the *Skylab* (1973-1979) that had been occupied for three missions during the years of activity.
In 1998, thanks to the collaboration of the previously mentioned agencies (the American NASA, the Russian RKA, the European ESA, the Canadian CSA and the Japanese JAXA) the first International Space Station (ISS) had been launched. From 1998 the ISS has been fully assembled and occupied by crews coming from the partner agencies. The ISS represents an orbiting laboratory in a unique environment that is the space. This environment allows scientists in the station to perform different experiments and research and to develop new technologies directed to space exploration and to potential Earth benefits. The majorities of the missions in the ISS are conducted in collaboration between the international agencies.

The two decades between 1980 and 1990 have been marked by an incremental study of the means of reaching space in a more economical and sustainable way. In the 1980s the presentation of the Space Shuttle, the first reusable launch system developed by the NASA to break down the huge costs necessary for building up the technologies to access space, opened the way for the invention in the following years of new technologies that reduced the weights of artificial satellites. This represents a milestone in the history of space exploration since after the development of these devices of just 500 Kg in the 90s, artificial satellites' exploitation expanded also to civilian purposes. This initiated the "satellites era", a period of technological revolution that allowed men to reach space with artificial satellites devoted not to exploration but to human uses, such as meteorological satellites, satellites for information transmissions (internet, television etc.) and a network of satellites for GPS (Global Positioning System). The business behind artificial satellites, while less considered by public interests, still represents one of the core activities for the

[21] The JAXA had been formed on the 1st October 2003 thanks to the merger of other three existing Japanese agencies: the National Space Development Agency (NASDA), the National Aerospace Laboratory of Japan (NAL) and the Institute of Space and Astronautical Science (ISAS).
[22] The Russian space agency is called RKA. It is also commonly known as Roscosmos.

space economy[23].

Beside to the technological innovations achieved during the last decades of the 20th Century, space exploration made important progresses: during April 1990 after decades of studies and engineering of the project, the NASA in collaboration with the ESA launched the Hubble Telescope. In more than 30 years of operations, extended because of some adjustments in the cutting-edge instruments of the telescope added during five servicing missions, the Hubble Telescope provide humanity with thousands of images and observations of locations at more than 13,4 billion light-years from earth[24]. The famous telescope has been the first device to be able to immortalize newborn galaxies, collapsing stars, dark energy and discovered the first exoplanets.

Starting from the beginning of the XXI Century the globalization of the space activities, combined with its digitalization, determined the beginning of a new period for the space industry development. This cycle is based on the universal use of space applications in numerous industrial fields and on the development of increasingly light artificial satellites made possible by the support of new discoveries in the field of microelectronics, materials sciences and of informatics[25]. Therefore, in the last decades the international competition between global powers has given way to a profound collaboration between international space agencies which nowadays, according to scholars[26] guarantees:

- A continuous monitoring of the resources and of the natural disasters of the planet Earth;

- A more in-depth study of the Solar system;

- More scientific research in astronomy, astrophysics and geophysics.

Furthermore, during the last 20 years, the increasingly constant presence of private companies in the space sector have altered again the relationships between the main actors in the space industry. Private companies have boosted studies, research and

23 (Messeni Petruzzelli & Panniello, 2019)
24 (NASA, 2021)
25 (Messeni Petruzzelli & Panniello, 2019)
26 (Petroni & Bianchi, 2016)

missions aimed at new and future space activities which include, among the points of greatest interest, human travel in space and an increasing use of the outputs produced by satellite infrastructures (signals and data) for consumer products. After all, if nowadays global markets are wider, the reason is mainly technological and it lies in the significant increase of the civilian use of the services provided by the artificial satellites.

In fact, according to a 2019 publication of the OECD, in the last 5 years the global landscape of space activities has evolved, with more and more countries investing in space projects, also thanks to an increasing participation of private investors[27].

[27] (OECD, 2019)

3. The New Space Economy

3.1. Boundaries of the Space Economy: its, definition, the actors, the critical factors and the drivers

The previous paragraphs reviewed the main historical events and human achievements that led to the formation of the space sector. This sector can be considered as a hybrid sector since it must guarantee reliability, durability in the long run and low costs, while experiencing continuous and profound transformations imposed by innovations. The space sector lies within the borders of the broad field of the Space Economy.

According to the OECD definition of Space Economy, it can be defined as "the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilizing space"[28]. For these reasons the Space Economy includes all the public and private actors involved into the development, supply and final utilization of the products and services produced by the space industry. These outcomes range from R&D to the production and utilization of space infrastructures (space stations, launch vehicles and satellites) that are necessary to enable applications such as navigations instruments (GPS), satellite phones and meteorological services that are reflected in the use that we do of space facilities.

The objectives of Space Economy go therefore beyond the borders of the space industry and sector, incorporating the continuous and diffused impacts of the field in the overall economy and on the society as a whole.

[28] (OECD, 2016)

The OECD defined at international level the three principal boundaries through which the Space Economy operates. These perimeters, displayed in *Figure 3.1,* are linked one with the other and the value created by one area irrigates the others and vice versa.

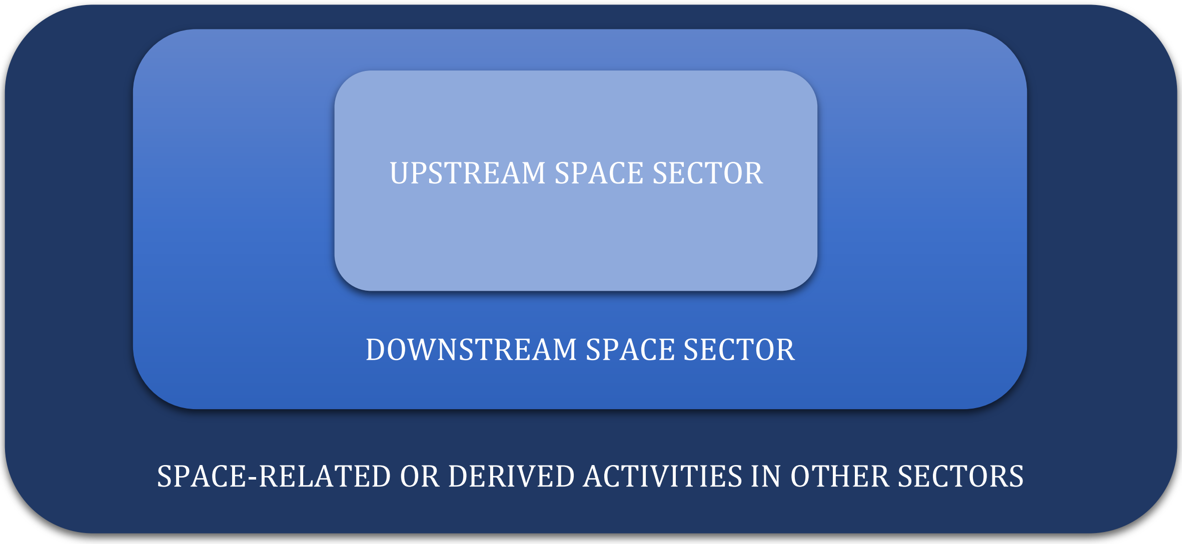

Figure 3.1 – OECD's three boundaries of the space industry.

1. *Upstream Space Sector:* includes scientific research, R&D and manufacturing. This perimeter comprehends all the services, technologies and products that are specifically connected to space activities such as space astronomy research, space component manufacturing and artificial satellites;

2. *Downstream Space Sector:* are all the space-enabled activities which would not exist or function without satellite signal or transmitted data. This comprehends GPS-enabled services and satellite television broadcast;

3. *Space-related or derived activities in other sectors:* involve activities in various economic sectors that may derive from or have relied on space technology transfers to develop. All the activities, products and services that are derived from space technology but not depend on it to function are included into this perimeter.

Within these boundaries it is possible to define the main actors that through specific industry-related drivers develop the technology that constitute the stream of value of the whole industry[29]. From a manufacturing point of view, the space sector is made up of a highly specialized industry with a particular emphasis on accuracy and verification procedures, with extremely low tolerance for error and risk. Specifically, the new qualified industrial procedures, adopted to reduce the production costs of spacecraft and other launch devices, have been largely influenced by the experience given by other industrial sectors (mainly automotive and aeronautics). Today only a few countries in the world have the technology to carry out an orbital space launch. It is possible to classify among the institutional **actors** involved in space activities, basing on their level of technology possessed. It is possible therefore to distinguish into two categories[30]: the already developed countries, the so-called *Developed Space Actors* (such as the United States of America, Russia, the ESA countries and Japan) and the *Emerging Space Actors* (EMSAs), i.e. all those countries not included in the DVSAs[31]. Within the broad boundaries of the EMSAs group, it is useful to create three sub-categories based on the skills and competences acquired by each country. At the top step it is possible to find the EMSAs' actors who possess the ability to autonomously produce space technologies: this category includes Brazil, India and China, the so-called BRICs. In second place are countries such as Iran, Israel, South Africa and Iraq, which possess some basic capabilities, which have recently established national space agencies and which are partly capable of producing their own space technology, but which need to collaborate with the most advanced countries to conduct major objectives. The third and last step includes all the other minor players, that is all those countries that do not act in the space field outside the collaboration with more advanced countries and that only exceptionally contribute to the production of new technologies in this field.

The increase in the number of actors involved in space exploration is attributable to various *critical factors* that have favored and accompanied the growth of the space industry. Among these, it is possible to identify three key elements:

[29] (Messeni Petruzzelli & Panniello, 2019)
[30] (Petroni & Bianchi, 2016)
[31] Acronym for "Developed Space Actors".

1. The new generation of "small satellites", resized and with a weigh even less than a kilo, which have considerably reduced the cost of launching;
2. The increased ability to launch and the implementation of modern platforms for launching satellites into orbit, which exploit innovative techniques for the reusability of rockets;
3. GNSS signals (Global Navigation Satellite Systems), which includes American Global Positioning System (GPS) technology.

Beside this, according to Messeni Petruzzelli & Paniello, it is possible to detect three other *drivers* that have contributed in the last 70 years to space research and innovation and that can be identified as the reasons for major investments of countries and private companies in the sector. Primarily, the persistence of scientific and national security objectives that have led more countries to invest in space programs, building technological know-how and attributing national prestige thanks to new technologies or discoveries. A second driver can be identified in the extension of space downstream applications, that is to say, in the development of space applications with the aim of solving problems on Earth as well as to generate profit and future new markets. Just consider the amount of mobile devices that in the last 20 years have developed applications with integrated satellite systems services ranging from image transmission and satellite telecommunications to leisure applications such as the famous Pokémon Go, which is based on the use of satellite position signals. This is a clear example of how a technology developed by the space industry may find use in different sector downstream, with startling achievements in terms of revenues: in fact, Pokémon Go in the biennium 2020-2021 generated around 900 thousands US dollars per year, doubling the amount since 2017 (*Figure 3.2*)[32].

[32] (Statista, 2022)

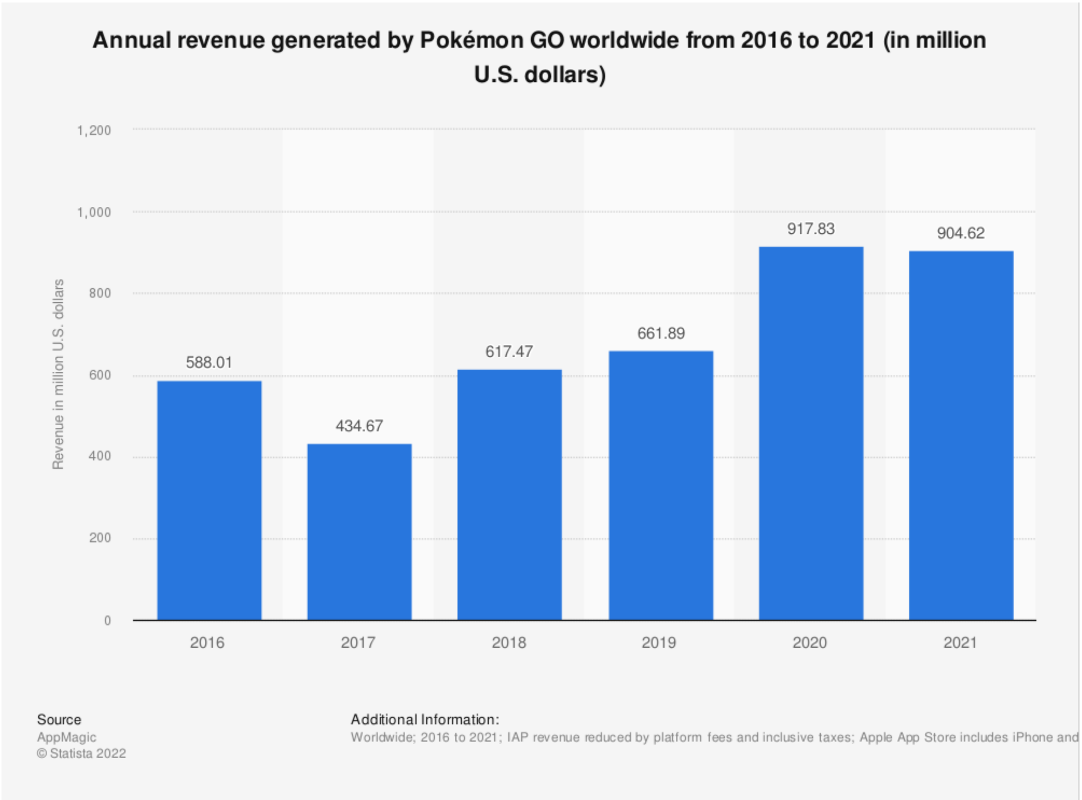

Figure 3.2. – Annual revenue generated by Pokémon Go worldwide from 2016 to 2021 (in million US dollars).

The third and last driver involve man into space. This exploration has been widely criticized by the public opinion due to the high costs for preparing and conducting exploration missions. Nevertheless, human exploration into space remains one of the principal guidelines of international agencies and private companies' space programs. Indeed, the propensity of investments towards human application into space is predominant in the private sector, with private organizations investing more compared to international agencies into exploring new human-related activities into space. During the last 10 years the research in this field conducted by this companies is opening a new subset in the space sector, the one of "leisure": companies such as Blue Origin (owned by Jeff Bezos, the billionaire owner of Amazon) and Virgin Galactic (part of the Virgin Group, driven by the magnate Richard Branson).

From this overview of the space sector, of its actors, critical factors and drivers, it emerges clearly how from one side the space provides nowadays a complex structure in terms of value chain division, while representing a great opportunity in terms of investments.

3.2. Sectors and fields of the Space Economy

According to the OECD[33], the "Advanced Research in Telecommunication System" (ARTES)[34], a long-term space program developed by the European Space Agency in collaboration with multiple business investors, in the last years has led to numerous innovative applications in different economic sectors such as security, finance, tourism and many more. The aim of the program is in fact the one of transforming R&D investments into successful commercial products and services by offering varying degrees of support to projects with different levels of operational and commercial maturity. With the over 192 projects developed by the end of 2019, the ARTES produced the 40% of the outcomes as commercial products or services, the 18% as operative result in terms of research but not commercial, while the other 42% remained to its initial status without progress. *Figure 3.3* displays the effectiveness of the research of the program considering the number of applications developed in different sectors.

---

[33] (OECD, 2016)

[34] The ARTES program seeks to keep the European industry at the leading edge of a fiercely competitive global market by nurturing innovation. Through the support of the ESA and different private actors, an industry or a company can pursue research and development that would otherwise not be economically viable. According to the ESA and to the actual results of the program, the new pace-enabled applications and services developed by the ARTES stimulates the wider economy, creating new businesses and jobs across almost every sector targeted. The aim of the program is thus creating services using space capabilities. This would benefit society on a daily basis and on a global and local scale, such as improving education in rural areas, assisting search and rescue, providing remote healthcare and monitoring natural resources and the environment (ESA - European Space Agency, 2022).

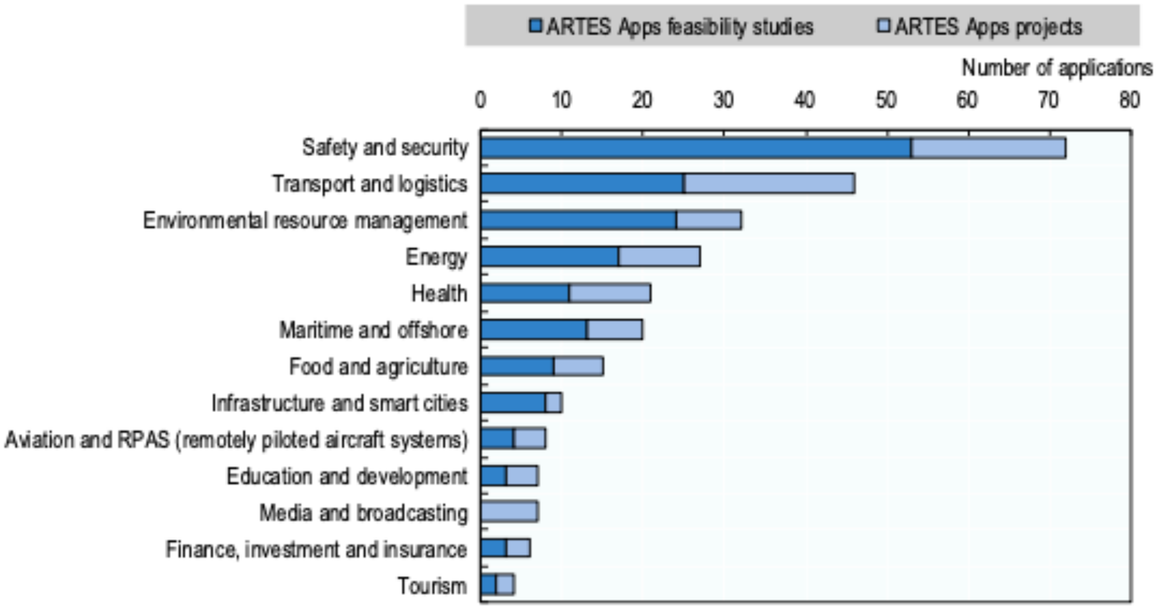

Figure 3.3 – Sectors affected by satellites innovations for communication systems developed in the ARTES program (OECD, 2016)

All this allows us to understand how pervasive the space economy is in the life of our society and the infinite possibilities that it can create. The technologies and the benefits offered by the space are now part of our life. If, for example, all the satellites active today are switched off even for a single day, we will go back at least fifty years.

Globally, the entire Space Economy sector generated 350 billion dollars in 2018, the 70% represented by the turnover of services and the 30% by that of manufacturing. This represents an exponential growth for the sector: for decades the space has been for the exclusive use of government international space agencies around the world. However nowadays the dynamics behind the collaboration between the actors have changed because the sector represents a new scientific and technological frontier, with significant financial returns: each euro invested has a financial return between 6 and 9 euros[35].

Space capabilities provide vital information on the environment, food safety, public health, water management, human rights, disaster relief and nuclear safety. Furthermore, the services provided by satellites are essential for many modern infrastructures and represent a kind of economic multiplier and engine for other sectors including the air, sea and land transport sectors, the banking sector, telecommunications services and the

[35] (Cottone, 2018)

internet, the health care sector, the energy sector and agriculture. In addition to all this, space technologies support activities such as water management, dams, the energy network, weather forecasting and monitoring/management of environmental disasters and climate change studies. Space therefore has a positive economic impact on the various markets.

Before analyzing the solution that the space industry offers to the issues existing in all the sectors, it is important to review the principal substrate on which the majority of the space technologies are based: the artificial satellites. It is possible to divide artificial satellites in three different groups, based on the type of sector in which they operate and on the information that they provide to Earth[36]:

- *Earth Observation satellites* contribute to numerous activities including agricultural improvement, water management, locating refugee populations, weather forecasting, disaster monitoring, carrying out relief operations and national defense. In recent years, due to the growing interest in monitoring the Earth's temperature and the level of water and glaciers caused by the rise in Earth's temperature, Earth Observation satellites are finding ever greater utilization. The value chain for Earth Observation satellites is less developed than that of communications satellites, but they nevertheless generated a significant economic return of $ 2.1 billion in 2012. The number of Earth Observation satellites launched into orbit from 26 countries between 2001 and 2010 is 140. These numbers are constantly growing, reaching in 2020 around 298 satellites launched from 46 countries. Furthermore, an increasing number of these satellites are now being built by private industry.

- The *Global Navigation Satellite System (GNSS)* network is a technology that has revolutionized transport and navigation capabilities by ensuring more efficient routes, improving safety standards and reducing operating costs. This technology constitutes for most of the American GPS system, but it also includes the European

[36] (Messeni Petruzzelli & Panniello, 2019)

Galileo program (developed by ESA, the European Space Agency, with a large contribution from ASI, the Italian Space Agency). These satellites provide a flexible, more accurate and low-cost method of tracking positions, planning routes and scheduled arrival/shipping times in air, sea and land transport. Furthermore, the private use of GPS by motorists has also developed and in recent years has skyrocketed. GNSS satellites have also contributed to the development of efficient and economical water management systems and electricity grids: the result is that these infrastructures have also become more accessible to developing countries. As regards the global market, the production of GNSS devices from around 50 billion euros in 2012 to 100 billion euros in 2019 is destined to grow further; while that generated by GNSS services was worth 150 billion dollars in 2012 and it is expected to reach 250 billion dollars by the end of 2022.

- The third and most important group is that of *Communications Satellites*. They make up the majority of the satellites in orbit, providing television broadcasting, internet and telephony services. They have reinforced the information revolution by allowing long distance communications, also in areas where land, distance or poor infrastructure make it more difficult to install electrical cables. The benefits range from banking services, to distance education and to telemedicine in remote areas. It is possible to say that thanks to internet services these satellites are starting to bridge the digital divide between developed and developing countries. Indeed, by taking advantage of the tools offered by already established global players in the satellites telecommunications field, new entrants such as the United Arab Emirates, Chile, Laos and Nigeria are paying less for the gap with the more developed countries[37].

  From a commercial point of view, the space communications satellite industry is the most mature with over $ 100 billion in global revenues in 2019, driven

[37] These countries have joined the International Telecommunication Union (ITU) to use communications satellites in their countries and have started contracting for manufacturing and launch services.

primarily by broadcasting services. Within it, the satellite television industry is the one that has experienced the greatest growth in the last 20 years.

Information and communication technologies (ICT) are indispensable for economic, social and cultural development: communication has become an indispensable element and it is expected that over the years it will become free and accessible at any time, in any place and through any device. However, there is still a strong digital divide between more developed and less developed countries. Although it is not possible to see them from Earth, satellites are everywhere around us and through their use we could compensate for the digital divide by connecting users wherever they live and thus making the world a better place for everyone. For this reason, one of the biggest challenges right now is to ensure affordable access to education in remote, rural and sparsely populated places. With satellite technology it is in fact possible to ensure high-speed internet access even to these communities, to reach teachers and students who would otherwise remain out of basic education. One of the most promising and consolidated educational applications is in fact that based on satellite technology for distance learning.

A recent example of how space technology can support population in critical areas is the one of Elon Musk's Starlink satellites, activated by the SpaceX CEO under the approval of the US Government to support the Ukrainian population during the Russian invasion in the first months of 2022. Starlink is a unit of Musk's space company, SpaceX. The service uses terminals that resemble TV dishes equipped with antennas and are usually mounted on roofs to access the Internet via satellite in rural or disconnected areas. According to Mykhailo Fedorov, minister of digital transformation of Ukraine, while the country is still under constant attack of the Russian army, the thousands of antennas received by Musk's companies and by other European allies, have proven to be "very effective" together with Starlink's satellites in order to provide a free access to the internet to the Ukrainian population in this time of war, necessary to all the citizens to acquire major information and communication about the progress of the invasion and about the protection measures adopted by the Ukrainian Goverment[38].

In addition to the areas and sectors mentioned above, the Space Economy finds utilization in many other economic sectors thanks to the use of its satellites. In particular, using satellites for Earth Observation and GNSS satellites for geolocation, it is possible to tackle the problem of climate change and the occurrence of natural disasters. Through the continuous measurement of the Earth by satellites, useful information are provided to better understand and to manage more effectively all the problems related to climate change: it is therefore possible to implement immediate actions and mitigation measures, such as environmental conventions or international agreements. Furthermore, these types of satellites are among the most suitable technologies for measuring and detecting some natural disasters, including earthquakes, hurricanes, floods or tsunamis. The satellites provide monitoring mechanisms both before the disaster strikes and after, for example ensuring coordinates to locate the missing during rescue missions. In this case, the satellites are subsequently involved in the transmission of communications, which allow active communication even when the terrestrial infrastructures have been destroyed.

Environmental monitoring by satellites also extends to natural resources. Some Earth Observation satellites are entirely dedicated to the observation of resources such as water, glaciers and forests, transmitting information about the current state of health of these resources and about the negative impacts generated by their deterioration. Nowadays, these data are very useful and are also at the center of the public debate given the continuous emergency situations caused by rising temperatures, melting glaciers, deforestation and increasingly repetitive fires.

Another field of use of space technologies is that of agriculture: if on the one hand the Earth Observation satellites allow us to monitor the level of global deforestation in favor of agricultural activities[39], on the other hand, they allow us to monitor the progress of the

[38] (Lerman & Zakrewski, 2022)
[39] 75% of global deforestation is caused by agricolture.

latter, understanding which activities can be negative for the planet and proposing solutions in terms of food security to have a more sustainable management of resources.

Other utilization of space resources and of signals transmitted by satellites can be telemedicine (that can support also populations in critical and rural areas), the monitoring of illegal fishing and illegal aerial and naval activities, the monitoring of armaments and nuclear structures.

On the other hand, satellites and space technology, together with the Earth itself, must be protected and preserved from the possible catastrophic risks that come from space. This criticality is always answered through monitoring by satellites that transmit information necessary in order to prevent or mitigate their effects. In particular, there are two main catastrophic risks coming from space: extreme space weather conditions, which can damage or destroy satellites orbiting the earth, and the possibility of large objects hitting the earth at high speed, causing even more serious damage. The likelihood of these disasters occurring is very low, however, being aware of such threats and taking appropriate action and precautionary measures in this regard is of paramount importance.

There are currently more than 1100 satellites orbiting the earth, which provide tangible economic, social, scientific and strategic-military benefits. The greater the use of space, the greater the challenge will be to preserve its long-term sustainability and protect its resources and its environment. According to Messeni Petruzzelli & Paniello, only through collaboration between nations, the development of global norms and codes of conduct is it possible to improve access to space, awareness on space issues and develop sustainable and collaborative solutions to face global challenges and continue to benefit from space. We are therefore talking about a sustainable Space Economy with far-reaching and far-reaching effects on the global economy[40].

According to Roberto Battiston (2018), ex-president of the Italian Space Agency (ASI) "The satellites that we have in orbit are increasingly sophisticated and provide us a lot of data for observing the earth. In addition, applications are increasingly entering our daily

[40] (Messeni Petruzzelli & Panniello, 2019)

life, starting with the mobile phone which, for example, lets you navigate from a point to the other of the city thanks to a satellite". Furthermore, another growing trend in space activities is the one concerning the use of satellite information and its access. Battistoni in fact affirms that an important business opportunity will be that of exploiting the future challenges for the management of the data coming from space, the so-called Big Data, which refer to the complexity and variety of digital data generated by the ever increasing number of sensors and devices integrated in space technologies. In addition, the big challenge right now is figuring out how to extract the hidden economic value in the mountain of data that space produces[41].

This is the most challenging objective that the space industry is pursuing at the moment, and it is also the one that synthetizes and creates a link between all the previously cited field of activity that through satellite technology are trying to add value in human everyday activities.

3.3. Benefits and contribution of the Space Economy in the Global Economy

Nowadays, as explained in the previous paragraphs, governments are the main investors in space activities, with public investments reaching almost 75 billion dollars in 2017, and constantly growing in the next years[42]. If we compare this value with the amount of worldwide expenditure in 2008, that was of 52 billion dollars, it is impressive to see how investments in the sector have risen, symptoms of an industry that creates benefits for both investors and users.

The presence of governments in space investments is mainly represented by national and international space agencies, research institutes and universities. Moreover, in the last five years the global landscape for space activities has evolved, with new countries

[41] (Cottone, 2018)
[42] (OECD, 2019)

investing in the research and development of the sector and getting involved in different processes of the value chain. *Figure 3.4* displays how the number of countries able to perform a satellite launch has evolved in the years. The number is in constant growth, meaning that more and more countries over the years have been able to acquire the competences necessary to prepare a successful satellite launch.

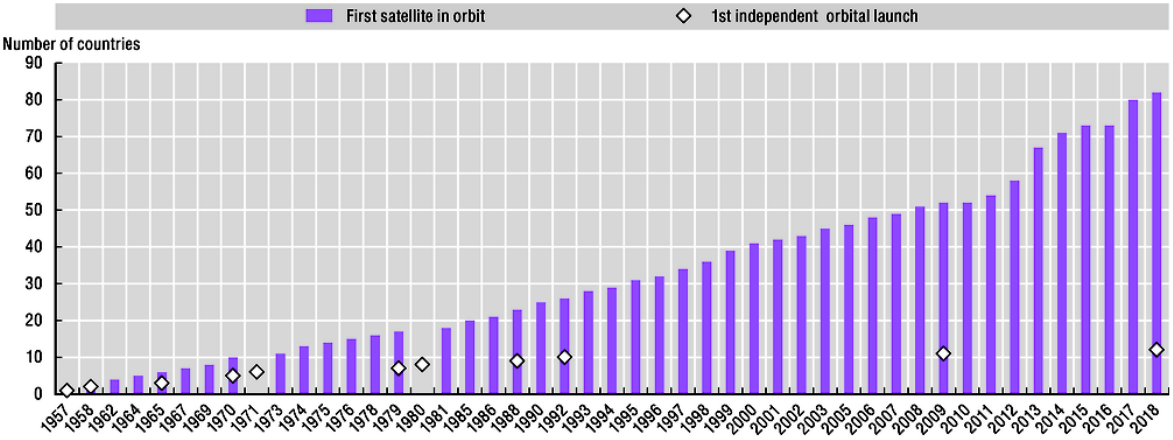

Figure 3.4 - Number of countries with a satellite on orbit (launched by a third party or independently between 1957 and April 2018) and number of countries having launched a rocket successfully.

In addition, in the last ten years, private funding of commercial projects has also grown, with unprecedented private capital flows in the space sector from angel and venture capital investments.

The ratio of space budget to the national domestic product of a country (GDP) is one of the most useful indicators to measure and compare space funding intensity. In 2017, the budget of the United States accounted for 0,24% of national GDP. In the same year, the USA has been followed by Russia, with a ratio at 0,17%, France at 0,1%, China at 0,08% and Japan at 0,07%. *Figure 3.5* displays the results[43]. The majority of space budgets constitute less than 0.05% of GDP in 2017 and they included civil and military space activities (thus not only expenditures in research and development)[44].
Even if in the European Union's countries the ratio in average is lower compared to other countries, with only one country (France) in the top five in 2017, the overall budget of the

[43] (OECD, 2019)
[44] Evolutions in a space budget's share in GDP may be affected not only by changes in funding levels but also by rapidly contracting or expanding GDP.

ESA (European Space Agency) is constantly increasing through the years, with more and more innovative projects started between 2018 and 2022, positioning the international agency as one of the most important payers worldwide.

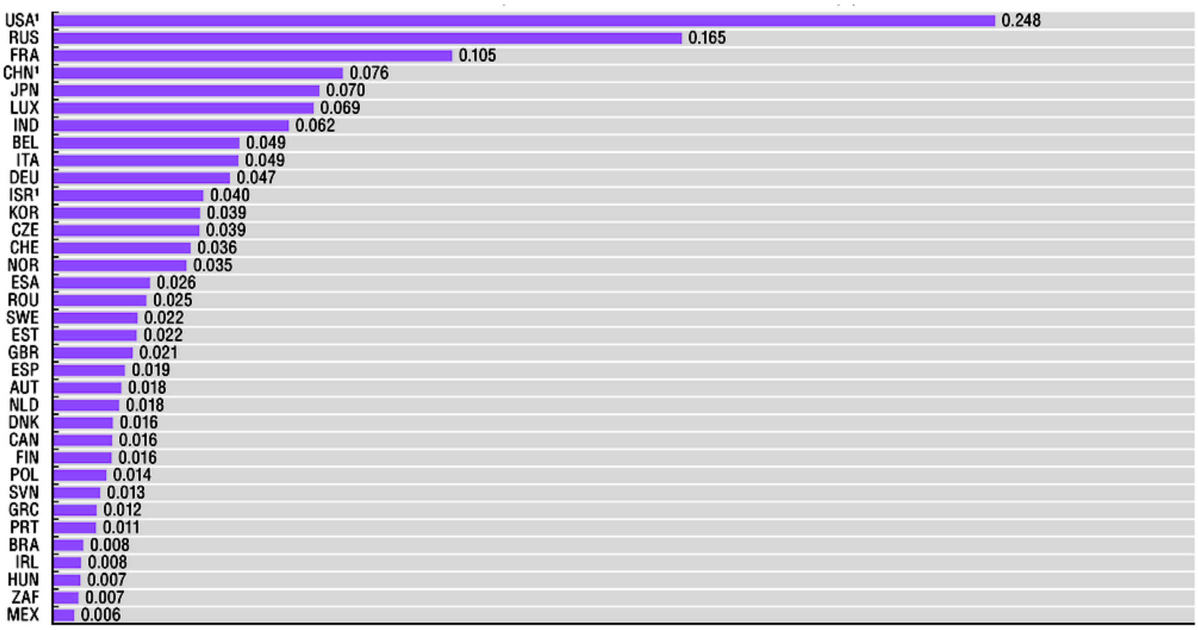

Figure 3.5 - Space budget estimate as a share of GDP (%) of OECD countries and partner economies in 2017.

For what concerns the private sector, the way for private investments had been opened by high returns in the commercial satellites for communications, followed by investments of venture capitalists, angels and start-ups on other fields in the industry. In fact, according to the trends of the last years, the main sources of funding for new firms in the space sector are the founder's own funds with investments from bank loans, equity capital and government support. Some of the most active actors include for example Boeing's HorizonX Ventures, Airbus Ventures, Thales Corporate Ventures (which will be further discussed in *chapter 5*, with the Leonardo SpA case), and the Dassault System Venture Fund.

The number of private investment transactions in the sector almost doubled between 2011 and 2017, with around 200 deals in 2011 and around 400 in 2017[45]. According to a

[45] (OECD, 2019)

study of Bryce Space & Technology[46], in 2021 a record amount of 15,4 billion dollars was invested in start-up space companies worldwide (nearly doubling the investments of 2020 in the same field)[47].

An OECD study of 2017 investigated the socio-economic effects derived from space investments[48]. The study covered 77 impact assessments and programmed evaluations published between 1972 and 2018 and divided the benefits into each sector, as *Figure 3.6* displays. According to the research, space investments, other than the overall economy, benefits the most the environmental management sector (11,3%), the transport and urban planning sector (9,7%), the R&D and science sector (9,4%), the climate monitoring and meteorology sector (8,1%) and the telecommunications sector (6,9%).

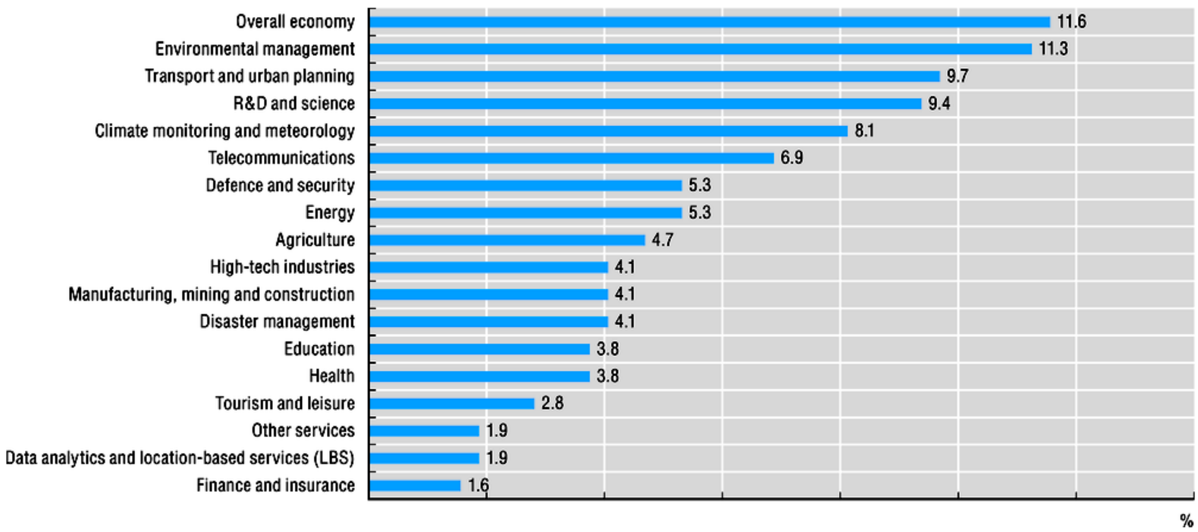

Figure 3.6 - Sectors that, according to OECD, benefit from socio-economic effects derived by space investments (expressed as a share of total occurrences identified between 1972 and 2018)

In addition, the same OECD study reveals that the benefits derived by space investments goes beyond the single space industry, with effects also outside the space sector. The research in fact analyzed four different fields that revealed positive effects after space investments, investigating whether the benefits remained constrained in the space industry or if it extended outside it, reflecting positive effects also in surrounding

[46] Bryce Tech is an analytics and engineering firm that partners with science and technology clients and that delivers government program support and business consulting.
[47] (Bryce Tech, 2022)
[48] (OECD, 2019)

industries[49]. Results can be summarized as follows, with positive results outside the space sectors that most of the times overtake the ones within the boundaries (*Figure 3.7*):

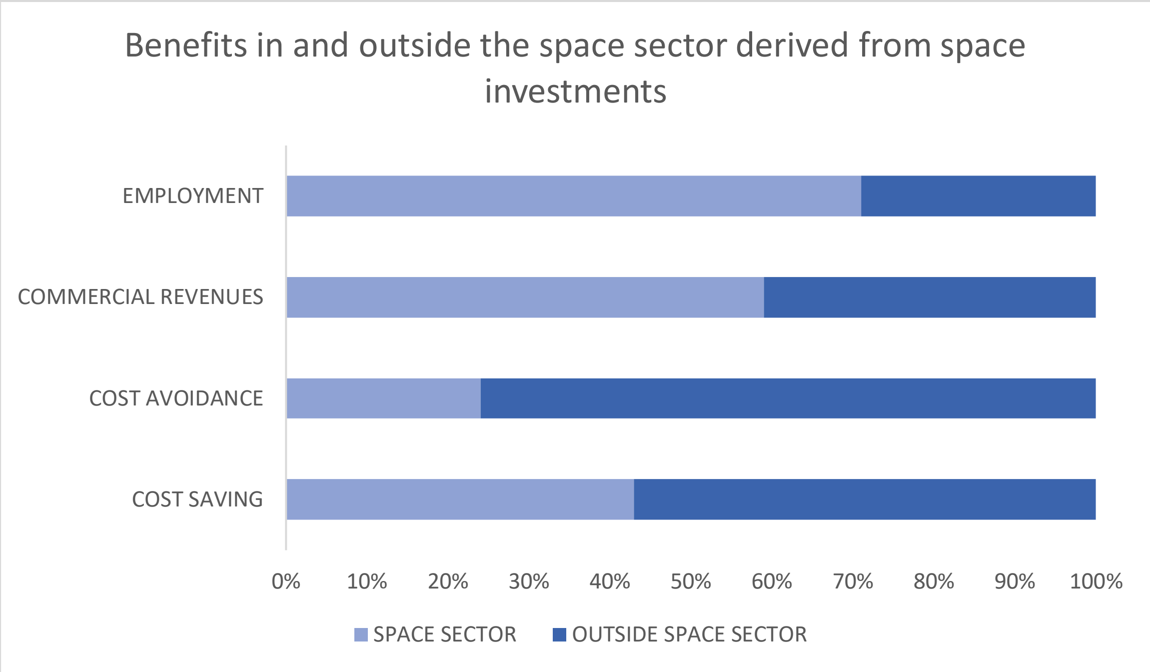

Figure 3.7 - Benefits in and outside the space sector derived from space investments

It is important to notice that the benefits resulted in the research study of OECD goes in the same directions as the results displayed in the previous chapter (*"Sectors and fields of the Space Economy"*), placing the environmental-climate monitoring sector (Earth monitoring), the research-scientific sector and the telecommunications sector as the ones with the greatest interests both in terms of investments and in terms of final socio-economic benefits.

[49] (OECD, 2019)

3.4. New technologies and business opportunities

As discussed in the previous chapter, most of the agencies that have operated so far in the space sector have been managed by national governments. In the last decade, however, the space industry has undergone a profound transformation with the entry of actors belonging to the private sector. A major change has thus occurred: the space projects previously fully funded by national governments have also passed into the hands of private individuals. In fact, every year it is tangible the creation of new start-ups that intend to exploit space resources to provide additional functionality to space. As discussed in the previous paragraphs, most of the global space activity in recent years is aimed at the commercial sector: these emerging companies, collaborating with national agencies, provide governments with opportunities for access to space and provide them with an incredible quantity of information generated by a myriad of satellites positioned in Earth orbit. As a consequence, in the future the space sector will affect more and more sectors beyond the governmental one and the future of space activity will not focus only on activities in space but above all on trade and services that are made possible through activities carried out in space. Thus, the interaction of space activities with other forms of earth activities is already creating and will continue to create new opportunities for terrestrial businesses.

The benefit that the space economy generates into other adjoining sectors is a classic example of positive externality[50]: a positive benefit to a direct or an indirect third party that arises thanks to the activity of another actor or group of actors. In this case companies operating in the space sectors are the ones that generate positive benefits (i.e. positive externalities) to other companies operating in other sectors or to the society as a whole. This concept has been deeply explored in the previous section but, in this paragraph the aim is that of capturing the positive benefits that the space economy, through its

[50] (Westfall, et al., 2020)

investments and researches, can potentially create in the future (both in the immediate future and in the long term).

As a consequence of the latest transformation of the sector in the last years, the future benefits of the space economy are strongly related to the commercial applications of the services offered by the industry. In fact, the insertion of private actors in the field is motivated by the economic returns of the projects even if national agencies are still focusing researches and activities devoted to scientific knowledge and space observation and exploration. Business opportunities offered by EGNOS and Galileo (both projects of the European Space Agency) move exactly in this direction. EGNOS (European Geostationary Navigation Overlay Service)[51] for example is the European regional satellite-based augmentation system that is used to improve the performance of global navigation satellite systems (GNSSs), such as GPS and Galileo. The network created by EGNOS and Galileo combines space receivers with microchips and software available devices at disposals of everyone, such as mobile phones. Furthermore, with the EGNOS technology the quality of the services is improving on a yearly basis. As *Figure 3.8* displays[52], the global revenues generated by the GNSS downstream market directly linked to the technologies offered by Galileo and EGNOS increase year by year with a long term forecast of around 350 billion euros in 2031 (related to downstream added-values services).

[51] (ESA - European Space Agency, 2021)
[52] (EUSPA EO and GNSS, 2022)

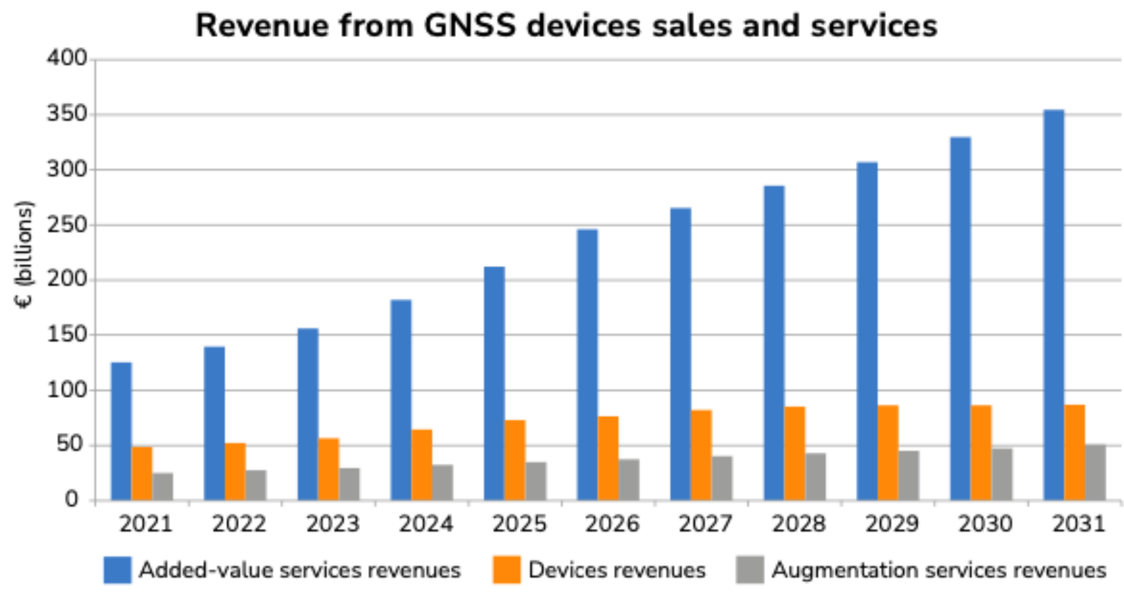

Figure 3.8 – Global revenues generated by the GNSS downstream market, divided by typology of source.

By specifically analyzing the subdivision and diversification of the annual economic returns of the GNSS and EGNOS sector, including both the actual revenues and the predicted revenues until 2031, the returns benefit different sectors such as (*Figure 3.9*):

- *Road & Automotive*, representing the 29,2% of the cumulative revenue
- *Consumer Solutions*, Tourism & Health, with a cumulative share of 61% of the cumulative revenue

Notice that these two sectors represent together almost the 90% of the total cumulated income.

- *Agriculture*, 3,8%
- *Urban Development and Cultural Heritage*, 2,9%
- *Rail & Aviation and Drones*, 0,9%

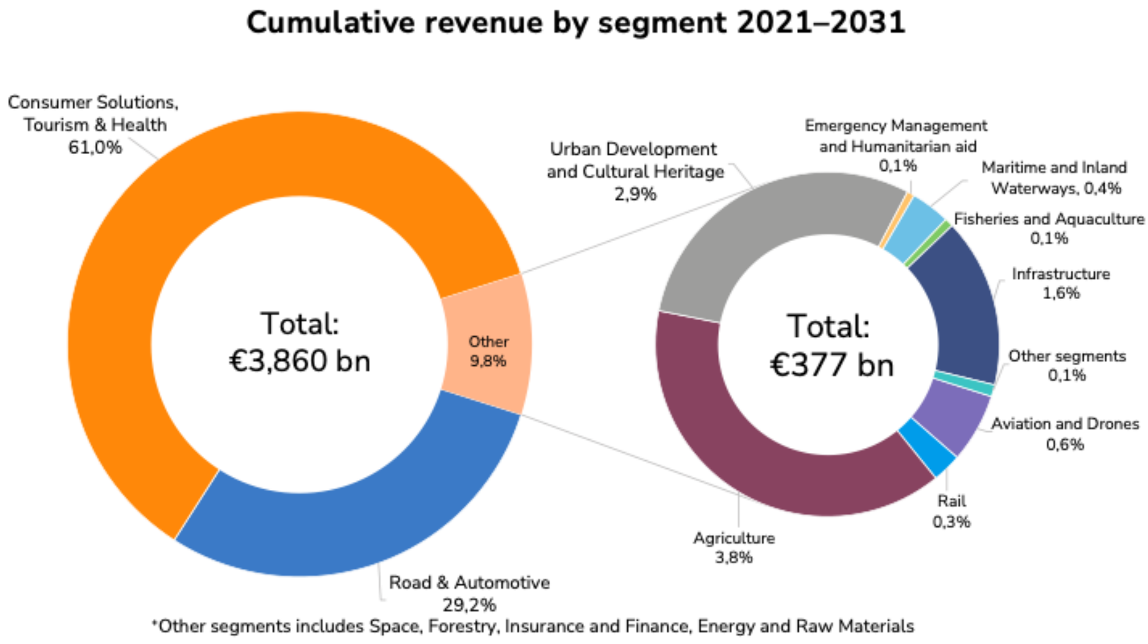

Figure 3.9 – Cumulative returns (2022-2031) of the GNSS sector divided by segment

In practice, the solutions offered by GNSS technologies include a broad spectrum of technologies and applications that we often find in everyday life. Some of these include *Internet of Things (IoT)* that through the development of the internet allows different devices (such as mobile phones, vehicles, buildings etc) to be interconnected between them. This solution strongly depends on the services offered by GNSS infrastructures (such as GPS) and offers different benefits especially for monitoring agriculture and logistics. Moreover, nowadays GNSS satellites are really useful when dealing with the uprising *Smart Cities*. For example, London was the first city to launch an operational control system capable of monitoring and managing more than 8000 buses via satellite: the result was a 20% reduction in traffic in one of the busiest cities in the world (with benefits also from an environmental point of view). Another example is provided by Barcelona, which through the strengthening of GNSS and EGNOS technologies has provided an efficient monitoring and efficiency service for electric scooter sharing. According to Messeni Petruzzelli & Maniello[53], there are many cities that are planning to invest in this type of applications in the coming years, with the aim of increasing the

[53] (Messeni Petruzzelli & Panniello, 2019)

efficiency of transport within the cities, creating a positive impact also to the surrounding environment.

Currently, one of the challenges that the space economy is facing is that of the sustainability of its economy. In fact, the space industry of the future, to be able to achieve some important objectives, such as the colonization of Mars and the Moon (which will be discussed in more detail in the next chapter, dealing directly with the objectives of the companies involved in this kind of investments), must be able both to guarantee a commercial spin-off on the Earth, and to be sustainable from an environmental point of view. Various companies and start-ups are moving in these two directions, studying and investing more and more in research for "*Space Mining*" and in the management of "*Space Waste*".

Space mining consists of exploiting mineral resources, such as water, niche, iron, platinum and many others present in asteroids in large quantities. This activity represents a fundamental passage to the colonization of the Solar System, as only after having begun to exploit the resources present within it, without depending solely on those present on earth, can we speak of real colonization.

That asteroids are rich in minerals is a certainty, but it is necessary to understand if the cost-benefits for their extraction are actually sustainable. The most relevant example when it comes to asteroids with a high metallic composition is the asteroid Psyche, discovered in 1852 by the Italian Annibale De Gasparis in an orbit between Mars and Jupiter and with an estimated value of about 10,000 quadrillion dollars (incomparable with the mineral value of the Earth amounting to about 74 trillion dollars)[54]. To study its surface and contents, NASA has defined the Psyche mission[55], with a probe that will depart from Earth at the end of 2022 and will arrive in the asteroid in 2026.

The feasibility of extracting the economic resources present within the asterioid, however, is closely linked primarily to the attraction of the asteroid to the Earth, without however generating risks for the planet itself and for other celestial bodies. Professor

[54] (Aimasso, 2021)
[55] (NASA, 2022)

Minghu Tan of the University of Glasgow is working on this important project. Secondly, given that finding useful materials in space is part of the plans of numerous private companies (including ConsenSys Space[56] and Deep Space Industries[57]), it is necessary to identify the high costs associated with the extraction, to then compare them to the economic returns and then understand the economic spin-off that this operation would have. The United States has already worked in this sense, introducing the Commercial Space Launch Competitiveness Act of 2015[58], legalizing the private trade of material coming from asteroids, thus lightening the bureaucratic burden of such operations.

NASA underlines how this type of research is fundamental not only for commercial purposes, but also to make human presence in space more convenient, thanks to the exploitation of resources such as platinum, palladium and rhodium, elements necessary for human survival and subsistence in space. and scarcely present, as well as expensive, in the Earth.

Future space exploration activities will benefit from the use of space resources, where available, to build, procure and safeguard scientific instruments. For example, future space stations (such as the new International Space Station, the Lunar Gateway[59], launching in 2024) and future space satellites and probes, would benefit from hydrogen used as rocket propellant or necessary oxygen to breathe, that came directly from space.

A second important consideration regarding the future perspectives on space innovations is the one regarding the so-called space debris: space pollution, junk, waste, trash and garbage. These include tones of rockets, spacecrafts, instruments and pollution generated by propellants that have been launched into space since the beginning of the space era in 1957.

According to the ESA the quantity of space debris is dramatically increasing in the last years (*Figure 3.10*)[60].

[56] (ConsenSys Space, 2022)
[57] (Deep Space Industries, 2022)
[58] (Congress of Unites States of America, 2015)
[59] (NASA, 2022)
[60] (ESA - European Space Agency, 2020)

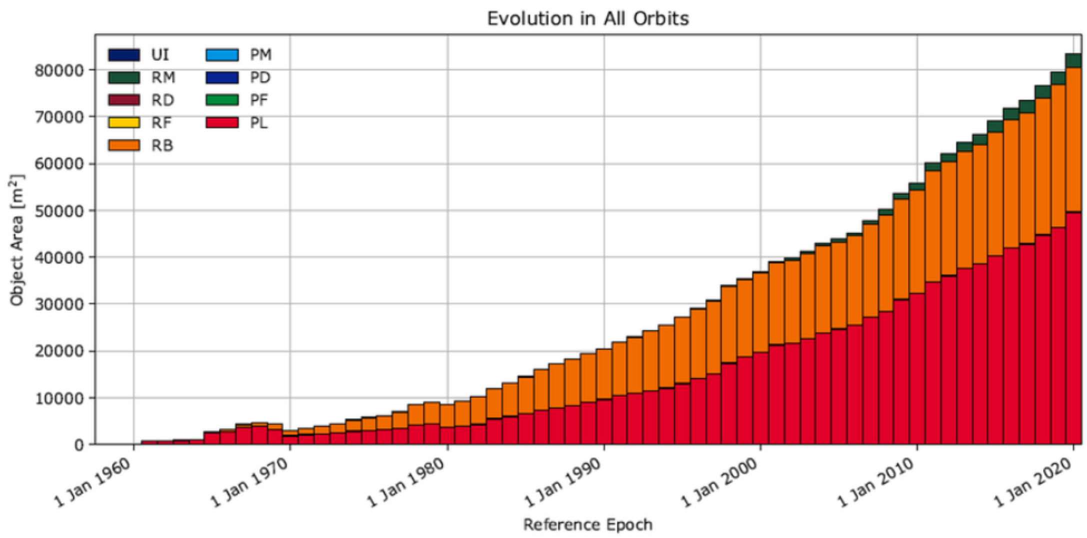

Figure 3.10 – Increasing area of objects in space (Red (PL) = Payload; Orange (RB) = Rocket Body; Dark Green (RM) = Rocket Mission Related Objects

Furthermore, the types of debris created is augmenting (*Figure 3.11*).

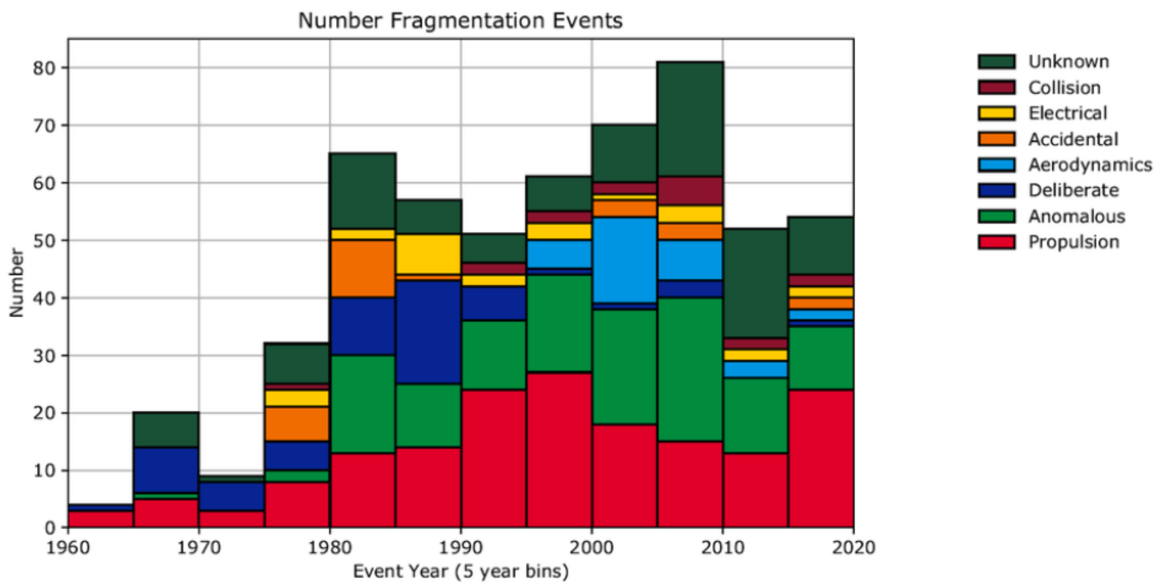

Figure 3.11 – Number of pieces of debris created for each type of "fragmentation event"

Since according to the data collected by ESA the quantity of space debris has dramatically increased in the last years, some international guidelines have been proposed, with more and more national agencies and companies trying to comply on them generating positive benefits, but still not enough to reach an equilibrium level. In this sense, it is important both the overall commitment of all these organizations and some manufacturing technologies that allows to reduce the quantity of waste, pollution and garbage generated during space launches. Falcon 9, the reusable rocket developed by Space X, is a startling example of a new technological device able to increase the performance of the previous technology, to decrease the costs of launch and to decrease the level of space debris created in every launch procedure. The reusable rocket in fact is able to take off from Earth land assisting the first part of the launch and then to land back on the Earth ground, saving all the rocket infrastructure (that thus would have been leaved in space, generating space debris). After going through all the safety checks and reloading, the rocket is able to reflight. Using this technology, until mid-2022 Space X has been able to carry out 174 launches with 134 successive successful landings and then to reuse the rockets for 113 reflights[61].

The ESA believes that space environment should be conceived as a shared and limited natural resource. The continue creation of space debris will lead to the Kessler syndrome: a situation when the density of objects in low Earth orbit is high enough that collisions between objects and debris create a cascade effects, with continue collusions that will make certain orbits around Earth entirely inhospitable. In this sense the ESA is working in a challenging mission to remove an amount of space debris from the Earth's orbit[62].

[61] (Space X, 2022)
[62] (ESA - European Space Agency, 2019)

4. Players in the Space Economy

The initial rivalry between the major countries in the space sector during the 50s had given way to a tight competition between countries and organizations. Starting from the last years of the 60s, the legislative framework that regulates and define the boundaries of the extra-atmospheric space exploration and exploitation remains the Outer Space Treaty, stipulated in 1967. The treaty governs the activities of States in the exploration and use of outer space, including the Moon and other celestial bodies[63]. In particular, the treaty defines that:

- the extra-atmospheric outer space is free to be explored by anyone and therefore any Nation or Country can prevent to another the legitimate access to it;

- the purposes behind space exploration must be pacific, that is to say non-aggressive and non-military;

- Governments are to be considered responsible both for the activity of their own organization into space and for the activity conducted by companies or private citizens into space.

Considering the increasing investments into the space economy and taking into consideration the commercial use of space outputs devoted to multiple use, it is important to specify that the existent international treaties do not support or prohibit the private exploitation of space resources. Thus, the Outer Space Treaty actually lacks a specific normative regarding the ownership of space resources (or, in other words, the property of utilization of these resources). At the moment this deficiency is partially compensated by the numerous agreements between the principal space agencies within the contracts and treaties stipulated between them.

[63] (United Nations Office for Outer Space Affairs, 2022)

Space thus represents a "borderless infrastructure" whose infinite potential is not yet clear to us. However, as discussed in the previous chapter, over the years an increasing number of space applications have proven their usefulness in different sectors. The Space Economy therefore proves to be one of the most attractive frontiers in terms of State investment, with a growing number of companies and countries investing in this ever-growing sector. Clearly, such a great market, that in the last decade has doubled its value[64], is made up of several actors which can be broadly divided into:

- *National & International Public Agencies*

- *Private companies*

Every day national space programs around the world continue to cover a wide range of technologies: from launchers to artificial satellites and activities in the space stations, from studies on astronomy and on Earth's events to telecommunication and navigation. Generally, the proponents of space programs are the national space agencies, that often collaborate and establish multilateral agreements of international cooperation. Moreover, partnership with private companies and investors are becoming more and more common in the space segment.

This chapter aims at describing the major characteristics of the two groups, investigating the contribution of each one in the overall Space Economy and the relationship existing between them. Moreover, some of the most successful national and international space public agencies, as well as some private companies are discussed, displaying their history, purposes and active projects.

[64] In fact, according to Messeni Petruzzelli et al. in 2017 the value reached by the space economy was of 383,51 billion dollars, more than two times the value recorded in 2005 that was of 175,65 billion dollars. Furthermore, in 2017, the 80% of the overall value of the space economy was the expression of commercial activities, while the remaining was the derived from the public spending budget distributed between the USA (slightly prevalent compared to other nations) and the rest of the world (Messeni Petruzzelli & Panniello, 2019).

4.1. National & International Public Agencies

4.1.1. NASA

The National Aeronautics and Space Administration, commonly known as NASA, is the US independent governmental agency. It was established in 1958 with the aim of researching and developing vehicles and activities for the exploration of space within and outside Earth's atmosphere. The organization is internally organized into four different divisions that clearly identify the purposes of the agency[65]:

- *Aeronautics Research*: dedicated to the development of advanced aviation technologies.

- *Science*: this department deals with different programs dedicated to the understanding of the origin, structure and evolution of the Universe, the Solar System and space in general.

- *Space Technology*: dedicated to the research and development of space science and exploration technologies.

- *Human Exploration and Operations*: this section concerns all the management of crewed space missions, including all the ISS's missions (International Space Station's missions). This department includes also all the operations related to space transportation, space communication with both crowded and robotic explorations programs and includes also all the activities related to space launch services.

[65] (The Editors of Encyclopaedia Britannica, 2022)

Moreover, NASA constantly collaborates with numerous additional research centers that contributes to the realization of joint projects.

Figure 4.1 displays NASA's space budget trends through the years and NASA's budget by program in 2017[66].

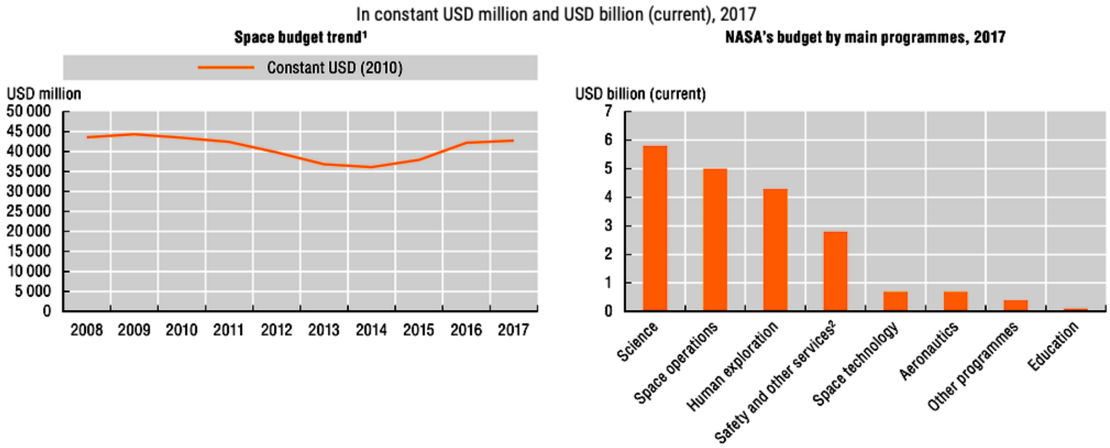

Figure 4.1 – NASA's space budget trend (from 2008 to 2017) and NASA's budget by main programmes (2017)

Starting from the 60s[67] and for the following 50 years, the US space agency defined the strategy for the exploration of the use of space and coordinated the structure of the space market characterized by a strong government contribution. The agency has an active role in the majority of the space missions worldwide: through the years NASA contributed in successful projects such as the first man landing on the Moon in 1969, that positioned the agency as the most advanced global organization in terms of competences and investments.

In the last years NASA has been working on multiple projects and space missions, some of them developed jointly with other international space agencies, such as the ESA, and a another major part with a strict collaboration of private companies such as Space X and Blue Origin. An example is *Artemis I*[68], the mission that aims at putting the first woman

[66] (OECD, 2019)
[67] In response to the creation of the URSS's first space programs.
[68] (NASA, 2022)

and next man on the Moon, with the major objective of establishing a long-term and sustained presence there and then proceed further establishing a connection with Mars.

This mission is the most important example of how the various actors operating in the space industry can collaborate with each other to achieve multiple common goals. In the Artemis I mission, managed precisely by NASA, the European collaboration (through ESA) is evident. The European Space Agency has in fact contributed to the mission by developing the "*Service Module*", that is the powerhouse that fuels and propels the spacecraft in space. It provides propulsion, thermal control, and electrical power generated by solar arrays. On missions with astronauts, the service module will also provide life support systems for the crew including water, oxygen, and nitrogen. Second, some private companies play a crucial role in the mission. Blue Origin and Space X separately developed two proposals presented to NASA in 2020 regarding the "*Human Landing System"*, the system that will be used to transport human beings, with attached devices to conduct scientific experiments on the Moon's surface. Blue Origin on its side presented the *Blue Moon*, a Lunar landing vehicle designed to provide reliable and cost-effective delivery of a wide variety of payloads to the lunar surface: the landing vehicle will be thus reusable. Blue Moon was also designed to be able to transport several tons of equipment on the Moon, including rovers and ascent rockets. The main objective of the vehicle will be that of facilitating science research, infrastructure development and logistics missions for government, academia, and commercial customers on the Moon's surface[69].

On the other hand, Space X, the actual winner of the call that will bring a human crew back to the Moon by 2024, has developed *Starship*, a Lunar landing vehicle born with a greater goal of bringing humans to the Moon. Starship represents a fully reusable transportation system designed to carry both crew and cargo to the Moon: it will be the world's most powerful launch vehicle ever developed, with the ability to carry in excess of 100 metric tons to Earth orbit[70].

[69] (Blue Origin, 2022)
[70] (Space X, 2022)

This type of collaborations are just one example of how national space agencies collaborate both with each other and with private entities, to achieve common goals including scientific research and the enormous commercial possibilities that a new and continuous lunar correspondence would bring. Space X and Blue Origin, as will be explained in the second part of this chapter, are pioneering companies in this and they already position themselves as industry leaders, collaborating on an ongoing basis with the various national and international space agencies.

According to NASA's 2020 "Economic Impact Study" of the agency[71], commissioned by the agency to monitor the spin-offs it creates during 2019 fiscal year. Both in monetary and social terms, NASA has generated great benefits for the United States during fiscal year 2019. From an investment of approximately $ 7 billion from Federal, State and local taxes, the agency has[72]:

- Generated more than $ 64,3 billion in total economic output;

- Supported more than 312,000 jobs nationwide.

This data make it clear how NASA, the space agency that pioneers the majority of the actual space achievements, compared to its direct competitors from other nations, operates in an economy that is capable of generating annual revenues ten times higher than the initial funds allocated. The data is just another example of the economic, technological but also social potential that the space industry currently represents.

The following section will deal with analyzing in detail the ESA, the European Space Agency. Although the agency was born after NASA and lives on the continuous support of the national agencies that compose it, the economic impact that the agency generates every year is very positive if we compare it to the contribution of the various countries. The ESA, while setting itself different objectives from those of NASA, is still among one of the most important governmental entities in the world and it is a fundamental players

[71] (The Nathalie P. Voorhees Center for Neighborhood and Community Improvement, University of Illinois at Chicago, 2020)

[72] The results displayed are that of greater impact defined in the report, which however develops and considers various application areas of NASA's investments and operations.

both in terms of internal initiative projects and in terms of supporting projects for external initiatives (as in the case of the Artemis I mission).

4.1.2. ESA & ASI

Given the size of their space projects, European countries have decided to coordinate their technological and financial resources to implement their space policy through the European Commission, in collaboration with the European Space Agency (ESA), an intergovernmental agency managed by 22 European countries[73]. The ESA budget in 2021 was approximately € 6.49 billion, divided into "*mandatory*" and "*optional*" activities (*Figures 4.2*). The "*mandatory*" activities include the agency's basic activities such as studies on future projects, technology research, shared technical investments, information systems and training programs. All Member States contribute to these programs on a scale based on their Gross National Product (GNP). On the other hand, "*optional*" activities and projects are at the discretion of each Member State, which freely decides if and at what level to contribute to the project. Optional programs cover areas such as Earth observation, telecommunications, satellite navigation and space transportation: as an example, the International Space Station and microgravity research are financed by optional contributions. *Figure 4.3* displays the division of the ESA 2021 budget divided by founding source.

[73] The 22 member states of ESA are: Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Norway, Netherlands, Poland, Portugal, Romania, United Kingdom, Czech Republic, Spain, Sweden and Hungary. Slovenia is an associate member while Canada only participates in some projects (ESA - European Space Agency, 2022).

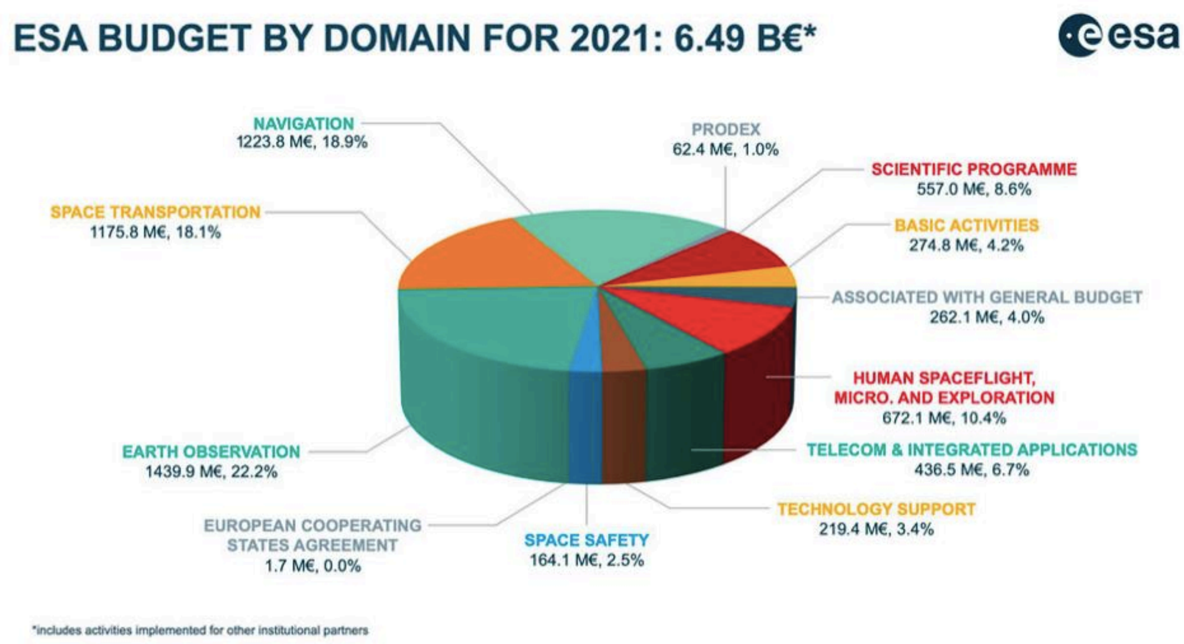

Figure 4.2 - ESA 2021 budget by activity

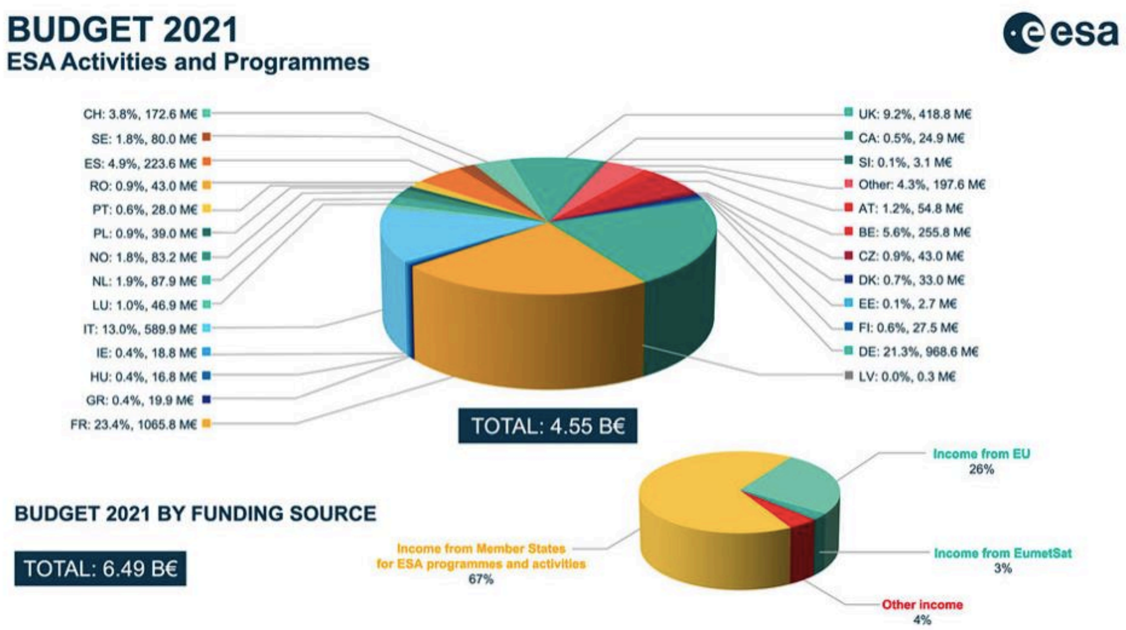

Figure 4.3 - ESA's Member States funding contribution in 2021

ESA's main commitment is to develop European space capabilities and to ensure that the investments made for the conquest of space continue to produce benefits and positive effects for all European citizens. For this reason, European space policy focuses mainly on four aspects: space exploration, space research, the Galileo/EGNOSS satellite program and the Copernicus Earth observation system.

The EGNOSS and Galileo programs fall within the GNSS technological systems discussed in the previous chapter. In particular, as previously highlighted, satellite positioning has become a fundamental element of our daily life and is also of essential importance for other economic sectors such as agriculture, transport, science and emergency services. Furthermore, among the main contemporary technological developments benefiting from GNSS services it is relevant to highlight: the internet of things (IoT), Big Data, augmented reality, smart cities and multimodal logistics[74].
Specifically, the two main programs (i.e. EGNOS and Galileo) differ in some respects from the US GPS system. The EGNOS system was in fact designed as an enhancement of the two satellite navigation systems already existent: the US GPS and the Russian GLONASS. In particular, the exchange of data between the EGNOSS satellites and the four European mission/control centers ensures that positioning accuracy is achieved at a much higher level than previous systems and with an update time of just 6 seconds. The modern and efficient EGNOSS satellite infrastructure, combined with that of Galileo (created mainly to make ESA independent from the bureaucratic and service cost applied by other international agencies as regards satellites and positioning systems) ensure that the modern and efficient infrastructure European satellite will continue to strengthen, keeping Europe at the center of a commercial revolution based on positioning products and services and creating different economic benefits in multiple sectors and numerous jobs within the European Union. Italy, particularly contributed to the projects by designing and creating some of the Galileo program's technologies and devices. Through the ASI (Italian Space Agency), various companies played a fundamental role in the project, involving private actors such as the Finmeccanica group (i.e. Leonardo SpA), through Telespazio and Thales Alenia Space.

Copernicus[75], also known as GMES (Global Monitoring for Environment and Security) is a complex satellite observation program of the Earth, launched in 1998 by the European

[74] (Messeni Petruzzelli & Panniello, 2019)
[75] (ESA - European Space Agency, 2022)

Commission with the collaboration of a pool of other space agencies. Its main objective is to guarantee Europe a substantial independence in the collection and management of data on the state of health of the planet, supporting the needs of European public policies through the provision of precise and reliable services on environmental and safety aspects. In particular, it is possible to distinguish into five main domains with relative and different applications that can directly benefit from the Copernicus satellites:

1. *Services for the maritime environment*
2. *Services for the terrestrial environment*
3. *Services for the atmosphere*
4. *Services for the management of emergency responses*
5. *Services for monitoring climate change*

The Copernicus program makes an enormous amount of information about our planet available to citizens, public and governmental authorities, scientists, entrepreneurs and businesses in a complete, open and free manner. Its services are based on information from a constellation of six types of dedicated satellites called *Sentinels*, with the support of numerous other infrastructures with related roles. The construction of the Sentinel satellites has been entrusted to some of the main European companies, including the company Thales Alenia Space[76]. The various applications of the Sentinel satellites include forecasts on air quality, hurricane warning, early detection of drought and desertification, monitoring of oil spills, food security and forest monitoring. Furthermore, the system will acquire an important importance also in the security sector: Copernicus will in fact guarantee the possibility of managing precise and updated data on the movement of refugees, on the need for logistical support to military missions, on assistance to humanitarian aid and on any threats of terrorist character.

From a financial point of view, it has been estimated that the Copernicus project can directly generate around 1.97 billion euros, while indirectly (in the downstream sector), the economic added value can reach much higher values, bringing various benefits to different economic sectors. For istance, it is estimated that in Finland and Sweden, using satellite radar images for navigation in the Baltic Sea, the annual economic value

[76] For the construction of Sentinel 1 and Sentinel 3. The company is part of the group headed by the Italian Leonardo SpA, which will be further discussed and analyzed in *Chapter 5*.

generated by this technology will be between 24 and 116 million euros. In Sweden, on the other hand (again with the aid of satellite radar images) there is already a substantial decrease in annual costs (approximately between 16.1 and 21.6 million euros) for forest management[77].

Among the national agencies that form ESA, there is also the ***Italian Space Agency (ASI)***. The ASI, born in 1988, is the Italian public entity that deals with spatial political management, in compliance with the guidelines issued by the Italian government[78]. In addition to the headquarter in Rome, the agency has various bases in the Italian territory (such as in Matera and Sardinia) and has one of strategic importance in Kenya. The Kenyan territory represents a strategic base for both ASI and ESA, being both a research point and an important data reception point, due to its position close to the equator. Over the years, this base has been used by numerous government and non-governmental space agencies to launch probes and satellites into space. Nowadays ASI ranks as one of the main national agencies in support of ESA and actively participates in both European and global projects, also supporting NASA for the realization of some projects, thanks to the skills acquired by Italian scientists and astronauts in time. In fact, ASI, in addition to be one of the promoters of the International Space Station and having actively participated in the design and construction of numerous components, has been and still is one of the agencies that "frequents" the ISS more frequently. It is no coincidence that Samantha Cristoforetti on 28th September 2022 became the first European woman at command of the International Space Station.

The ASI is part of the Italian space economy, whose value has been gradually growing in recent years. According to Messeni Petruzzelli and Paniello, in 2018 the space economy in Italy was worth a total of 1.6 billion euros, compared to a total public funding of around 920 million euros. Between 2014 and 2017 the level of employment in the Italian space sector grew by 3%, giving jobs to around 6,000 people in 2017. Among the main skills of the Italian space industry[79], there is the ability to build satellites which are then put into orbit with the collaboration of ESA and, thanks to receptors present in Kenya and Sardinia, the transmission of data and their exploitation for various industrial applications and

[77] (Messeni Petruzzelli & Panniello, 2019)
[78] (ASI - Italian Space Agency, 2022)
[79] Including both the ASI and the private companies active in the sector.

innovative technologies for the market. *Figure 4.4* displays the ASI's space budget trends through the years and the main programs in which the agency invested in 2017[80].

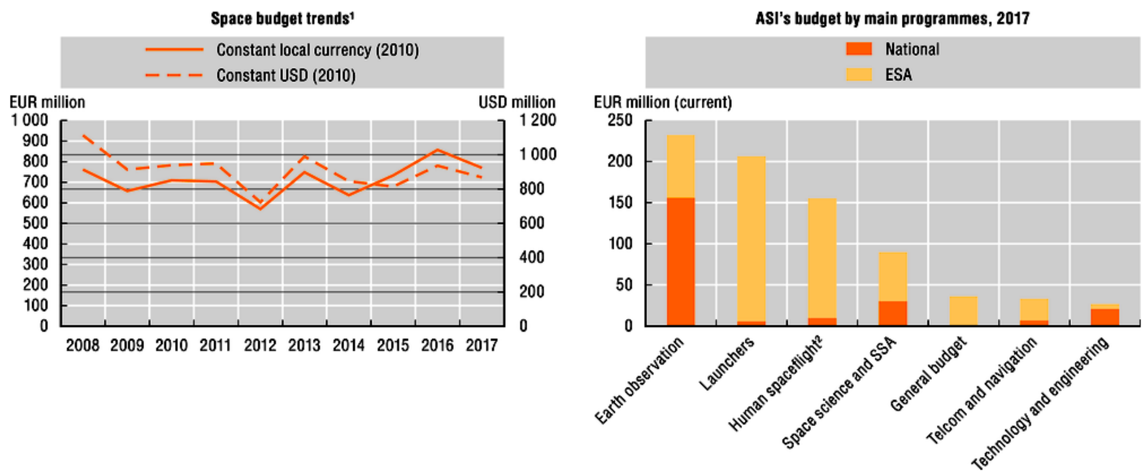

Figure 4.4 – ASI's space budget trends from 2008 to 2017 and budget for each main program in 2017

The *Strategic Vision Document*[81], published by ASI in 2016 encompasses all the major policy guidelines of the agency for the decade between 2016 and 2025. The report puts an increased emphasis on socio-economic returns of space activities and in particular on the development of its downstream activities. The Strategic Vision Document is divided into four strategic goal that can be summarized as follows:

1. ***Promote the development of services and applications for the Space Economy.*** According to ASI, the Italian space market is composed of around 250 companies (of which only 150 have space activities as their core business) that generate a total revenue of approximately 1,6 billion euros and that produce state-of-the-art technologies and devices especially devoted to space observation. The ASI believes that these activities should be the one that create major positive spin-offs in the downstream sector of the space economy. Furthermore, returns from the downstream sector generate from 4 to 5 times greater revenues compared to those of the upstream one. For these reasons the Italian Space Agency is planning to

[80] (OECD, 2019)
[81] (ASI - Italian Space Agency, 2016)

invest more on research and development of new technology that can create positive socio-economic benefits in the Italian Space Economy.

2. ***Promote the development and use of infrastructures for the Space Economy.*** The ASI believes that infrastructures represent a fundamental factor for the development of society, from both an economic and a social point of view. Infrastructures create a multiplying effect: their construction and operational management directly generate employment. The Copernicus program for istance, in collaboration with the ESA, is expected to generate alone around 20,000 new jobs in Europe. Furthermore, space infrastructures facilitate the emergence of an industrial and economic base around which other initiatives find fertile ground. This aspect is of fundamental importance to boost the agency's global presence in joint collaborations with foreign players.

3. ***Accelerate and support scientific and cultural progress (science diplomacy).*** The development of space devices such as artificial satellites made it possible to increase the number of missions capable of collecting and quantifying data. Furthermore, the ASI believes that: "The progress of scientific knowledge and scientific-technological development and its ability to respond to the great discovery and exploration challenges cannot, however, be separated from adequately spreading space "culture" among institutions and citizens, with initiatives capable of inspiring the dreams and ambitions of our future generations". For these reasons the agency is planning to invest more in the next years in initiatives of subjects such as astrophysics, solar system sciences, cosmology and Fundamental Physics and on research based on sciences on the International Space Station, such as biological sciences and the application of Medicine in the space environment.

4. ***Raise the country's international prestige (Space Diplomacy).*** With this goal the Italian Space Agency recognizes the unique and strategic opportunity of international relations to increase industrial activity in the national

space sector. All the cooperation activities, both in the context of the ESA and also in the relationships with the other national agencies, can be used to increase the wealth of the overall Italian space economic system, creating important benefits both for the space industry and also for all the other sectors connected to the space economy.

4.2. Private enterprises in the Space Industry

According to Andrea Sommariva[82], there are three phases that through the years defined the evolution of the space economy and they are all characterized by the increasing involvement of public and private actors in the economic scene[83]:

- *1950 – 1969*: the first phase was mainly defined by *governmental space programs*, that contributed to the development of space technologies becoming part of the global collective imagination. This phase was mainly pushed by the so call Rush to Space (described in *Chapter 2*) and culminated with the US landing on the Moon.

- *1970 – 2000*: the second phase was favored by the rapid growth in technology competences and by the digitalization of the industry that impacted both the production of space satellites and infrastructures and the availability of applications in different sectors, that facilitated the commercialization of space services through the years. That opened the way to a gradual entry of *private actors*. These inputs opened the way for the entry of private actors in the scene. Moreover, with the 1070 "Open Skies" policy, the United States allowed any qualified company to launch a communication satellite, encouraging the swift growth of private telecommunications and satellite broadcasting activities.

[82] Ex director of the SEE Lab (Space Economy Evolution Lab) at SDA Bocconi, a research lab created by the Bocconi University of Milan that supports organizations by expanding their wealth of knowledge and guiding them in the choice of new economic business platforms.
[83] (Sommariva, 2020)

- *2000 – now*: the third phase is recording an *increasing participation and contribution of private companies* in the space sector, the through their economical possibilities in term of investments are opening new research fields, mostly dedicated to commercial utilization of the services offered by the space.

In 2019 in fact, total revenues in the space economy reached the value of $ 424 billion. The contribution to this achievement was mainly given by private companies: two thirds of the turnover was created by commercial applications, while the remaining part was generated by institutional and military orders that still represented a significant share of the total profit (the remaining one third). Sommariva believes that two factors have favored this development[84]:

1) *Progress in artificial intelligence*: that boosted advanced activities such as satellite signals and data. By combining this with the introduction and advancements of small satellites, we obtain a network of industries that are able to reduce the costs of production of satellites and satellite services, while at the same time expanding the need and the demand for them. Today in fact, as previously discussed, a lot of daily activities of both individuals and companies depend on a service offered by one or more satellites (from the use of credit cards to navigation and observation services, from weather updates to the simple use of the internet).

2) Progress in spacecraft and space-access costs: significant progress has been made through the years in the design and development of cost-effective launch shuttles, some companies (SpaceX above all the others, as displayed in the previous chapter) are developing reusable rockets that can be used multiple times during the first stage of the launch[85]. As an example, NASA in the last decade moved all

[84] (Sommariva, 2020)
[85] Normally the rockets that give the initial thrust necessary to overcome Earth's atmosphere fell off after the first stage of the launch in the ocean as waste. These devices are really expensive to develop and they represented a huge cost for all companies specialized in launch systems. SpaceX has successfully developed a reusable rocket, that after the first stage of the launch comes back in the Earth's atmosphere and land in a determined place. This device reduces the cost of payload by more than 50%.

the launch management from a government-run process to a system which relies on different complementary private companies.

Thanks to these developments, many small and medium-sized companies, as well as educational and research institutions that possessed specific capabilities, have been provided with a competitive access to space and to the space industry. The entrance of all these companies in the industry favored the introduction of bigger capitals and of a more competitive environment. In addition, more and more application of different services had been implemented after the entrance of private companies in the scene. For what concerns the artificial satellites systems, for example, the application of the services offered expanded above the one of research and monitoring: access to satellite internet have been powered and expanded, logistic efficiency, natural resources management and precision agriculture have been optimized and above all, the implementation of all these technologies together expanded the stream of users of space applications, boosting again the whole industry. *Figure 4.5* summarizes some of the most important private companies engaged in space commercial activities, divided in sectors of interest[86].

[86] (Weinzierl, 2018)

Sector	Company (alphabetical by sector)	Year founded	Full-time equivalent workers (2016)[a]	Products/Services
Space access	Astrobotic	2008	11–50[b]	Transportation to the Moon
	Blue Origin	2000	875	Launch vehicles and engines, space tourism
	Boeing Aerospace	1978	2,800	Crewed LEO transportation
	Masten Space Systems	2004	11–50[b]	Suborbital launches of small payloads
	Orbital ATK	1982	12,700	Orbital launches of satellites and ISS cargo
	Sierra Nevada Corp.	1963	3,094	Cargo and crewed LEO transportation
	Space Adventures	1998	17	Crewed LEO, lunar transport, and tourism
	SpaceX	2002	5,420	Reusable launch vehicles, colonization
	Stratolaunch Systems	2011	501–1000[b]	Air-launched orbital launch services
	World View Enterprises	2012	11–50[b]	High-altitude private spaceflight balloons
	United Launch Alliance	2006	4,000	Orbital launch services
	Virgin Galactic	2004	200	Space tourism; rapid commercial flight
	XCOR Aerospace	1999	23	Suborbital launches, human spaceflight
Remote sensing	Iceye	2012	11–50[b]	Synthetic aperture radar remote sensing
	Planet (including Terra Bella)	2010	251–500[b]	Earth imaging and video, data provision
	Spire Global Inc.	2006	101–250[b]	Data gathering; Earth observation network
Satellite data access and analytics	Analytical Space	2016	10	Optical LEO comms network, full service
	Astroscale	2013	11–50	Space Debris Removal
	Bridgesat	2015	3	Optimal comms network, hardware
	Kepler Communications	2015	5	Internet communications to crafts in orbit
	Maxar	n/a	5,000+	Diversified: satellites, imaging, robotics
	OneWeb	2012	101–250[b]	Large-scale satellite constellation
	Oxford Space Systems	2013	11–50[b]	Deployable satellite structures
	Qwaltec	2001	58	Satellite and network operations
	Skywatch	2014	11–50[b]	Satellite data integration Earth observation
	Vector Space Systems	2016	11–50[b]	Micro satellite space vehicle
Habitats and space stations	Axiom	2015	11–50[b]	Commercial space station building off ISS
	Bigelow Aerospace	1999	135	Inflatable space habitats
	Ixion Initiative Team	2016	n/a	Commercial use of rocket upper stages
	Made In Space	2010	50	Additive manufacturing in space
	Nanoracks	2009	40	Payload transport, deployment hardware
	Space Tango	2014	5–10	Microgravity research platforms
Beyond low Earth orbit	Deep Space Industries	2012	11–50[b]	Asteroid mining
	Golden Spike	2010	11–50[b]	Human lunar expeditions
	Mars One	2011	11–50[b]	Mars colonization
	Moon Express	2010	51–100[b]	Moon exploration and mining
	Planetary Resources, Inc.	2010	11–50[b]	Asteroid mining

Figure 4.5 - Main private companies engaged in space commercial activities, divided in sectors of interest

"Space access" companies are focused on launching humans and devices into space; *"remote sensing"* companies provide images of the Earth and are closely related to *"satellite data access & analytics"* companies; the *"habitats & space stations"* companies plan to provide safe means for production, research and even tourism in LEO[87]; *"beyond*

[87] LEO: Low Earth Orbit

low Earth orbit" companies pursue goals ranging from the space manufacturing industry to asteroid mining and colonization of the Moon and of Mars[88].

In parallel, many international space agencies are planning of returning to the moon in the next years. Moreover, in the next 10-15 years, the use of space resources will be crucial for the success of expeditions to the Moon and to other planets: Moon and natural satellites can provide propellant (for in-orbit refueling) and multiple natural resources that many believes will be the next source of energy both for in the Earth activities and for orbital ones. For this reason, according to Sommariva, a new form of public-private partnership is rising.

The next part of this chapter aims at describing of how private companies operating in the sector contribute, cooperate and participate in the space economy, while trying at the same time to pursue their challenging objectives, that have an economic reasoning behind. For this reason, Space X and Blue Origin, two of the most famous private companies operating in the space sector and in particular in the "space access" segment[89], are taken into consideration.

4.2.1. Space X & Blue Origin

Space X has been founded in 2002 by Elon Musk and is one of the leader private companies in the aerospace sector. This company is regarded as one of the most important companies in the world operating in the space sector. The company's core business is to design, manufacture and launch advanced spacecraft. The technologies offered by Space X have been so revolutionary over the years that they aspire to a much greater goal: to allow humans to be able to live on other planets and, first of all, on Mars.

[88] Private research companies are not included in *Figure 4.5*.
[89] According to the definition provided in Figure 4.*5* by Weinzierl (Weinzierl, 2018).

Over the years, the company has been the bearer of several technological innovations, including the *Falcon 9* rocket[90], a reusable rocket that allows both to limit the amount of space debris emitted for each launch and to limit the total launch costs. Also thanks to this important innovation, over the years Space X has been able to offer a much lower launch cost than competing companies[91], winning numerous missions and contracts to support important international projects. The close relationship between Space X and NASA in fact allowed the company to win the contract for the transport of equipment and goods to the ISS92. To support this type of services, Space X is developing and testing Starship[93], the transporter rocket, built with the aim of transporting human crews and cargo into space. Starship rockets could therefore be used to transport objects such as satellites into orbit, without having to build a rocket specifically dedicated to launching it. In addition to the Falcon 9 reusable rocket, the US company was able to create the *Falcon Heavy*[94], the most powerful rocket ever built, also equipped with a reusable launcher, now a trademark of the company owned by Elon Musk.

As for the satellite business, the company is very active with the *Starlink* project[95], which aims to create a network of satellites in low orbit around the earth[96] to provide a stable, fast and accessible anywhere on the Earth surface internet connection[97]. This type of technology was and is still used by Musk to provide a free and stable internet connection to the Ukrainian people during the conflict that arose at the end of February 2022, after the invasion of Ukrainian territory by the Russian army.

Among the various missions, however, the main objective of Musk and Space X is to bring man permanently to Mars and into space, creating human colonies outside the Earth's atmosphere and using the Moon as a transit port between Earth and Mars. The

---

[90] (Space X, 2022)
[91] (Stiennon , 2018)
[92] The "Commercial Orbital Transportation Services" (COTS) stipulated in 2003 and the "Commercial Cargo Resupply Services" (CRS) stipulated in 2018 are two commercial contracts signed between NASA and several private companies, including Space X, which respectively provide for the transportation of crews and goods on the International Space Station.
[93] (Space X, 2022)
[94] (Space X, 2022)
[95] (Space X, 2022)
[96] LEO Orbit: Low Earth Orbit
[97] Placed at a distance of about 550 km, which would therefore guarantee a faster response and communication with the earth by about 70 times compared to satellites currently orbiting in geostationary orbit and therefore about 35,000 km from the earth's surface.

challenging goal still remains far from being achieved, even if the company has planned some expeditions starting from 2023 and 2024. Despite this, according to Messeni Petruzzelli & Panniello[98], the achievement of this goal could open a new chapter of the space economy, with economic returns and opportunities for investment, research and exploration never seen before.

If on the one hand Musk with Space X primarily aims at space launchers and at the space transport industry, with the great goal of colonizing Mars, on the other Jeff Bezos with his Blue Origin argues that the primary objective of space colonization should be aimed at the Earth's main satellite, the Moon. The main objective of Blue Origin therefore is to return to the Moon to establish a continuous access to the Lunar surface and to its resources. The company founded by Jeff Bezos, the founder of Amazon, in 2000 is also one of the most important private leaders in space transport, both of goods and humans and like Space X it bases its success in access to space on the reusability of its rockets: the company in fact declares that it can reuse its rocket up to 25 times, significantly reducing the cost of launching, building and recharging the rockets, and making space flights more and more accessible to many more companies and individuals[99]. In addition to the reusability of its launchers and rockets, the company aims to make the space accessible to as many people as possible.

The primary goal of Blue Origin, as explained above, is to create an ongoing connection with the Moon, for both research and commercial purposes. With the aim of creating a new "*race to the Moon*", Blue Origin designed the *Blue Moon probe*, taking advantage of the collaborations established with companies such as Airbus and ESA[100]. This probe is initially dedicated to launching artificial satellites for space exploration. In the last years however, Blue Moon is getting closer and closer to the probe designed to transport a human crew to the Moon.

Since 2021, with the first mission successfully completed, Blue Origin has become the first company to have opened its doors to space tourism. In fact, on July 20, 2021, the US company successfully transported several tourists (non-astronauts) into space crossing

[98] (Messeni Petruzzelli & Panniello, 2019)
[99] (Blue Origin, 2022)
[100] (Blue Origin, 2022)

the Kàrmàn line (by covention the line that starts the space, located 100 km above ground level). After a year, the company completed another 5 missions of this type via the *New Shepard* rocket[101], for a total of 6 missions successfully completed after about a year.

This type of mission represents a revolutionary turning point for the space industry which definitively expands also in the tourism sector. At the moment, thanks to Blue Origin, only a few wealthy people have the ability to afford a ticket to space, but the technologies developed by the company are expected to improve year after year, reaching ever greater goals and making space more accessible for many more individuals.

---

[101] (Blue Origin, 2022)

5. The Italian situation: a financial review of Leonardo SpA, the Italian aerospace giant

This analysis on Leonardo SpA (LDOF)[102] from the FTSE MIB (FTSEMIB)[103] has been focused on the last five years of operations of the company, from the beginning of March 2017 to the end of February 2022. The analysis has been divided into four main parts:

1. The first part makes an overview of the company by describing its history and the principal milestones that Leonardo SpA achieved during the years. Moreover, the description of the company reviews and explains the main divisions present within the organization, touching the main sectors, technologies and solutions that Leonardo SpA offers to the global market;

2. The second part is a risk portfolio analysis that aims at comparing the return of the company to the return of the market, trying to understand the percentage of risk of the stock that can be attributed to the market and the percentage of it that is strictly connected to the company's operations. Furthermore, the Jensen's Alpha of the stock has been calculated as an indicator of the overall performance of the stock;

3. The third part analyses the capital structure of the company, examining the impact of equity and debt in terms of costs and in terms of specific weights within the company by estimating its capital structure. Afterwards, the results are combined for computing the Weighted Average Cost of Capital of Leonardo SpA;

4. The fourth part reports on what the pay-out policy of the company has been in the past three years of operations, critically analyzing the policy adopted by the company through the years.

[102] (Investing.com, 2022)
[103] (Investing.com, 2022)

Finally, giving the outcomes of the analyses, some conclusions on the overall performance of the company in the last years of operations are drawn.

For all the analyzes performed, data from the Integrated Financial Statements approved by the Board of Directors of Leonardo SpA during the years 2019, 2020, 2021 have been used. The decision to use the consolidated financial statements rather than the separate financial statements is justified by the fact that the space branch within the company is only one of the sectors in which the company carries out numerous activities, as displayed in the next paragraph. Given the impossibility of separating the data coming and generated only by the space branch, it has been decided to use the consolidated financial statements as the main source of data as it represents the most suitable source to fully represent the performance of the entire company in the last three years.

The main objective of the analysis is to investigate the paradigm highlighted in the previous chapters: private companies operating in the space industry are growing and are forming a new commercial sector (the New Space Economy) which, in addition to having large prospects for the future, it is already generating profits for investors currently investing in this sector. The analysis of the risk profile, of the capital structure and of the dividend policy try to answer this question from the point of view of the investor who tries to understand the actual level of health of the company under consideration. To do this, the last three years of activity (i.e. 2019, 2020, 2021), which were crossed by a pandemic, were consciously considered. The trend was certainly influenced by these events which, however, did not change the performance of a sector that nowadays is consolidated in the global economy.

5.1. Leonardo SpA

Figure 5.1 – Leonardo SpA's logo

Leonardo SpA was officially founded on 18 March 1948 under the name Finmeccanica - Società per Azioni[104]. Despite this, the company has industrial roots much older, since some of the companies that joined the group have origins dating back the beginning of '900. Thanks to the profound artisan tradition of the companies that compose the group, Finmeccanica distinguished itself from the first moment for the major ability and knowledge in different business fields. The aim under the formation of Finmeccanica was the one of support and relaunch a large number of companies that growth in size, scope and tasks during World War II, but whose business was not sustainable anymore during the second post-war Reconstruction years. Some of the major players under Finmeccanica, including Alfa Romeo, Ansaldo, Salmoiraghi and OTO Melara, were industrial brands with an important tradition and that would have remained successful brands over the following 50 years and beyond.

With more than 70% of employees coming from the shipbuilding industry, during the first decade of activity Finmeccanica focused mostly on the restructuring of shipbuilding. In 1959 the shipbuilding part of the company has been hived off and annexed to Fincantieri, a new company entirely dedicated to the shipbuilding industry.

104 (Leonardo SpA, 2018)

During the 1960s, the Group concentrated on sectors with a high emphasis on technology, undergoing an in-depth renewal of its scope of activities. In addition to managing the existing businesses, it began to create new ones, such as Selenia, which was established in 1960 to operate in the radar sector. This is a symptom, from the early years, of Finmeccanica's attention to innovation and, in particular, the emerging electronics field.

At the end of the '60, after separating the companies based on the mechanical and electronics industry, Finmeccanica started focusing on the automotive, thermoelectric and aerospace sector. In fact, in 1969, in a joint venture with FIAT, Finmeccanica initiated an ambitious project: create a large company with a major international role in the aeronautics and space sector. The joint venture gave birth to Aeritalia: a company born to bring together the best skills of both the two participants in the sector, soon becoming a strategic company for Italy and one of the most competitive in the world in terms of innovation and research. Furthermore, alliances with international companies during the years allowed Aeritalia to reach one of the highest level of technological know-how in the period.

During the 1973 energy crisis Finmeccanica took advantage of the period of recession that affected the world economy to redefine its strategic objectives, with a progressive focus on high-tech sectors: until the 1987 Finmeccanica sold several companies belonging to the group, redefining its boundaries and focusing more and more on the electromechanical and aerospace sector[105]. Alongside, the ownership of Aeritalia entirely passed in Finmeccanica's hand after the exiting of FIAT in 1976.

Thanks to the redefinition of its autonomous industrial capabilities Aeritalia moved from being a supplier for major companies to be one of the partners in the numerous qualifying programs and international initiatives, such as the creation of the ATR consortium[106] in 1981 for the production of regional aircrafts, which would become one of Finmeccanica Group's major aeronautical successes. In 1989 Finmeccanica to leverage the group common technological base, re-integrated some of the electronics companies that had been unbounded. This operation allowed the Finmeccanica Group to enlarge its

[105] As an example, as part of this redefinition framework, in 1986 the company sold Alfa Romeo to FIAT.
[106] The ATR consortium has been formed in 1981 by a joint venture between Aeritalia and the French company Aérospatiale, nowadays known under the name "Airbus".

electronics and system capabilities that could have been in service of the Aeritalia operations and projects. This period of redefinition of Finmeccanica Group's network ended with the creation of Alenia in 1990 (born from the merger of Aeritalia and the previously cited Selenia). At the time, the whole network encompassed a large industrial pool, with companies operating in aeronautics, space, electronic systems, radar, telecommunications, missiles and air traffic control.

The shifts in the internal composition proved to be a key advantage for the Finmeccanica Group also at the beginning 1990s, with the liberalization of the markets and the increasingly tight global competition. Between 1994 and 1996 Finmeccanica exploited the liquidation of some important companies such as Augusta (helicopters), Galileo (electro-optical systems) and other operating in the defense sector: from then on, 70% of Italy's national industrial capacity for aerospace would have been concentrated in the Finmeccanica Group.

Thanks to the strength achieved within Italy, Finmeccanica also started a policy of agreements and acquisition at the international level, seizing the best opportunities offered by the restructuring of the European aerospace industry and following its plan for reorganization and development designed in those years. In fact, in 2005 with the Eurosystem agreement Finmeccanica acquired some British assets in the avionics, military and secure communications and air traffic control sectors by creating the SELEX family[107]. Moreover, Finmeccanica managed to conquer its position as an European leader in the space sector thanks to two joint venture created in 2007: Telespazio[108] (engaged in satellites services) and Thales Alenia Space[109](space manufacturing). By the beginning of the new decade, Finmeccanica had acquired a solid international profile, with four domestic markets: Italy, United Kingdom, United States (thanks to the acquisition of DRS Technologies in 2008, a major Pentagon Supplier) and Poland (thanks to the acquisition of PZL- Świdnik in 2010, a Polish company who produced helicopters). Besides, the

[107] (Leonardo SpA, 2022)

[108] It is the branch of Finmeccanica Group dedicated to satellites services (Leonardo SpA, 2022).

[109] Created in 2007 by a joint venture between Thales Alenia Space (67% of the ownership) and the Finmeccanica Group (33% of the ownership), the company is committed in space manufacturing. The collaboration between the two companies started in 2004 with the COSMO-SkyMed project, an all-Italian double-satellite system with radars dedicated to Earth observation. After more than 15 years of operation, the joint venture Thales Alenia Space is still considered as one of the European leaders in the sector (Leonardo SpA, 2022).

company consolidated partnerships worldwide, progressively concentrating on its core business of Aerospace, Defence and Security. Particularly, in the space sector Finmeccanica operated along multiple part of the value chain, with presence in some of the most important international space programs and by exploiting the complementarity competences of it joint ventures Telespazio and Thales Alenia Space.

Due to the 2009 global financial crisis the company suffered a period of recession that affected all the traditional aerospace and defence markets and accentuated the global competitive pressure of the sector. For this reason, in order to defend its shareholders and to recover profitability, Finmeccanica both started new partnership in emerging markets and disinvest in some sectors such as the transportation one (with Ansaldo Trasporti) and the energetic one (with Ansaldo Energia).

The transition process culminated, at the beginning of 2016, with the transformation of the Finmeccanica Group into one company, an evolution dictated by the need of a more agile, integrated structure able to address global markets with one voice, exploiting the synergies between various business sectors. The activities of its wholly owned companies converged into seven divisions, coordinated by a Corporate Centre that also presided over the subsidiaries left outside the divisional perimeter. The final step occurred on April 26, 2016 when Finmeccanica became Leonardo: a name chosen in honor of Leonardo da Vinci[110].

Today Leonardo is turning 74 but its story begins long before 1948 since many of the companies that, over time, have merged with the Group, sometimes changing their names and business sectors, have origins that date back to well before World War II. Some even go back to the 19th century. The space division, the most "modern" field compared to the others in the company, was founded in 1916 with FIAT – Società Italiana Aviazione and started the first experiments on rockets and space flights in early 1940s.

[110] The Finmeccanica Group wanted a name (i.e. Leonardo) that represents creativity and innovation, but that creates an ideal bridge between the historical, cultural and scientific tradition of the founders companies from which the Group originated and the technological innovation towards which it is projected.

Nowadays Leonardo SpA extends its operations in different sectors such as[111]:

- ***Electronics***: with technological solutions devoted to earth, air, water and space vehicles. The principal solutions include commands and controls of the vehicles, radars, communications systems, air traffic management systems and defence systems;

- ***Helicopters***: with the cutting-edge technology developed during the multiple decades of experience in the sector, Leonardo SpA offers helicopters' solutions for both the defence/military sector, the civil and the parapublic sectors;

- ***Aircrafts***: after more than 100 years of history in the sector, Leonardo SpA produces latest generation aircrafts, responding to the needs of the most complex operational scenarios, from defence and surveillance, to training and humanitarian support. Through the years Leonardo SpA trained more than 20,000 pilots and produced, delivered and provide technical support to more than 30,000 aircrafts in all the world. At the moment the company is providing support for more than 1,500 aircrafts distributed in around 50 sites all over the world;

- ***Aerostructures***: As a partner of the world's leading manufacturers of commercial aircraft, Leonardo is specialized in the production and assembly of metal structural components for commercial and defense aircraft, helicopters and unmanned aircraft. Furthermore, Leonardo SpA participates in the most important programs in the sector such as the Boeing 787 Dreamliner and the Airbus A220;

- ***Unmanned systems***: Leonardo SpA unmanned systems are mainly used for the so called ISTAR applications (Intelligence, Surveillance, Target Acquisition, Reconnaissance). This systems integrates radars, electro-optical sensors and earth-based control sites in order to offer solutions for managing aircrafts and drone traffic, for protecting the security of airports and critical infrastructures from incursions. This technology includes 50 remote driving devices and more

[111] All the information of the following bullet points come from Leonardo SpA's official website (Leonardo SpA, 2022)

than 200 unmanned vehicles operating in more than 27 countries around the world. Furthermore, the company is committed for the development of the Skydweller, the first ever fully solar powered drone with unlimited autonomy;

- ***Cyber & security***: Leonardo SpA's cyber security department guarantees the secutity of digital ecosystems by protecting institutions, organizations and private citizens (around 100,000 users and 7,000 cyber-networks) in more than 50 countries in the world;

- ***Automation***: Leonardo SpA's automation is one of the main players in the world that offers integrated solutions for the management, sorting and tracking of all types of baggage, parcel and postal items, trying to serve the growing and challenging needs of airport, couriers and postal operators;

- ***Space***: the objective of Leonardo SpA in the space sector is the one of approaching Space to Earth for the benefit of citizens, institutions and companies.

Nowadays the company is covering the entire value chain of the space industry, from the manufacture of satellites and orbiting infrastructure to the production of high-tech equipment and sensors, through the management of satellite services to propulsion and launch systems. As previously displayed, these competences, acquired after over 60 years of experience in the sector, had been consolidated also through the strategic partnership between Leonardo SpA and Thales for the Space Alliance and the industrial participation of Leonardo SpA in Avio[112]. In fact, Space Alliance, born in 2005, is a strategic partnership between Leonardo SpA and Thales that includes two joint ventures: Telespazio[113] and Thales Alenia Space[114]. These two joint ventures were born with the specific intent of

[112] Avio is an Italian company leader in the space propulsion sector (Avio SpA, 2022). The company offers solution for launching institutional, governmental and commercial payloads into space. Avio had been part of the Finmeccanica Group for years and since 2017, Leonardo SpA is progressively extending its stake into the company. Avio's space propulsor are developed and built in collaboration with the most important companies and institutions such as the European Space Agency (Avio SpA, 2022).
[113] Leonardo SpA 67% - Thales 33%
[114] Thales 67% - Leonardo SpA 33%

combining the complementary competences of the two companies: Thales Alenia Space for satellite systems and Telespazio for all the services linked to satellites[115].

The solutions offered by Leonardo SpA's space branch range from:

- Satellite services of Telespazio such as Earth observation and monitoring (geoinformation from space), communication between space and Earth, Earth-based systems, sites and technologies dedicated to the control and monitoring of satellites in the space, navigation systems for satellites and for tracking and localize manned and unmanned devices, railways, ships and commercial transports all over the globe through the use of GNSS (Global Navigation Satellite System)[116];

- Infrastructures of Thales Alenia Space that develop and produces avant-garde satellites (equipped with cutting-edge technology), interplanetary probes and rovers dedicated to space exploration, orbiters (in fact, Thales Alenia Space produced more than the 50% of the orbiters that compose the International Space Station and will produce the orbiters of the future commercial orbiting station)[117];

- Tools and equipment. Leonardo SpA offers several solutions with space applications such as solar panels, atomic clocks, micro propulsors and robotic drills.

The following part will focus on analyzing Leonardo SpA's financial situation by analyzing its risk profile, its capital and debt structure and its payout policy.

[115] (Leonardo SpA, 2022)
[116] (Leonardo SpA, 2022)
[117] (Leonardo SpA, 2022)

5.2. Risk Profile

The purpose of this part is to evaluate the *risk profile* for the company. The intention is thus to investigate how *systematic risk factors*[118] are considered in the company by examining the sources of risk in order to evaluate its overall risk profile.

Specifically, by determining the risk profile of Leonardo SpA, the analysis wants to determine:

1. The *returns of the company*, calculated using the CAPM and through a regression analysis.

2. The *R squared*, that in finance can be defined as the amount of variability of a portfolio that is explained by the market. The R squared, in statistics defined as the *coefficient of determination*, assesses the "goodness-of-fit", that is to say the proportion of the variance of a dependendent variable (in our case, Leonardo SpA's stock option) that is explained by an independent one (in our case, the market). According to Cavezzali & Rigoni, the R squared can be also defined as the variance of a portfolio, and it must be distinguished from the correlation of two variables (i.e. the stock option analyzed and the market) that instead represents the strength of the relationship between these two variables[119].

3. *1 – R squared*. This, on the other side represents the proportion of variability of the portfolio that is explained by firm-specific factors.

---

[118] *Systematic risk*: it is the risk related to entire market or segment in which a company operates. This risk affects the overall market and not just a particular stock or industry. This type of risk is particularly unpredictable and difficult to avoid and it is difficult to mitigate it by investors, also when investments are highly diversified. In general, it reflects the impact of economic, geopolitical and financial factors or events of the whole economy (Chen, 2022). It is important to distinguish this type of risk to the systemic risk, that is the risk related to a single event at the company level and that could trigger severe instability or collapse an entire industry or economy (Nguyen, 2021).

[119] (Cavezzali & Rigoni, 2020)

4. The monthly and annualized *Jensen's Alpha*: this measure, adjusted for risk, provides a measure of whether an asset outperformed or underperformed the market during the period analyzed in the regression[120].

Table 5.2 displays the main information regarding Leonardo SpA's stock[121].

Name	Leonardo SpA
Acronym	LDOF
Market	Borsa Italiana - Milan Stock Exchange
Type	Equity
Industry	Aerospace & defense
Sector	Industrials

Table 5.2 - LDOF's main stock information

The first step for evaluating the risk profile of Leonardo SpA (LDOF) is to define its *R squared*, which can be estimated by firstly computing a regression analysis on the returns of the company in function of the returns of the market.

The returns of a security can be calculated using the Capital Asset Pricing Model (CAPM), as the following formula displays:

$$\boldsymbol{R_i = R_f + \beta * (Rm - R_f)} \quad (^{122})$$

[120] (Damodaran, 2011)
[121] Source: (Investing.com, 2022)
[122] (Cavezzali & Rigoni, 2020)

According to Damodaran[123], the CAPM equation can be rewritten in terms of raw returns, that are the returns not adjusted by the risk-free rate (meaning that the returns associated to the risk-free rate are not subtracted to the overall return of the stock. In this case, in fact the overall returns (i.e. raw returns) are calculated. Raw returns are thus expressed as:

$$\boldsymbol{R_i = R_f * (1 - \beta) + (\beta * Rm)}$$

Considering the return of the stock (R_i) and the return of the market (Rm) as the two variables of the equation, according to the CAPM theory the slope of the formula (β) measures the slope of the regression line and the riskiness of the stock. By rewriting the formula, in this case the intercept ($R_f * (1 - \beta)$) assumes a slightly different meaning compared to the one of the CAPM formula[124]. This isolated part of the formula is defined as the *Jensen's Alpha* of a stock (α or a) and measures weather the stock did better or worse than what expected by the CAPM regression determination (at least during the period of the regression). In order to evaluate the Jensen's Alpha, the "real" intercept (α) has to be compared to the "predicted" intercept ($R_f * (1 - \beta)$) that is the one predicted by the regression during the CAPM evaluation[125].

In order to evaluate the Jensen's Alpha, if:

- $\boldsymbol{\alpha > R_f * (1 - \beta)}$ then stock did better than expected during the regression period;
- $\boldsymbol{\alpha = R_f * (1 - \beta)}$ then stock did as well as expected during the regression period;

[123] Aswath Damodaran is a professor of Corporate Finance at the Stern School of Business at New York City University. He is known as an expertise of corporate finance valuation (Damodaran, 2022).
[124] In the CAPM formula, the intercept ($\boldsymbol{R_f}$) is represented only by the risk-free rate, meaning that the return of a stock is "at least" affected by the risk of the market, and cannot be less than the value of the risk-free rate.
[125] (Damodaran, 2011)

- $\boldsymbol{\alpha} < \boldsymbol{R_f} * (\mathbf{1} - \boldsymbol{\beta})$ then stock did worse than expected during the regression period;

The calculation of the Jensen's Alpha for Leonardo SpA will be performed in the second part of this paragraph.

For the sake of the analysis, since both the values of the intercept and of the slope are computed by the linear regression analysis, we can rewrite again the formula as:

$$\boldsymbol{R_i} = \boldsymbol{a} + (\boldsymbol{\beta} * \boldsymbol{Rm})$$

where "$\boldsymbol{R_i}$" represents the expected returns of Leonardo SpA, "$\boldsymbol{Rm}$" the returns of the market, "$\boldsymbol{a}$" the intercept of the regression curve and "$\boldsymbol{b}$" the slope of the curve.

"$\boldsymbol{b}$", as displayed in the previous formulas, can also be defined as the *beta* (β) of the stock and represents the volatility of a security compared to the one of the market[126]. The coefficient beta, in this analysis calculated through the regression analysis in the following part, in the CAPM represents and describes the relationship between the expected return of a stock and the systematic risk given by the market: it can be used by investors to estimate how much risk the selected security adds to the overall risk of the market (i.e. equal to 1).

For the purpose of this analysis, a good representation of the market is the FTSE MIB index. The Italian index is the primary benchmark index for the Italian equity market and it encompasses approximately the 80% of Italian domestic market capitalization. It includes and measures the performance of the most representative 40 companies in terms of capitalization traded in the Borsa Italiana (BIt), located in Milan. The FTSE MIB

[126] (Kenton, et al., 2022)

index seeks to reproduce the major sector weights of the Italian stock market[127] and it includes the stock of Leonardo SpA. *Table 5.3* summarizes the main information of the FTSE MIB (FTSEMIB) index:

Name	FTSE MIB
Acronym	FTSEMIB
Market	Borsa Italiana - Milan Stock Exchange
Type	Index

Table 5.3 – FTSEMIB's main information

To evaluate the risk profile of the company and examine the sources of risk, the following steps has been carried out (see "*APPENDIX A*" for all the calculations).

- *Step 1*: the data of 5 years of monthly-adjusted closing prices for the firm and the FTSE MIB index has been extracted from Investing.com. The exact time range of the data was thus from the 28th of February 2017 to the 28th of February 2022[128].

The monthly-adjusted closing prices for both LDOF's stock and FTSEMIB's index have been calculated using the expected returns formula[129]:

$$\boldsymbol{Return = \frac{Price\ at\ time\ t}{Price\ at\ time\ (t-1)} - 1} \qquad ([130])$$

[127] (Borsa Italiana, 2022)
[128] Using information provided by the financial website: www.investing.com
[129] In this case, Investing.com already computes the adjusted closing prices for the time-range indicated, filtered by month. Nonetheless, the logic behind the automatic calculations of the website remains the same as the ones of the formula for the calculation of the return of a stock.
[130] (Moles, et al., 2011)

- *Step 2*: using the monthly returns, a regression analysis has been conducted on the data collected for Leonardo SpA's returns against the ones of the FTSE MIB index.

The objective of the regression analysis is that of estimating the two unknowns of the previous equation (the intercept "$\boldsymbol{a}$" and the slope "$\boldsymbol{b}$"); furthermore, the regression analysis also estimates the value of the R squared (the results of the regression analysis are presented in *APPENDIX A*).

$$\boldsymbol{R_i} = \boldsymbol{a} + (\ \boldsymbol{b} * \boldsymbol{Rm}\ )$$

$$\boldsymbol{Returns\_LDOF} \quad = \boldsymbol{-0,009851696} + \boldsymbol{1,356057422} * \boldsymbol{Returns\_FTSEMIB}$$

The beta of a stock can be evaluated in the following way[131]:

- **β >1** then it is expected that volatility of stock will be more than the one of the market.
- **β < 1** then it is expected that volatility of stock will be less than the one of the market.
- **β =1** it is expected that volatility of stock will move with the market.

Since Leonardo SpA's beta is ≈ 1,36 it can be assumed that its volatility is higher than the one of the market, that is FTSE MIB. Moreover, this analysis of the beta is only based on the historical data on the market prices of the company.

[131] (Damodaran, 2011)

Table 5.4 displays the R squared and (1 – R squared) estimated by the regression.

	R^2	$1 - R^2$
Leonardo SpA	44,99 %	55,01 %

Table 5.4 – R squared and (1 – R squared) regression results

This estimation of the R squared suggests that the 44,99% of the risk of Leonardo SpA's stock comes from market sources (interest rates risk, inflation risk, etc.). On the other hand, 55,01% of the risk (that is, 1- R^2) can be attributed to a firm-specific risk component. The risk component connected to the firm should be diversifiable and for this reason it was unrewarded. Moreover, firm-specific risk of big companies such as Leonardo SpA linked to FTSE MIB index (that comprehend only the most 40 capitalized companies in Italy) are more affected by market sources than that in small companies. Market risk consists of four components: interest rate risk, equity price risk, foreign exchange risk and commodity risk. From an investing point of view, since these risks cannot be diversified, it is only possible to diversify (trying to decrease it) the firm-related risk by including more assets in the portfolio.

After having calculated the R squared index through the regression, it is useful to compute the Jensen's Alpha to have another quantitative measure of the return of the stock. Jensen's Alpha (or simply, Alpha α) is a risk-adjusted index that measures the performance of the incremental return produced by a stock[132]. It compares the actual results with the returns that the stock should have produced according to its associated systemic risk, that can be predicted using the Capital Asset Pricing Model (CAPM)[133]. In

[132] (Borsa Italiana, n.d.)
[133] (James Chen, 2020)

other words, Jensen's Alpha measures and compare the performance (and thus the return) of a stock compared to the returns of the overall market.

The measure accounts for the risk-free rate of return ($\boldsymbol{Rf}$) for the period. The proper measure for the risk-free rate of return is an Italian 5-years Bond Yield – Treasury Bond (BTP 5 Years[134]). According to Investing.com[135], at the 28th of February 2022 (ending date of the analysis) the level of the risk-free rate of return of the Italian 5-years Bond Yield was:

$$\boldsymbol{Rf} = \mathbf{0,893}\% \text{ (as of 28.02.2022)}$$

which on a per-month basis is:

$$\frac{\boldsymbol{Rf}}{\mathbf{12}} = \frac{\mathbf{0,893}}{\mathbf{12}} \approx \mathbf{0,074\%}$$

- *Step 3*: The monthly and the annualized Jensen's Alpha have been calculated using the formulas below (*Table 5.5*).

Monthly Jensen's Alpha
$Jensen'sAlpha = a - Rf * (1 - b)$ ([136])
$Jensen'sAlpha = -0,009851696 - 0,074\% * (1 - 1,356057422)$

[134] A bond yield of 5 years has been taken into account for the calculations since the time-range of the analysis is 5 years.
[135] (Investing.com, 2022)
[136] (Damodaran, 2011)

$$-\mathbf{0{,}959\%}$$
Annualized Jensen's Alpha
$$Annualised\ Jensen's\ Alpha = (1 + Monthly\ Jensen's Alpha)^{12} - 1 \quad (^{137})$$ $$Annualised\ Jensen's\ Alpha = (1 + (-\ 0{,}959)\ )^{12} - 1$$ **12,13%**

Table 5.5 – Formulas and computations of the Jensen's Alpha

Since the annualized Jensen's Alpha of Leonardo SpA is positive (12,13%), the stock of the firm performed better the expected during the period, given its beta (1,36) and the market's performance over the period.

5.3. Capital Structure

Capital is vital for companies to carry out day-to-day and investment activities and can take the form of equity or debt. The right balance between equity and debt of a company

[137] (Damodaran, 2011)

can be seen in its balance sheet and is a fundamental indicator of the overall wellbeing of the company. The optimal capital structure of a company is thus the best mix of debt and equity that maximizes the company's market value and minimizes its cost of capital[138]. For this reason, the calculation of the WACC (Weighted Average Cost of Capital) is a fundamental procedure for companies. Furthermore, the WACC is very useful since it can be used as a *hurdle rate* (or IRR) while evaluating investing decisions: managers of organizations, to create economic value for the firm, should not invest in any project that has a return that is less than the hurdle rate defined by the WACC formula[139]. In particular, the WACC formula allows companies to understand and evaluate the specific proportion of equity and of debt that impact on the final rate.

The WACC formula is defined as:

$$K_{FIRM} = (X_{DEBT} * K_{DEBT}) + (X_{EQUITY} * K_{EQUITY}) \quad (140)$$

Where:

- K_{FIRM} is the WACC.
- X_{DEBT} is the weight of debt.
- K_{DEBT} is the after-tax cost of debt.
- X_{EQUITY} is the weight of equity.
- K_{EQUITY} is the cost of equity.

The next sections estimate all the elements necessary to calculate the WACC for Leonardo SpA (all the calculations are reported in Appendix B).

At the end of the calculations, an overall analysis of the capital structure of the company is proposed.

---

138 (Hayes, 2020)
139 (Cavezzali & Rigoni, 2020)
140 (Damodaran, 2011)

Estimating the Cost of Equity (K_{EQUITY})

According to Cavezzali & Rigoni[141], the Cost of Equity can be estimated using the CAPM formula:

$$E(r_i) = r_f + \beta_i \, [\, E(r_m) - r_f \,]$$

where the Cost of Equity (*$E(r_i)$, return on the stock*) is determined using the risk-free rate (r_f), the beta of the stock (β_i) and the risk premium ($E(r_m) - r_f$).

For this analysis, the **yearly risk-free rate** has been estimated using the level of the Italian 5-years Bond Yield – Treasury Bond (BTP 5 Years) on the 28th of February 2022 which is 0,893%[142]. The annual rate is used because the value of the market risk premium is also calculated on an annual basis. Furthermore, the Italian market risk premium, that is the difference between the expected return on the market and the risk-free rate, has been pulled out from the table of "Market Default Spreads and Risks Premium" of Professor Damodaran[143]. Finally, the beta for the company has been taken from the calculations on the previous part.

The following table (*Table 5.6*) summarizes all the findings and the Cost of Equity of Leonardo SpA:

Risk-free rate	Italian Market Risk Premium	Beta (part 1)	Cost of Equity

[141] (Cavezzali & Rigoni, 2020)
[142] (Investing.com, 2022)
[143] Aswath Damodaran is a professor of Corporate Finance at the Stern School of Business at New York City University. He is known as an expertise of corporate finance valuation (Damodaran, 2022). In his personal website, he periodically computes and provides, making them public, his evaluations on "Countries Default Spreads and Risk Premiums" (Damodaran, 2022). The value for the Italian Equity Risk Premium has been taken directly from Professor Aswath Damodaran's spreadsheet and it is updated to the 5th of January 2022.

		(b)	(c)	(d)=(a)+[(c)*(b)]
Leonardo SpA	0,893%	6,42%	1,36	9,59%

Table 5.6 - Leonardo SpA's Cost of Equity calculation

Since the level of the risk-free rate (Italian BTP 5 years) is always the same for companies in the same country, the result on the cost of equity highly depends on the level of systematic risk of a company: this means that beta is the important factor which decides the level cost of equity for companies in the same country (same risk-free rate) and same period (same risk premium).

Estimating the After-tax Cost of Debt (K_{DEBT})

The cost of debt is the second part of a company's capital structure and consists in the return that a company should give to its debtholders in exchange for the risk assumed by the lenders[144]. All the calculations for the estimation of the after-tax cost of debt are included in *Appendix B*.
After-tax Cost of Debt is identified as the borrowing rate, multiplied by *1 – tax rate*:

Cost of Debt = borrowing rate * (1 – tax rate) ([145])

In the formula, the *borrowing rate* is identified as the before-tax cost of debt. It can be calculated by summing up the risk-free rate (0,893%[146]) and the default spread. The outcome of this calculation is greater than the risk-free rate because for an investor it is riskier to lend money to a private company (in this case, Leonardo SpA) compared to lend the money to the Italian Government (Italian Bond) and for this reason he would be asked

144 (Corporate Finance Institute, n.d.)
145 (Damodaran, 2011)
146 (Investing.com, 2022)

to pay a slightly premium price over the risk-free rate for the operation.

On the other hand, the default spread can be defined as the in-yield difference between two bonds. Commonly it is defined as the difference between a U.S. Treasury bond, that has a high credit rating, and another bond of the same maturity but with different credit quality[147]. It is measured in basis points: this means that a difference of 1% in the yields is equal to a spread of 100 basis points. Default spreads are also generally defined as "credit spreads" or "bond spreads". This indicator allows comparisons between a corporate bond and a risk-free alternative.

To simplify the complex calculations on the default spread, its value had been extracted from the following table (*Table 5.7*), provided by Professor Damodaran's website[148]:

If interest coverage ratio is			
greater than	≤ to	Rating is	Spread is
-100000	0.499999	D2/D	14.34%
0.5	0.799999	C2/C	10.76%
0.8	1.249999	Ca2/CC	8.80%
1.25	1.499999	Caa/CCC	7.78%
1.5	1.999999	B3/B-	4.62%
2	2.499999	B2/B	3.78%
2.5	2.999999	B1/B+	3.15%
3	3.499999	Ba2/BB	2.15%
3.5	3.9999999	Ba1/BB+	1.93%
4	4.499999	Baa2/BBB	1.59%
4.5	5.999999	A3/A-	1.29%
6	7.499999	A2/A	1.14%
7.5	9.499999	A1/A+	1.03%
9.5	12.499999	Aa2/AA	0.82%
12.5	100000	Aaa/AAA	0.67%

Table 5.7 – Damodaran's table for the evaluation of a company rating and default spread.

147 (Akhilesh Ganti, 2022)
148 (Damodaran, 2022)

According to Damodaran's evaluations in the table, the value of the default spread of a company depends on its Interest Cover Ratio[149]. Leonardo SpA's Interest Cover Ratio can be calculated using Leonardo SpA's EBIT[150] and its Interest Expenses (both taken from its 2020's Income Statement[151]):

$$\textbf{Interest Cover Ratio} = \frac{EBIT}{Interest\ Expenses} = \frac{517\ Mln^{152}}{14\ Mln^{153}} \approx \mathbf{36{,}93} \qquad (^{154})$$

This means that Leonardo SpA can pay its interest payments 36,93 times with its operating profits. This value for the Interest Cover Ratio is very high and, as highlighted in the previous table corresponds to the highest rating-level for a company (Aaa/AAA)[155].

As displayed in Table 5.7, with an Interest Cover Ratio of 36,93, Leonardo SpA's default spread corresponds to **0,67%**.

The before-tax cost of debt, as explained, can be obtained by summing up the risk-free rate and the default spread (*Table 5.8*).

Finally, the after-tax cost of debt is calculated by multiplying the before-tax cost of debt by *"1 – tax rate".* The tax rate corresponds to the updated corporate tax-rate. According to

---

149 The interest cover ratio is a debt and profitability measure used to determine how well a company can pay interests on its outstanding debts. It is used by lenders and investors to determine the riskiness of lending capital to a company. Mathematically, it is obtained by dividing the EBIT (Earnings Before Interest and Taxes) of a company by its interest expense. A high interest cover ratio means that a company is safer (Adam Hayes, 2021).

150 EBIT = Earnings Before Interests Expenses and Taxes Expenses

151 The data have been taken from Leonardo SpA's 2020 Income Statement because at the date of the analysis of the Cost of Debt (*February 2022*) it was the most updated Income Statement available for the company. For the sake of this analysis, the level of the EBIT and of Interest Expenses updated to 2020 is still representative of the actual status of the company: for a solid and enduring company such as Leonardo SpA it can be expected to obtain a high level of the Interest Cover Ratio, corresponding to a higher rating (Aaa/AAA). This will result in a low level of default spread, as displayed in *Figure 5.7*.

152 (Leonardo S.p.A., 2020)

153 (Investing.com, 2022)

154 (Adam Hayes, 2021)

155 A corporate credit rating is an opinion of an independent agency regarding the likelihood that a corporation will fully meet its financial obligations as they come due. A company's corporate credit rating indicates its relative ability to pay its creditors (Tuovila, et al., 2021).

OECD Statistics, the database of the "Organization for Economic Cooperation and Development", the level of the corporate tax rate for 2021 was 27,8%[156].

The next table (*Table 5.8*) displays all the calculations needed to arrive at the after-tax cost of debt:

	Risk-free rate	**Interest Cover ratio**	**Default Spread**	**Before-tax Cost of Debt**	**Corporate Tax Rate**	**After-tax Cost of Debt**
	(a)	(b)	(c)	(d)=(a)+(c)	(e)	(f)=(d)*[1-(e)]
Leonardo SpA	0,893%	36,93	0,67%	1,563%	27,8%	1,13%

Table 5.8 – Evaluation of Leonardo SpA's Cost of Debt

Cost of Equity and Cost of Debt alone are meaningless for the WACC calculation if the weights of equity and debt are not calculated. The next section analyzes the estimation of the weight of debt and of the weight of equity for Leonardo SpA.

Estimating the amounts and weights of Equity (X_{EQUITY}) and of Debt (X_{DEBT})

The amount of equity corresponds to the level of Market Capitalization of Leonardo SpA. Market Capitalization (commonly referred to as "Market Cap") is the total dollar market value of a company's outstanding shares of stock or, in other words, the overall market value of all the outstanding shares of a company[157]. It is calculated multiplying the current market price of one share of a defined company by its total number of outstanding shares.

To ease the calculations, the value of Leonardo SpA's market capitalization has been

[156] (OECD Statistics, 2021) Data under the heading "Combined corporate income tax rates" for Italy.
[157] (Jason Fernando, 2022)

checked on the financial website "Morningstar, Inc."[158], that computes an up-to-date level of market capitalization of all the companies listed in the major stock exchanges.

According to Morningstar, Inc.[159], Leonardo SpA's market capitalization (updated at the 25th of March 2022, date of the calculation, is: 5,36 Billions (EUR) that corresponds to 5360 Millions (EUR).
Figure 5.9 summarizes the results extracted from the financial website:

Figure 5.9 – Summary output extracted by Leonardo SpA's webpage on Morningstar, Inc (Morningstar, Inc., 2022).

Secondly, the Amount of Debt can be extracted from the balance sheet of Leonardo SpA. The amount of debt of a company can be defined as the "Total Borrowings" of that company and it consists in the sum of the current debts and of the long-term debts of that company. Since the debts of a company are always listed in its balance sheet, it is possible to extract the value of the amount of debt of Leonardo SpA from its most recent balance sheet (published on the 10th of March 2022 and relative to the fiscal year 2021). In this case, it is important to consider a data updated and aligned with the data of the other parts in order to obtain a reliable outcome.

Thus, the amount of debt can be obtained from Leonardo SpA's 2021 balance sheet[160] by summing up the values corresponding to the headings:

Total Current Liabilities (*Passività correnti*) = 15.596 Millions (EUR)

Total Long-Term Debts (*Passività non correnti*) = 6.328 Millions (EUR)

158 (Morningstar, Inc., 2022)
159 (Morningstar, Inc., 2022)
160 (Leonardo SpA, 2022)

Figure 5.10 displays the simplified 2021 balance sheet of Leonardo SpA published on Leonardo SpA official webpage[161] and computes the calculations for the total borrowings of the company.

Bilancio consolidato al 31 dicembre 2021

Situazione finanziaria-patrimoniale consolidata

(€mil.)	*Note*	**31 dicembre 2020**	*Di cui con parti correlate*	**31 dicembre 2021**	*Di cui con parti correlate*
Attività immateriali	*9*	6.647		7.079	
Attività materiali	*10*	2.015		2.122	
Investimenti immobiliari		70		46	
Diritti d'uso	*11*	527		530	
Investimenti in partecipazioni valutate con il metodo del patrimonio netto	*12*	1.066		1.319	
Crediti	*13*	412	*8*	619	*13*
Attività per imposte differite	*32*	1.093		1.035	
Altre attività non correnti	*13*	53	-	60	-
Attività non correnti		**11.883**		**12.810**	
Rimanenze	*15*	5.882		5.486	
Attività derivanti da contratti	*16*	3.059		3.748	
Crediti commerciali	*17*	3.033	*663*	3.203	*640*
Crediti per imposte sul reddito		116		86	
Crediti finanziari	*17*	167	*149*	61	*45*
Altre attività correnti	*18*	648	*75*	489	*6*
Disponibilità e mezzi equivalenti	*19*	2.213		2.479	
Attività correnti		**15.118**		**15.552**	
Attività non correnti possedute per la vendita	*33*	72		17	
Totale attività		**27.073**		**28.379**	
Capitale sociale	*20*	*2.498*		*2.499*	
Altre riserve		*2.769*		*3.929*	
Patrimonio Netto di Gruppo		5.267		6.428	
Patrimonio Netto di Terzi		11		27	
Totale Patrimonio Netto		**5.278**		**6.455**	
Debiti finanziari non correnti	*21*	3.880	*127*	4.112	*126*
Benefici ai dipendenti	*23*	400		362	
Fondi per rischi ed oneri non correnti	*22*	584		583	
Passività per imposte differite	*32*	233		340	
Altre passività non correnti	*24*	779	-	931	-
Passività non correnti		**5.876**		**6.328**	
Passività derivanti da contr				7.942	
Debiti commerciali				3.372	*347*
Debiti finanziari correnti				1.558	*760*
Debiti per imposte sul redd				44	
Fondi per rischi ed oneri co				1.111	
Altre passività correnti	*24*	1.319	*12*	1.569	*12*
Passività correnti		**15.894**		**15.596**	
Passività direttamente correlate ad attività possedute per la vendita	*33*	25		-	
Totale passività		**21.795**		**21.924**	
Totale passività e patrimonio netto		**27.073**		**28.379**	

Total Current Liabilities (Passività correnti) = 15.596 Millions (EUR) +
Total Long-Term Debts (Passività non correnti) = 6.328 Millions (EUR) =

Total amount of Debt = 21.924 Millions (EUR)

Figure 5.10 – Leonardo SpA's 2021 Balance Sheet

[161] (Leonardo SpA, 2022)

Summing up the amount of equity and the amount of debt, the *amount of capital* will be obtained. The relevant weight of equity and weight of debt are the ratio between the amount of respectively equity with the total amount of capital and debt with the total amount of capital.

Table 5.11 summarizes the results:

	Amount of Equity	**Amount of Debt**	**Total amount of Capital**	**Weight of Equity**	**Weight of Debt**
	(1)	(2)	(3)=(1)+(2)	(1)/(3)	(2)/(3)
Leonardo SpA	€ 5.360 Mil	€ 21.924 Mil	€ 27.284 Mil	0,196	0,804

Table 5.11 – Computations on amounts and weights of equity and debt for Leonardo SpA

Leonardo SpA's weight of equity corresponds to the 19,6% of its total amount of capital, while its weight of debt corresponds to the 80,4% of its total amount of capital.

WACC Estimation

Finally, the WACC can be estimated using the formula displayed at beginning of this section:

$$K_{FIRM} = (X_{DEBT} * K_{DEBT}) + (X_{EQUITY} * K_{EQUITY})$$

The results for Leonardo SpA are presented in the last column of *Table 5.12*.

	Cost of Equity K_{EQUITY}	Cost of Debt K_{DEBT}	Weight of Equity X_{EQUITY}	Weight of Debt X_{DEBT}	WACC K_{FIRM}
	(a)	(b)	(c)	(d)	(e)=[(a)*(c)]+[(b)*(d)]
Leonardo SpA	9,59%	1,13%	0,196 = 19,6%	0,804 = 80,4%	2,79%

Table 5.12 - WACC estimation

According to Moles et al.[162], the WACC consists in the weighted average of the costs of the two types of capital analyzed (equity and debt); each type of cost is then multiplied by the proportion of the total capital that it represents. For Leonardo SpA, the estimation of its Weighted Average Cost of Capital (dated March 2022) is equal to 2,79%.

Moreover, Moles et al. suggested that a company's *optimal capital structure* should be able to:

1. *Minimize its cost of capital*
2. *Minimize the rate it pays to use money*
3. *Maximize its market value*

Point 1 and 2 are directly associated with the WACC since it is a balanced estimation of the overall cost of capital and, as explained above, it can be used as a hurdle rate while deciding on investment projects. For these reasons the WACC is a fundamental element in analyzing a company's capital structure and organizations struggle in maintaining the WACC as lower as possible with the right combination of equity and debt. In addition,

[162] (Moles, et al., 2011)

while considering the right balance between equity and debt, it is important to consider that in general cost of debt is lower than cost of equity, because interest on debt is tax-deductible. On the other hand, while being cheaper, debt carries the risk of bankruptcy when companies are not able to respect payments on time[163].

For what concerns the result on Leonardo SpA's Weighted Average Cost of Capital (2,79%), it is important to consider the composition of the WACC of the company: Leonardo SpA has a *debt-to-capital ratio* (i.e. weight of debt XDEBT) ≈ 80% (80,4%). This is usually common in big and consolidated companies as Leonardo SpA, that compared to smaller and emerging companies have less need of external equity funding for their expansion.

Table 5.13. displays the ROCE ratio (Return on Capital Employed) of the company for the last three years.

The ROCE index is calculated by dividing Earnings Before Interests and Tax expenses (EBIT) by the Capital Employed, that in turn is the difference between Total Assets and Current Liabilities. The calculation for the ROCE in 2019, 2020 and 2021 for Leonardo SpA is displayed in *APPENDIX B*.

The ROCE index is a measure of a company's profitability and, in particular, of the capital efficiency of a company: a higher return on capital employed is an indicator of a more efficient company[164].

	ROCE		
	2019	2020	2021
Leonardo SpA	48%	47%	43%

Table 5.13 – Leonardo SpA ROCE results in 2019, 2020 and 2021

[163] (Loth, et al., 2022)
[164] (Hayes, et al., 2022)

Leonardo SpA's ROCE has stayed almost flat in the last three years of operations (between 48% in 2019 and 43% in 2021), with a slight decrease of 4 percentage points in 2021 compared to 2020. This means that the company has been able to propose a good mix of equity and debt in the last years even considering the shakedowns generated by the Covid-19 pandemic through the period.

In conclusion, considering the size of the company and that its financial performance in the last years has not been slowed down (also considering the pandemic shakedown), Leonardo SpA should maintain this direction in terms of balance between EBIT and Capital Employed.

Furthermore, the WACC value of 2,79%, that is the main argument of the paragraph, can be considered as a good value for investors as hurdle rate for future investments. In addition, the company should struggle to maintain the same level of WACC while slightly decreasing the amount of debt employed, since it represents a risk for investors in case of bankruptcy.

5.4. Payout Policy

According to Moles et al[165], the cash flow between a firm and its shareholders is a fundamental part of the managerial decision process of a company. *Figure 5.12* displays the cash flow diagram of a business entity[166], with particular emphasis on its payout flow.

[165] (Moles, et al., 2011)
[166] Exhibit inspired by the book "Corporate Finance" (Moles, et al., 2011).

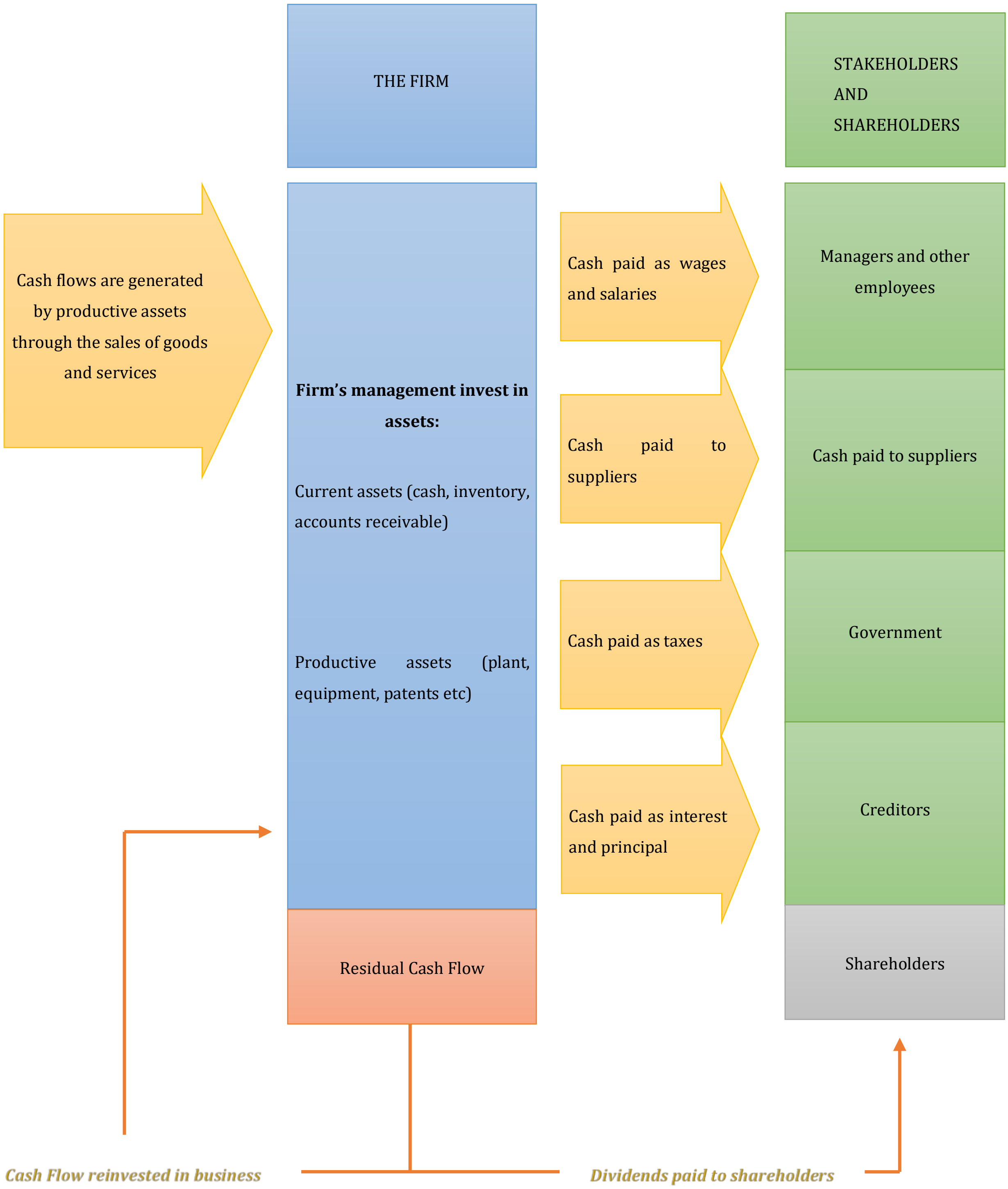

Figure 5.12 – Cash Flow of a business entity

As the scheme displays, the flow generated from the productive activities and the assets of the company is firstly used by the managers for two principal reasons:

- To *invest in assets* such as current assets (cash, inventory, accounts receivables and so on) and such as productive assets (plants, equipment, technology, patents, buildings);
- To *commit the company's payments obligations* for wages and salaries to managers and employees, to *pay all the suppliers* for the furniture, to *pay taxes* to the government and to *commit interests and principal* payments to creditors.

Finally, the residual cash flow of the company can be reinvested in business and/or used to pay dividends to shareholders. Furthermore, a dividend is distributed to a firm's shareholders on a pro-rata basis: this means that dividends are distributed to shareholders in proportions to the percentage of the firm's share that they own.

To understand the payout policy of Leonardo SpA, an analysis of the *dividend payout ratio* across the last three fiscal years of operation of the company (i.e. 2019 – 2020 – 2021) has been proposed. The dividend payout ratio expresses the percentage of earnings of the company paid out as dividends in the last three years[167]. The dividend payout ratio is represented in *Figure 5.12* as the orange arrow that starting from the residual cash flow of the company, goes directly to its shareholders. It is calculated by dividing the total amount of dividends paid in that year by the total net income of the company. The ratio represents the amount of money that a company returns to its shareholders and it is usually compared to the amount of money that the company keeps for itself, reinvesting these money in growth, paying off debts or adding cash reserves.

Dividend Payout Ratio Analysis

Mathematically, the Dividend Payout Ratio can be calculated by dividing the total amount of dividends paid in that year by the total net income of the company, as the following formula displays:

[167] (Hayes, et al., 2022)

$$Dividend\ Payout\ Ratio = \frac{Dividends\ Paid}{Total\ Net\ Income} \quad (^{168})$$

The next table (*Table 5.13)* summarizes the results for the Dividend Payout Ratio of Leonardo SpA calculated in *APPENDIX C*. The analysis had been done on the company's last three fiscal years and the data on the company accounts had been taken from Leonardo SpA's last three available Financial Reports, provided by the company's website[169].

Results can be summarized as follows:

		Dividends Paid	Net Income (Net Profit)	Dividend Payout
		(a)	(b)	(a) ÷ (b)
Leonardo SpA	**2019**	€ 81 Mil	€ 822 Mil	9,8%
	2020	€ 81 Mil	€ 243 Mil	33,3%
	2021	-	€ 1154 Mil	*Not Applicable*

Figure 5.13 – Dividend Payout Ratio calculations for Leonardo SpA in 2019, 2020, 2021.

According to Leonardo SpA's historical integrated financial statements, the Board of Directors of the company is used to pay dividends every year of an amount of € 81 Millions. Nonetheless, in 2020, the Board of Directors decided to change policy for one

[168] (Hayes, et al., 2022)
[169] (Leonardo SpA, 2022)

year, declaring not to pay dividends in 2021 in order to partially cover a loss generated and recorded in Leonardo SpA separated financial statement. For the sake of the analysis, that regards mostly the performance of the entire group, the net profit of the group has been taken into consideration.

The following graph displays graphically the trend of Leonardo SpA's Dividend Payout through the years:

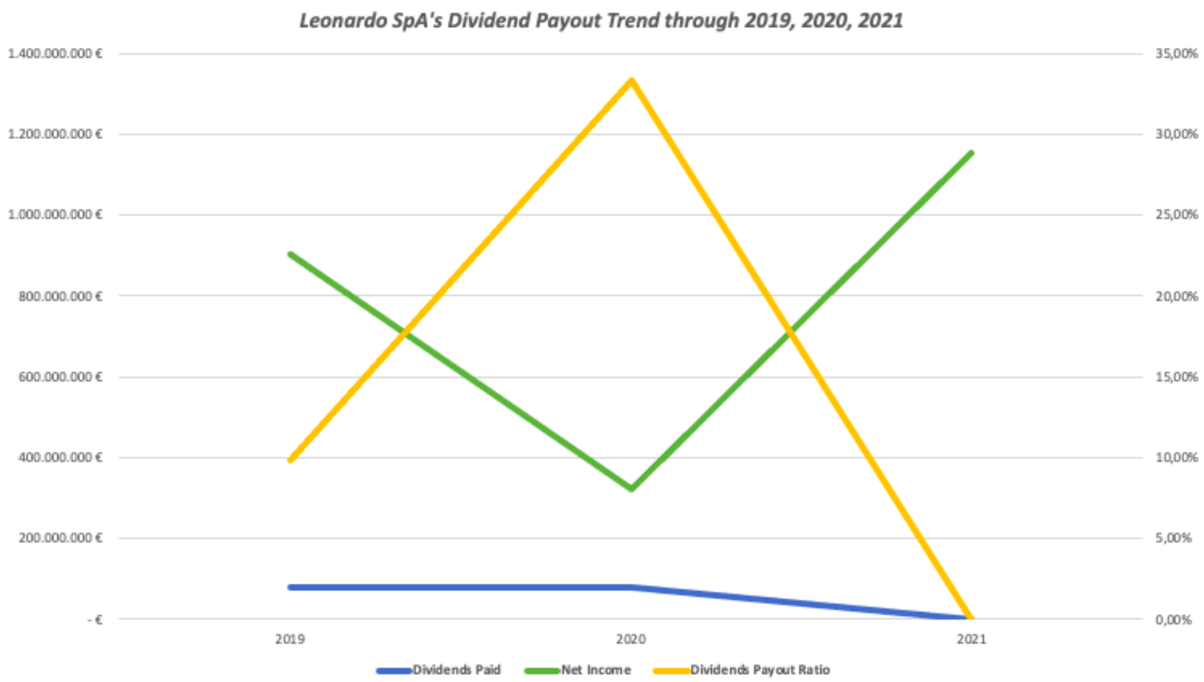

Figure 5.14 – Leonardo SpA's Dividend Payout Trend through 2019, 2020, 2021

The results on the level of the dividend payout ratio are usually interpreted in this way:

- A *Low Dividend Payout Ratio* means that a company is reinvesting more money back into its business. This means that they are either not sharing or sharing partially the earnings of the company with its shareholders. This is typical of new and expanding companies, that wants to invest in business growth to attract more investors in the future.

- A *High Dividend Payout Ratio* means that the company is reinvesting less money back into its business and prefers to share earnings with its investors in a periodical basis. This is common in mature and established companies, that are usually subjected to a slower rate of growth and have less need to invest in new projects or infrastructures.

The two types of managing dividends attract different types of investors that on one side (low or null dividend payout ratio) are attracted by the potential profits of the company and by the potential future high price of each share. On the other hand, investors are attracted by companies that shares periodically a high share of dividends because they prefer the assurance of a steady stream of income compared to a high potential (and thus, higher risk) for growth in share price.

In this case, Leonardo SpA represents a situation that stays in between the two extremes: the company is a well-established and mature company that decides to reward its investors with a constant flow of dividend each year. In fact, except for financial year 2020, Leonardo SpA have constantly paid out a steady level of dividend to its investors through the years (also before the first year analyzed, 2019, the company paid € 81 Millions each year, independently from its level of net income and also in 2021 integrated financial statement, the company came back to its usual policy of paying a defined amount of dividends to its shareholders). The decision of not paying dividends in 2020 is mainly justified by two reasons: first of all, the Board of Directors, as previously displayed, decided to retain more earnings of the entire group to cover the loss generated by Leonardo SpA[170] (single company); secondly, the drop in net profits of the company in 2020 is a consequence of the though period suffered by the global economy due to the Covid-19 pandemic spread of 2019 and 2020. As the majority of the companies worldwide, also Leonardo SpA had been hit by the pandemic even if the group maintained a positive net profit trend also in 2020. This is an important signal for investors that want to invest in a company that manages to stay healthy also in period of recession.

If on one hand the company proved to have a constant and predictable dividend policy (excluding 2020 fiscal year), on the other hand Leonardo SpA is constantly reinvesting most of its yearly earnings back in the business. For this purpose, it is possible to calculate the *Retention Ratio*, that is the proportion of earnings that a company decides to keep back

[170] From Leonardo SpA 2020 separated financial statements accounts.

in the business to reinvest as retained earnings. This can be defined as the opposite of the dividend payout ratio:

$$Retention\ Ratio = 1 - Dividend\ Payout\ Ratio \qquad (171)$$

		Dividend Payout Ratio	Retention Ratio
		(a)	1 - (a)
Leonardo SpA	2019	9,8%	90,2%
	2020	33,3%	66,7%
	2021	*Not Applicable*	100%

Figure 5.14 – Retention Ratio for Leonardo SpA in 2019, 2020, 2021.

A high level of the Retention Ratio implies thus a low level of Dividend Payout Ratio. On the other hand, a low level of the Retention Ratio implies a high level of the Dividend Payout Ratio. Furthermore, the reasonings behind the level of the retention ratio goes accordingly with the ones behind the dividend payout ratio.

171 (B. Murphy , et al., 2021)

5.5. Conclusion and Recommendations for Leonardo SpA

The analysis and comments on the performance of Leonardo SpA in the years 2019, 2020, 2021 take into account two important premises:

- First of all, since the analysis focuses on the performance of a private company operating in the space field, it is necessary to take into account that the results come from the general performance of the Leonardo SpA Group (since data have been taken from the Group's integrated financial statements). The performance and the results, therefore, are certainly representative of the branch dedicated to the space industry, but are also subject to the performance of the other compartments of the company.

- Secondly, and this is perhaps the most important point to be considered in the analysis phase, the three years taken into consideration have been affected and influenced by a global pandemic, that of Covid-19, which has impacted the entire global economy. The impact was also important in the space sector, which suffered of lower investments by both governmental and private entities.

In light of the results obtained in the analysis, Leonardo SpA confirms to be a stable company that generates a constant return to its investors. In particular, analyzing the risk profile of the company it is immediately evident how the beta coefficient, calculated using a linear regression and the CAPM and equal to ≈ 1,36, has a volatility not largely greater than that of the market (i.e. by definition, equal to a 1). This figure represents a safety point for investors less accustomed to risk, as Leonardo SpA is therefore a more stable company and less subject to price shakedowns on the stock exchange.

A second important result is given by the linear regression: the coefficient R squared. The coefficient, with a calculated value of 44,99%, explains to the investor that about 45% of the risk linked to the stock of Leonardo SpA is given by the market (i.e. it can therefore be linked to systematic risk factors, such as fluctuations in interest rates or inflation risk).

Explained in other words, about 45% of the variability of the stock can be explained and predicted by the variations that the entire market has (in the case analyzed, by market we mean the FTSEMIB coefficient, which represents about 80% of listed Italian companies on the Milan stock exchange). From a practical point of view, therefore, an investor who intends to invest in Leonardo SpA knows that he cannot mitigate the risk deriving from the market, but can try to reduce the risk directly connected to the company (in this case 1 - R Squared ≈ 55%), diversifying as much as possible the financial products included in its portfolio.

The last interesting point given by the linear regression analysis in the fiscal years 2019, 2020, 2021 is the annualized value of the Jensen's Alpha coefficient. Leonardo SpA's annualized Jensen's Alpha, equal to 12,13%, compares the financial results actually obtained by the company with the results predicted by the linear regression. In this case, the company overperformed the regression expectation in the analyzed period, a symptom of a positive performance despite the pandemic related difficulties faced by the global economy in the last three years.

As regards the company's Weighted Average Cost of Capital (WACC), the value of 2,79% dated March 2022 represents an excellent level if we consider the WACC as a hurdle rate (or Internal Rate of Returns, IRR) while evaluating investing decisions. In fact, Leonardo SpA's Return on Capital Employed (ROCE) proved to be very stable during the pandemic, falling from 2019 to 2021 by only 5 percentage points (48% in 2019, 47% in 2020 and 43% in 2021). From the investor's point of view, however, what is of greater importance is the composition of the WACC and in particular the weight of capital and the weight of debt. For Leonardo SpA, in fact, the weight of debt turned out to be around 80% of the total, representing the company as particularly dependent on its debts. This can be seen as a risk from the investor's point of view, who must take into account any risk of bankruptcy in the event that the company is no longer able to repay its debts. For this reason, the Board of Directors of Leonardo SpA in the next years should struggle to maintain the same level of WACC while slightly decreasing the amount of debt employed.

Finally, the dividend payout trend policy of Leonardo SpA through the period 2019 - 2021 has been analyzed. The company, which annually pays dividends of € 81 Millions, for the first time in fiscal year 2021 did not pay dividends to its shareholders, declaring that it intends to bear a loss linked to the single return of Leonardo SpA (and not of Leonardo SpA as a group). The dividend payout trend, which started from 9,8% in 2019, to 33,3% in 2020, then fell to zero in 2021. A company's periodic dividend payments have great implications for its shareholders and can often be one of the most important reasons when considering an equity investment. Moreover, a periodic dividend payout policy is typical of stable and consolidated company as Leonardo SpA. The Board of Directors, however, with the closure of the 2021 financial statements declared that they intend to restart the policy of periodic payment of dividends to its shareholders, bringing the total level of payments back to that of the previous years (€ 81 Millions per year).

Overall, Leonardo SpA constitutes a financially stable reality, with rather safe and reliable returns in the medium and long term. The price of its shares is not usually subject to large fluctuations and this guarantees a cardinal principle of stability for the investor less accustomed to risk. On the other hand, however, the predictable behavior of the stock leaves less room for those who intend to speculate on market prices.

6. Conclusions

The purpose of this thesis was to analyze how the space industry has evolved over the last few decades. The main changes can be summarized as follows.

Firstly, if throughout the twentieth century the actors active in the space sector were mainly represented by governmental bodies, in recent decades companies and private investors have increasingly taken hold within the sector. The entry of private individuals has profoundly changed the existing paradigm within the space industry. After the first "Rush to Space" between the USA and Russia, which ended with the landing of the American Apollo 11 on the Lunar ground, governmental agencies have had a limited budget for years, dictated by national governments and under the great pressure of taxpayers. The objective of these agencies was in fact to improve the performance of space devices as much as possible, while reducing the risk of failure of experiments and projects as much as possible, that represented a cost that is difficult to justify at the eyes of taxpayers. With the entry of private individuals into the sector this paradigm has changed. The objectives are shifted and are no longer represented by maximizing performance and reducing risks, but by time-to-market: the possibility of offering new solutions in a short time, satisfying the customer's expectations, and secondly offering an economic return to those who invest in this type of sector. The company or private investor is therefore more inclined to accept a failure, even if associated with a cost, as long as this can lead to offering a more complete product and in the best possible time to its customers.

The second point highlighted in this dissertation is defined by the variation of objectives within the space industry. Historically, from this point of view three different moments can be defined. The meeting point of all periods, however, is the curiosity that mankind have always had towards space.

At first, between the early 1900s and 1969, man's push towards space was mainly dictated by the *potential geopolitical push* that could represent the "conquest of space" for a nation. The competition between the United States and the USSR, as well as on space competences was also based on a political level: the "conquest" of the Moon by the USA represented the conclusion of this competition, which must certainly be lowered within the historical period in which occurred.

Later, after 1969, space became a *shared research environment* between nations. The International Space Station, born in 1998, is certainly the greatest example of this. The collaboration between the largest national and international governmental bodies, such as NASA, ESA, JAXA and many others, has created a great push towards research and in this period the overall competences in the space sector increased enormously. The annual launches of satellites or shuttles into space have increased of ten times from 1969 to 2000 and some of the most important research missions have begun in these years: the Hubble telescope for example, which has allowed humanity to go as far as 13 billion light years from Earth, exploring new galaxies, exoplanets, stars, black holes and more, was launched in 1990 and is still operational.

The third period, that is the current one, is dictated by the *economic interest* that the space can offer. This is the main reason for private players to enter the scene. The space industry is already creating great business opportunities and is expected to create many more in the years to come. The increase in technical skills and knowledge in the sector, which took place also thanks to the research of governmental agencies, mede sure that costs fell (such as the launch and construction costs of space devices) and that new opportunities have been created.

This implication is beneficial to both the upstream and downstream space sectors. From the upstream point of view, the most relevant example is represented by the Artemis mission, which aims to create a continuous correspondence with the Moon (and subsequently also with Mars), with the aim of "colonizing" the main satellite of the Earth. The downstream sector, on the other hand, is the one that is currently experiencing the greatest benefits, both social and economic. In particular, the satellite industry encompasses many of the activities that each individual performs daily (such as web searches, sending emails, calls, etc.) creating economic added value for the producer and social value for the end user. In addition, high-tech devices embedded in artificial satellites, such as earth observation and temperature sensing devices, generate numerous positive spin offs. Furthermore, other business prospects such as space tourism and space mining, with great economic potential, remain possible only thanks to the entry on the scene of private actors who invest large capital in the development of technologies suitable for this type of mission.

Finally, in the last part of the thesis, the analysis of the financial profile of the Italian Leonardo SpA, operating within the space industry for several decades, had the aim of supporting the theses explained in the previous points. In fact, Leonardo SpA, through its branch Thales Alenia Space, has had a more than positive performance from a financial point of view in the last three years, resisting the crisis matured with the advent of Covid-19. The company, which over the years has contributed to several projects in the space sector, including the construction of various components of the new International Space Station, represents for an investor a mature and solid company, with a rather predictable equity behavior thanks to the annual payment (except for the 2020 fiscal year) of a portion of dividends to its shareholders. Furthermore, given the solidity demonstrated during the pandemic, it can be said that its performance is rarely subject to shakedowns, but that it follows more the behavior of the market, also considering the value of its R squared of around 45%. Leonardo SpA therefore represents a less attractive company for the investor who intends to speculate on the purchase of shares.

In conclusion, the space industry and space businesses thanks to the advent of private individuals is undergoing a great boost, which is already creating great benefits and positive spin offs also in adjoining fields and sectors, with solutions that have not only scientific applications, but also commercial, thus giving life to a new branch of the global economy: the New Space Economy.

7. APPENDICES

APPENDIX A

All the following data have been extracted from the financial website Investing.com.

PART A – REGRESSION ANALYSIS FOR THE EVALUATION OF THE RETURN EQUATION AND THE R-SQUARED

Monthly returns for Leonardo SpA (LDOF).

Month	Price	Open	High	Low	Volume
Feb-22	8.000	6.420	8.220	6.048	150.32M
Jan 22	6.382	6.318	6.980	6.070	145.62M
Dec 21	6.300	6.026	6.420	5.814	86.86M
Nov-21	5.982	6.350	6.686	5.756	137.68M
Oct 21	6.338	7.026	7.376	6.312	155.90M
Sep 21	7.114	6.956	7.280	6.488	101.26M
Aug 21	6.898	6.700	7.066	6.604	84.11M
Jul 21	6.636	6.838	7.036	6.012	95.82M
Jun 21	6.812	7.136	7.440	6.730	76.95M
May 21	7.110	6.838	7.260	6.622	123.80M
Apr-21	6.794	6.960	7.362	6.614	133.67M
Mar-21	6.904	6.794	8.010	6.500	244.43M
Feb-21	6.630	5.802	7.144	5.694	202.34M
Jan 21	5.736	5.970	6.186	5.420	162.42M
Dec 20	5.910	6.118	6.646	5.430	173.47M
Nov-20	6.064	4.119	6.398	4.032	316.79M
Oct 20	4.088	5.032	5.266	4.005	160.97M
Sep 20	5.000	5.734	6.008	4.620	142.44M
Aug 20	5.668	5.412	6.350	5.206	78.11M
Jul 20	5.410	5.930	6.596	5.400	132.75M
Jun 20	5.900	5.758	7.298	5.696	134.34M
May 20	5.600	6.122	6.280	5.092	97.28M
Apr-20	6.294	5.870	7.448	5.858	90.93M
Mar-20	6.072	9.424	9.478	4.380	140.89M
Feb-20	9.238	11.220	11.875	9.080	61.13M

Jan 20	11.180	10.500	11.550	10.405	55.41M
Dec 19	10.450	10.600	10.840	10.140	42.59M
Nov-19	10.615	10.440	11.680	10.385	54.95M
Oct 19	10.410	10.885	10.995	9.742	58.18M
Sep 19	10.790	11.170	11.890	10.495	42.03M
Aug 19	11.130	10.980	11.270	9.656	54.05M
Jul 19	11.040	11.280	11.840	10.955	43.53M
Jun 19	11.145	9.874	11.355	9.780	46.34M
May 19	9.942	10.340	10.460	9.364	67.31M
Apr-19	10.295	10.440	10.745	10.120	47.01M
Mar-19	10.360	8.906	10.475	8.352	89.21M
Feb-19	8.866	8.450	9.016	8.402	45.01M
Jan 19	8.458	7.628	8.534	7.452	64.65M
Dec 18	7.678	8.832	8.958	7.490	43.45M
Nov-18	8.706	9.566	9.880	8.140	73.17M
Oct 18	9.590	10.350	10.980	9.046	77.71M
Sep 18	10.380	9.640	10.900	9.586	58.98M
Aug 18	9.650	10.230	10.710	9.576	67.90M
Jul 18	10.250	8.386	10.315	8.250	76.04M
Jun 18	8.466	8.900	9.150	8.088	59.21M
May 18	8.724	9.696	10.120	8.266	111.10M
Apr-18	9.610	9.310	10.040	9.012	79.97M
Mar-18	9.378	8.810	9.640	8.466	101.11M
Feb-18	8.850	9.800	9.934	8.396	96.24M
Jan 18	9.720	9.940	11.450	9.512	143.13M
Dec 17	9.920	10.090	10.370	9.710	73.03M
Nov-17	10.040	14.960	15.090	9.520	138.18M
Oct 17	14.830	15.930	15.980	14.500	35.16M
Sep 17	15.850	14.240	16.060	14.180	36.88M
Aug 17	14.210	14.700	14.860	13.860	26.21M
Jul 17	14.730	14.600	15.680	14.510	30.15M
Jun 17	14.550	15.700	16.110	14.400	37.36M
May 17	15.680	14.560	15.870	14.320	56.45M
Apr-17	14.430	13.390	14.900	13.040	40.57M
Mar-17	13.290	13.110	14.180	12.750	78.89M

Monthly returns for FTSE MIB (FTSEMIB).

Month	Price	Open	High	Low	Volume
Feb-22	25.415,89	27.023,82	27.549,62	24.507,08	10,40B
Jan 22	26.814,05	27.408,89	28.212,68	25.784,68	8,86B
Dec 21	27.346,83	26.039,43	27.496,55	25.783,03	7,74B
Nov-21	25.814,34	27.020,30	27.968,91	25.517,71	15,42B

Oct 21	26.875,96	25.305,64	27.049,32	25.276,17	8,94B
Sep 21	25.683,81	26.186,00	26.397,76	24.941,19	8,46B
Aug 21	26.009,29	25.535,52	26.687,97	25.275,77	6,06B
Jul 21	25.363,02	25.256,77	25.540,91	23.817,66	7,26B
Jun 21	25.102,04	25.272,66	25.926,66	24.903,25	7,33B
May 21	25.170,55	24.196,26	25.278,91	23.898,05	9,12B
Apr-21	24.141,16	24.730,95	24.939,00	23.916,97	7,22B
Mar-21	24.648,56	23.123,23	24.777,97	22.795,55	12,76B
Feb-21	22.848,58	21.737,03	23.652,45	21.618,50	10,21B
Jan 21	21.572,53	22.398,06	23.003,56	21.311,51	8,55B
Dec 20	22.232,90	22.193,10	22.395,11	21.087,10	8,25B
Nov-20	22.060,98	17.967,70	22.387,26	17.806,44	12,72B
Oct 20	17.943,11	19.176,56	19.764,74	17.636,38	8,93B
Sep 20	19.015,27	19.776,36	20.140,84	18.545,92	8,94B
Aug 20	19.633,69	19.136,52	20.471,63	18.948,81	7,86B
Jul 20	19.091,93	19.452,48	21.133,43	19.013,37	9,45B
Jun 20	19.375,52	18.437,40	20.399,38	18.236,52	13,66B
May 20	18.197,56	17.156,75	18.414,02	16.551,28	9,53B
Apr-20	17.690,49	16.600,06	18.302,85	16.384,35	9,50B
Mar-20	17.050,94	22.333,17	22.361,13	14.153,09	20,54B
Feb-20	21.984,21	23.297,09	25.483,05	21.697,94	11,20B
Jan 20	23.237,03	23.606,97	24.197,66	23.207,90	8,22B
Dec 19	23.506,37	23.297,68	24.003,64	22.581,12	6,33B
Nov-19	23.259,33	22.734,64	23.827,58	22.721,16	8,29B
Oct 19	22.693,77	22.184,75	22.783,36	21.127,43	8,88B
Sep 19	22.107,70	21.390,48	22.282,94	21.311,18	8,44B
Aug 19	21.322,90	21.307,36	21.605,79	19.936,13	8,61B
Jul 19	21.398,19	21.463,79	22.357,39	21.235,08	8,67B
Jun 19	21.234,79	19.679,84	21.511,39	19.593,70	8,08B
May 19	19.802,11	21.834,44	21.914,77	19.535,50	10,29B
Apr-19	21.881,33	21.404,00	22.052,83	21.348,90	8,29B
Mar-19	21.286,13	20.798,07	21.483,53	20.385,86	10,01B
Feb-19	20.659,46	19.752,12	20.683,05	19.267,89	9,82B
Jan 19	19.730,78	18.191,76	19.904,79	17.959,39	10,06B
Dec 18	18.324,03	19.589,95	19.674,86	17.914,03	7,38B
Nov-18	19.188,97	19.014,88	19.623,64	18.453,86	9,05B
Oct 18	19.050,22	20.602,28	21.078,01	18.411,43	11,32B
Sep 18	20.711,70	20.269,06	21.680,00	20.253,27	9,14B
Aug 18	20.269,47	22.224,31	22.224,46	20.236,27	7,69B
Jul 18	22.215,69	21.411,00	22.243,62	21.168,66	7,38B
Jun 18	21.626,27	22.251,33	22.516,62	21.157,47	9,93B
May 18	21.784,18	24.014,71	24.544,26	21.122,51	13,34B
Apr-18	23.979,37	22.288,50	24.073,69	22.205,68	9,23B

Mar-18	22.411,15	22.527,12	22.938,06	21.460,46	10,16B
Feb-18	22.607,61	23.639,28	23.809,51	21.907,71	9,24B
Jan 18	23.507,06	21.898,69	24.050,15	21.613,89	8,46B
Dec 17	21.853,34	22.396,59	22.838,32	21.833,80	7,08B
Nov-17	22.368,29	22.909,89	23.133,42	21.932,57	9,21B
Oct 17	22.793,69	22.714,12	22.899,36	22.021,02	8,44B
Sep 17	22.696,32	21.743,06	22.696,32	21.581,89	7,37B
Aug 17	21.670,02	21.543,10	22.065,42	21.329,21	6,62B
Jul 17	21.486,91	20.710,89	21.690,61	20.703,95	7,78B
Jun 17	20.584,23	20.781,43	21.271,49	20.537,35	9,39B
May 17	20.731,68	20.697,77	21.828,77	20.572,22	11,88B
Apr-17	20.609,16	20.510,37	20.883,66	19.442,71	9,52B
Mar-17	20.492,94	19.067,87	20.495,62	19.028,49	12,67B

Monthly-adjusted closing prices for both LDOF's stock and FTSEMIB's index, calculated using the following formula[172]:

$$\boldsymbol{Return = \frac{Price\ at\ time\ t}{Price\ at\ time\ (t-1)} - 1}$$

Month	LDOF Returns	FTSE MIB Composite Returns
Feb-22	25,35%	-5,21%
Jan 22	1,30%	-1,95%
Dec 21	5,32%	5,94%
Nov-21	-5,62%	-3,95%
Oct 21	-10,91%	4,64%
Sep 21	3,13%	-1,25%
Aug 21	3,95%	2,55%
Jul 21	-2,58%	1,04%
Jun 21	-4,19%	-0,27%
May 21	4,65%	4,26%
Apr-21	-1,59%	-2,06%
Mar-21	4,13%	7,88%
Feb-21	15,59%	5,92%
Jan 21	-2,94%	-2,97%
Dec 20	-2,54%	0,78%

[172] In this case, Investing.com already computes the adjusted closing prices for the time-range indicated, filtered by month. Nonetheless, the logic behind the automatic calculations of the website remains the same as the ones of the formula for the calculation of the return of a stock.

Nov-20	48,34%	22,95%
Oct 20	-18,24%	-5,64%
Sep 20	-11,79%	-3,15%
Aug 20	4,77%	2,84%
Jul 20	-8,31%	-1,46%
Jun 20	5,36%	6,47%
May 20	-11,03%	2,87%
Apr-20	3,66%	3,75%
Mar-20	-34,27%	-22,44%
Feb-20	-17,37%	-5,39%
Jan 20	6,99%	-1,15%
Dec 19	-1,55%	1,06%
Nov-19	1,97%	2,49%
Oct 19	-3,52%	2,65%
Sep 19	-3,05%	3,68%
Aug 19	0,82%	-0,35%
Jul 19	-0,94%	0,77%
Jun 19	12,10%	7,23%
May 19	-3,43%	-9,50%
Apr-19	-0,63%	2,80%
Mar-19	16,85%	3,03%
Feb-19	4,82%	4,71%
Jan 19	10,16%	7,68%
Dec 18	-11,81%	-4,51%
Nov-18	-9,22%	0,73%
Oct 18	-7,61%	-8,02%
Sep 18	7,56%	2,18%
Aug 18	-5,85%	-8,76%
Jul 18	21,07%	2,73%
Jun 18	-2,96%	-0,72%
May 18	-9,22%	-9,15%
Apr-18	2,47%	7,00%
Mar-18	5,97%	-0,87%
Feb-18	-8,95%	-3,83%
Jan 18	-2,02%	7,57%
Dec 17	-1,20%	-2,30%
Nov-17	-32,30%	-1,87%
Oct 17	-6,44%	0,43%
Sep 17	11,54%	4,74%
Aug 17	-3,53%	0,85%
Jul 17	1,24%	4,39%
Jun 17	-7,21%	-0,71%
May 17	8,66%	0,59%

Apr-17	8,58%	0,57%
Mar-17	2,47%	8,35%

Using the monthly returns, a regression analysis has been conducted on the data collected for Leonardo SpA's returns against the ones of the FTSE MIB index. The regression analysis estimated the two unknowns of the equation:

$$\boldsymbol{R_i} = \boldsymbol{a} + (\ \boldsymbol{b} * \boldsymbol{Rm}\ )$$

- The intercept "$\boldsymbol{a}$" (orange in the "coefficients" table): ≈ **0,0098**
- The slope "$\boldsymbol{b}$" (blue in the "coefficients" table): $\approx \mathbf{1,3561}$
- **R squared** (green in the "Regression Statistics" table): ≈ **0,4499**

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,670817049
R Square	0,449995513
Adjuster R Square	0,440512677
Standard Error	0,091542001
Observations	60

ANOVA

	gdl	*SQ*	*MQ*	*F*	*Significance F*
Regression	1	0,397658935	0,397658935	47,4536851	4,50735E-09
Residual	58	0,486036399	0,008379938		
Total	59	0,883695333			

	Coefficients	*Standard Error*	*t Stat*	*P - value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*

Intercept (a)	-0,009851696	0,011893001	-0,828360803	0,410861985	-0,033658123	0,013954732	-0,033658123	0,013954732
Variable X 1 (b)	1,356057422	0,196853485	6,888663521	4,50735E-09	0,962012359	1,750102485	0,962012359	1,750102485

The returns equation for Leonardo SpA becomes:

$$\boldsymbol{Returns\_LDOF} = \mathbf{-0,009851696 + 1,356057422} * \boldsymbol{Returns\_FTSEMIB}$$

PART B – EVALUATION OF THE JENSEN'S ALPHA (α)

Since the formula for the monthly Jensen's Alpha is:

$$Jensen's Alpha = a - Rf * (1 - b)$$

Where:

- The intercept "***a***" and the slope "***b***" are the one calculated in the previous part
- The annualized risk free rate, as of 28.02.2022 (ending date of the evaluations), is:

$$\boldsymbol{Rf} = \mathbf{0.893}\% \quad (^{173})$$

$$\frac{\boldsymbol{Rf}}{\mathbf{12}} = \frac{\mathbf{0.893}}{\mathbf{12}} \approx \mathbf{0.074\%}$$

The result for the monthly Jensen's Alpha is:

$$Jensen's Alpha = a - Rf * (1 - b)$$

$$Jensen's Alpha = -0{,}009851696 - 0.074\% * (1 - 1{,}356057422)$$

$$\mathbf{-0,959\%}$$

[173] From Investing.com.

Annualized Jensen’s Alpha is:

$$Annualised\ Jensen's\ Alpha = (1 + Monthly\ Jensen's Alpha)^{12} - 1$$ [174]

$$Annualised\ Jensen's\ Alpha = (1 + (-\ 0{,}959)\ )^{12} - 1$$

12,13%

[174] (Damodaran, 2011)

APPENDIX B

The cost of capital (WACC) can be computed with the estimates of the costs of equity and debt and the weights of each of the components:

$$K_{FIRM} = (X_{DEBT} * K_{DEBT}) + (X_{EQUITY} * K_{EQUITY})$$

*Cost of capital for the FIRM = (Weight of Debt * After Tax Cost of Debt) + (Weight of Equity * Cost of Equity)*

In order to understand the composition of the WACC's formula it is useful to divide it into:

- The **ORANGE** part of the formula, that is the **DEBT PART**.
- The **YELLOW** part of the formula, that is the **EQUITY PART**.

STEP 1 – Cost of Equity for Leonardo SpA

$$E(r_i) = r_f + \beta_i [E(r_m) - r_f]$$

This means that:

Expected Return of Leonardo's Equity = Risk-free Rate + Beta * (Expected Return on the Market Portfolio - Risk-free Rate)

Since:

- Expected Return is also known as Cost of Equity
- The Risk-Free Rate - Rfr = 5 yrs italian bond = **0,893%**
- Market Risk Premium for Italy = (Erm-Rfr) = **6,42%**[175]

[175] (Damodaran, 2022)

- Beta of the company (βi) = 1,356057422 ≈ **1,36**%

Cost of equity for Leonardo SpA = 0,893% + 1,36 * (6,42%) = 0,09598889 = **9,59%**

Step 2 – Evaluation of the after-tax cost of debt

The after-tax cost of debt can be defined as:

Cost of Debt = borrowing rate x (1 – tax rate) ([176])

Since the cost of debt is defined as the after-tax cost of debt, the borrowing rate as the before-tax cost of debt and the optimal tax rate is the corporate tax rate, the formula becomes:

After-Tax Cost of Debt = Before-Tax Cost of Debt x (1 – Corporate tax rate)

Where:

- **Before-Tax Cost of Debt** = Risk-Free rate + Default Spread of Debt = 0,893% + 0,67% = **1,563%**

- Corporate Tax rate = 27,8% from OECD Statistics[177]

Thus, the After-Tax cost of Debt is:

After-Tax Cost of Debt = Before-Tax Cost of Debt x (1 – Corporate tax rate)

[176] (Damodaran, 2011)
[177] (OECD Statistics, 2021)

After-Tax Cost of Debt *= 1,563% * (1 – 27,8%)*

After-Tax Cost of Debt *= 1,128486% ≈* ***1,13%***

STEP 3 – Estimation of the amounts and on the weights of equity and debt for Leonardo SpA

The computation on the weights of equity and debt requires a previous estimation of the amount of equity and debt of the company:

- **Amount of Equity** = actual Market Cap → **€ 5.360 Millions**
- **Amount of Debt** = Total Borrowings = Current Liabilities (*Passività correnti*) + LT debts (*Passività non correnti*) = € 15.596 Millions + € 6.328 Millions = **€ 21.924 Millions**
- **Total Amount of Capital** = Amount of Equity + Amount of Debt = € 21.924 Millions + € 5.360 Millions = **€ 27.284 Millions**

The weights of equity and debt correspond to the in-percentage contribution of each part to the total amount of capital of the firm:

- **Weight of Equity** = $\frac{\text{Amount of Equity}}{\text{Total amount of Capital}} = \frac{€\ 5.360\ \text{Mil}}{€\ 27.284\ \text{Mil}}$ = 0,196 = **19,6%**
- **Weight of Debt** = $\frac{\text{Amount of Debt}}{\text{Total amount of Capital}} = \frac{€\ 19.319\ \text{Mil}}{€\ 27.284\ \text{Mil}}$ = 0,804 = **80,4%**

The following table summarizes the results:

	Amount of Equity	Amount of Debt	Total amount of Capital	Weight of Equity	Weight of Debt
	(1)	(2)	(3)=(1)+(2)	(1)/(3)	(2)/(3)
Leonardo SpA	€ 5.360 Mil	€ 21.924 Mil	€ 27.284 Mil	0,196	0,804

Computations on amounts and weights of equity and debt for Leonardo SpA

STEP 4 – Estimation of the WACC

Data on the costs and on the weights of Equity and Debt for Leonardo SpA are summarized in the following table:

	Cost of Equity K_{EQUITY}	Cost of Debt K_{DEBT}	Weight of Equity X_{EQUITY}	Weight of Debt X_{DEBT}
	(a)	(b)	(c)	(d)
Leonardo SpA	9,59%	1,13%	0,196 = 19,6%	0,804 = 80,4%

Data summary for WACC

The next calculations display the computations for Leonardo SpA's Weighted Average Cost of Capital:

$$K_{FIRM} = (X_{DEBT} * K_{DEBT}) + (X_{EQUITY} * K_{EQUITY})$$

$$WACC = (Weight_{DEBT} * Cost_{DEBT}) + (Weight_{EQUITY} * Cost_{EQUITY})$$

$$WACC = (80,4\% * 1,13\%) + (19,6\% * 9,59\%)$$

$$WACC = 2,79\%$$

ROCE CALCULATION

ROCE is equal to:

$$ROCE = \frac{\text{EBIT}}{\text{Capital Employed}}$$

$$ROCE = \frac{\text{Earnings Before Interest and Tax expenses}}{(\text{Total Assets} - \text{Current Liabilities})}$$

All these elements can be extracted from Leonardo SpA's updated Balance Sheets[178] and Income Statements[179]. The following table summarizes the results:

	Measure	2019	2020	2021
Income Statement	EBIT (Gross Profit)	€ 5615 Mil	€ 5290 Mil	€ 5461 Mil
Balance Sheet	Total Assets	€ 26893 Mil	€ 27073 Mil	€ 28379 Mil
Balance Sheet	Current Liabilities	€ 15318 Mil	€ 15894 Mil	€ 15596 Mil

Leonardo SpA's balance sheets and income statements recap for EBIT, Total Assets and Current Liabilities in 2019, 2020, 2021

[178] (Investing.com, 2022)
[179] (Investing.com, 2022)

The next table displays the results for the ROCE in each year analyzed:

	EBIT	Total Assets	Current Liabilities	Capital Employed	ROCE
	(a)	(b)	(c)	(d) = (b) – (c)	(e) = (a) / (d)
2019	€ 5615 Mil	€ 26893 Mil	€ 15318 Mil	€ 11575 Mil	0,485 = 48%
2020	€ 5290 Mil	€ 27073 Mil	€ 15894 Mil	€ 11179 Mil	0,473 = 47%
2021	€ 5461 Mil	€ 28379 Mil	€ 15596 Mil	€ 12783 Mil	0,427 = 43%

Leonardo SpA's ROCE calculation in 2019, 2020, 2021

APPENDIX C

Dividend Payout Ratio Analysis

According to Hayes et al., the Dividend Payout Ratio can be calculated as:

$$Dividend\ Payout\ Ratio = \frac{Dividends\ Paid}{Total\ Net\ Income} \qquad ([180])$$

Data on "Dividends Paid" and on "Total Net Income" has been taken from Leonardo SpA 2019, 2020, 2021 Balance Sheets and Income Statements, provided in the official archive of the company[181].
In particular:

- Dividends Paid: under the heading "Dividends Paid" in the *Consolidated Statement of Cash Flows*.

- Total Net Income: under the heading "Net Profit/(Loss) for the Period" in the *Consolidated Separate Income Statement*.

The next section displays the exports of the financial statements for each year (2019, 2020, 2021) and computes the calculation of the Dividend Payout Ratio.

[180] (Hayes, et al., 2022)
[181] (Leonardo SpA, 2022)

2019[182]

Consolidated Statement of Cash Flows 2019

Annual financial report at 31 December 2019 – Consolidated financial statements

Consolidated statement of cash flows

(€ millions)	***Note***	**2018**	***of which with related parties***	**2019**	***of which with related parties***
Gross cash flows from operating activities	*35*	1,669		1,847	
Change in trade receivables/payables, contract assets/liabilities and inventories	*35*	(321)	*150*	(528)	*164*
Change in other operating assets and liabilities and provisions for risks and charges	*35*	(440)	*(26)*	(390)	*(40)*
Interest paid		(235)	*3*	(216)	*1*
Income taxes received/(paid)		14	-	(68)	-
Cash flows generated (used) from operating activities		**687**		**645**	
Investments in property, plant and equipment and intangible assets		(577)		(594)	
Sales of property, plant and equipment and intangible assets		24		17	
Other investing activities		203	-	111	-
Cash flows generated (used) from investing activities		**(350)**		**(466)**	
Term Loan and BEI Subscription		498		300	
Bond redemption		(513)		(423)	
Net change in other loans and borrowings		(91)	*(75)*	(58)	*1*
Dividends paid		(81)		(81)	
Cash flows generated (used) from financing activities		**(187)**		**(262)**	
Net increase (decrease) in cash and cash equivalents		150		(83)	
Exchange rate differences and other changes		6		2	
Cash and cash equivalents at 1 January		1,893		2,049	
Net increase (decrease) in cash of discontinued operations		-		(6)	
Cash and cash equivalents at 31 December		**2,049**		**1,962**	

The data at 31 December 2019 have been determined by applying IFRS 16. On the contrary, the data for the comparative period have not been restated in accordance with the transition rules set forth and described in Note 5.

Consolidated Separate Income Statement 2019

[182] Both the statements have been taken from the same source: *Annual Financial Report 2019* (Leonardo SpA, 2020)

Consolidated accounting statements

Consolidated separate income statement

(€ millions)	*Note*	2018	*of which with related parties*	2019	*of which with related parties*
Revenues	*27*	12,240	*1,811*	13,784	*1,895*
Other operating income	*28*	599	*6*	551	*4*
Purchase and personnel expenses	*29*	(11,173)	*(565)*	(12,136)	*(669)*
Amortisation, depreciation and financial assets value adjustments	*30*	(656)		(619)	
Other operating expenses	*28*	(511)	*(1)*	(587)	*(1)*
Income before tax and financial expenses		**499**		**993**	
Financial income	*31*	148	*7*	168	*5*
Financial expenses	*31*	(396)	*(4)*	(475)	*(4)*
Share of profits/(losses) of equity-accounted investees	*12*	234		183	
Operating profit (loss) before income taxes and discontinued operations		**485**		**869**	
Income taxes	*32*	(64)		(147)	
Profit (loss) from discontinued operations	*33*	89		100	
Net profit/(loss) for the period attributable to:		**510**		**822**	
- owners of the parent		*509*		*821*	
- non-controlling interests		*1*		*1*	
Earnings/(losses) per share	*34*	*0.888*		*1.428*	
- basic and diluted from continuing operations		*0.733*		*1.254*	
- basic and diluted from discontinued operations		*0.155*		*0.174*	

The data at 31 December 2019 have been determined by applying IFRS 16. On the contrary, the data for the comparative period have not been restated in accordance with the transition rules set forth and described in Note 5.

COMPUTATIONS 2019:

$$Dividend\ Payout\ Ratio = \frac{Dividends\ Paid}{Total\ Net\ Income}$$

$$Dividend\ Payout\ Ratio = \frac{€\ 81\ Mil}{€\ 822\ Mil} = 0{,}098 = 9{,}8\%$$

2020[183]

Consolidated Statement of Cash Flows 2020

Consolidated Financial Statements at 31 December 2020

Consolidated statement of cash flows

(€ millions)	*Note*	*2019*	*of which with related parties*	*2020*	*of which with related parties*
Gross cash flows from operating activities	35	1,847		1,701	
Change in trade receivables/payables, contract assets/liabilities and inventories	35	(528)	164	(656)	(117)
Change in other operating assets and liabilities and provisions for risks and charges	35	(390)	(40)	(425)	(112)
Interest paid		(216)	1	(247)	(2)
Income taxes received/(paid)		(68)	-	(98)	-
Cash flows generated (used) from operating activities		**645**		**275**	
Investments in property, plant and equipment and intangible assets		(594)		(311)	
Sales of property, plant and equipment and intangible assets		17		18	
Other investing activities		111	-	(145)	-
Cash flows generated (used) from investing activities		**(466)**		**(438)**	
Bond issue		-		492	
BEI Subscription and CDP Loan		300		100	100
Bond redemption		(423)		-	
Net change in other borrowings		(58)	1	(51)	65
Dividends paid		(81)		(81)	
Cash flows generated (used) from financing activities		**(262)**		**460**	
Net increase (decrease) in cash and cash equivalents		(83)		297	
Exchange rate differences and other changes		2		(46)	
Cash and cash equivalents at 1 January		2,049		1,962	
Net increase (decrease) in cash of discontinued operations		(6)		-	
Cash and cash equivalents at 31 December		**1,962**		**2,213**	

Consolidated Separate Income Statement 2020

[183]Both the statements have been taken from the same source: *Integrated Annual Report 2020* (Leonardo SpA, 2021)

CONSOLIDATED ACCOUNTING STATEMENTS

Consolidated separate income statement

(€ millions)	*Note*	*2019*	*of which with related parties*	*2020*	*of which with related parties*
Revenues	*27*	13,784	*1,895*	13,410	*1,738*
Other operating income	*28*	551	*4*	655	*14*
Purchase and personnel expenses	*29*	(12,136)	*(669)*	(11,984)	*(1,169)*
Amortisation, depreciation and financial assets value adjustments	*30*	(619)		(795)	
Other operating expenses	*28*	(587)	*(1)*	(792)	*(1)*
Income before tax and financial expenses		**993**		**494**	
Financial income	*31*	168	*5*	147	*2*
Financial expenses	*31*	(475)	*(4)*	(414)	*(4)*
Share of profits/(losses) of equity-accounted investees	*12*	183		26	
Operating profit (loss) before income taxes and discontinued operations		**869**		**253**	
Income taxes	*32*	(147)		(12)	
Profit (loss) from discontinued operations	*33*	100		2	
Net profit/(loss) for the period attributable to:		**822**		**243**	
- owners of the parent		*821*		*241*	
- non-controlling interests		*1*		*2*	
Earnings/(losses) per share	*34*	*1.428*		*0.419*	
- basic and diluted from continuing operations		*1.254*		*0.416*	
- basic and diluted from discontinued operations		*0.174*		*0.003*	

COMPUTATIONS 2020:

$$Dividend\ Payout\ Ratio = \frac{Dividends\ Paid}{Total\ Net\ Income}$$

$$Dividend\ Payout\ Ratio = \frac{€\ 81\ Mil}{€\ 243\ Mil} = 0{,}333 = 33{,}3\%$$

2021[184]

Consolidated Statement of Cash Flows 2021

Consolidated Financial Statements at 31 December 2021

Consolidated statement of cash flows

(€ millions)	*Note*	**2020**	*of which with related parties*	**2021**	*of which with related parties*
Gross cash flows from operating activities	*35*	1,701		1,623	
Change in trade receivables/payables, contract assets/liabilities and inventories	*35*	(656)	*(117)*	(643)	*1*
Change in other operating assets and liabilities and provisions for risks and charges	*35*	(425)	*(112)*	(2)	*78*
Interest paid		(247)	*(2)*	(183)	*(3)*
Income taxes received/(paid)		(98)	-	(53)	-
Cash flows generated (used) from operating activities		**275**		**742**	
Investments in property, plant and equipment and intangible assets		(311)		(615)	
Sales of property, plant and equipment and intangible assets		18		19	
Other investing activities	*35*	(145)	-	55	-
Cash flows generated (used) from investing activities		**(438)**		**(541)**	
Bond issue	*21*	492		-	
BEI Loan and term loan subscription	*21*	-		800	
CDP Loan	*21*	100	*100*	-	-
Bond redemption	*21*	-		(739)	
Net change in other borrowings		(51)	*65*	(31)	*73*
Dividends paid		(81)		-	
Cash flows generated (used) from financing activities		**460**		**30**	
Net increase (decrease) in cash and cash equivalents		297		231	
Exchange rate differences and other changes		(46)		35	
Cash and cash equivalents at 1 January		1,962		2,213	
Cash and cash equivalents at 31 December		**2,213**		**2,479**	

Consolidated Separate Income Statement 2021

184 Both the statements have been taken from the same source: *Annual Report 2021* (Leonardo SpA, 2022)

CONSOLIDATED ACCOUNTING STATEMENTS AT 31 DECEMBER 2021

Consolidated separate income statements

(€ millions)	*Note*	*2020*	*of which with related parties*	*2021*	*of which with related parties*
Revenues	*27*	13,410	*1,738*	14,135	*1,818*
Other operating income	*28*	655	*14*	573	*5*
Purchase and personnel expenses	*29*	(11,984)	*(1,169)*	(12,770)	*(1,134)*
Amortisation, depreciation and financial assets value adjustments	*30*	(795)		(525)	
Other operating expenses	*28*	(792)	*(1)*	(626)	-
Income before tax and financial expenses		**494**		**787**	
Financial income	*31*	147	*2*	137	*1*
Financial expenses	*31*	(414)	*(4)*	(309)	*(4)*
Share of profits/(losses) of equity-accounted investees	*12*	26		138	
Operating profit (loss) before income taxes and discontinued operations		**253**		**753**	
Income taxes	*32*	(12)		(166)	
Profit (loss) from discontinued operations	*33*	2		-	
Net profit/(loss) for the period attributable to:		**243**		**587**	
- owners of the parent		*241*		*586*	
- non-controlling interests		*2*		*1*	
Earnings/(losses) per share	*34*	*0.419*		*1.019*	
- basic and diluted from continuing operations		*0.416*		*1.019*	
- basic and diluted from discontinued operations		*0.003*		*0.000*	

COMPUTATIONS 2021:

Since Dividends in 2021 *have not been paid out,*

it is not possible to compute the Dividend Payout Ratio.

8. References

Adam Hayes, M. J. K. M., 2021. *Interest Coverage Ratio.* [Online] Available at: https://www.investopedia.com/terms/i/interestcoverageratio.asp [Accessed 03 2022].

Aimasso, A., 2021. *L'asteroide 16 Psyche: una "miniera d'oro" nello spazio.* [Online] Available at: https://sciencecue.it/asteroide-16-psyche-miniera-oro-spazio-nasa/32870/
[Accessed 08 2022].

Akhilesh Ganti, G. S. T. L., 2022. *Credit Spread.* [Online] Available at: https://www.investopedia.com/terms/c/creditspread.asp [Accessed 03 2022].

ASI - Italian Space Agency, 2016. *Strategic Vision Document 2016 - 2025,* s.l.: s.n.

ASI - Italian Space Agency, 2022. *THE ITALIAN SPACE AGENCY IN SHORT: PROFILE AND ACTIVITIES.* [Online]
Available at: https://www.asi.it/en/the-agency/the-italian-space-agency-in-short-profile-and-activities/
[Accessed 09 2022].

Avio SpA, 2022. *Partners and Customers.* [Online] Available at: https://www.avio.com/partners-customers-avio [Accessed 05 2022].

Avio SpA, 2022. *Who we are.* [Online] Available at: https://www.avio.com/who-we-are [Accessed 05 2022].

B. Murphy , C., Smith, A. & Perez, Y., 2021. *Retention Ratio.* [Online] Available at: https://www.investopedia.com/terms/r/retentionratio.asp [Accessed 08 2022].

Blue Origin, 2022. *About Blue Origin.* [Online] Available at: https://www.blueorigin.com/about-blue/ [Accessed 08 2022].

Blue Origin, 2022. *Blue Moon - Back to the Moon - to stay.* [Online] Available at: https://www.blueorigin.com/blue-moon/ [Accessed 08 2022].

Blue Origin, 2022. *New Shepard - Suborbital Spaceflights.* [Online] Available at: https://www.blueorigin.com/new-shepard/ [Consultato il giorno 08 2022].

Borsa Italiana, 2022. *FTSE MIB.* [Online] Available at: https://www.borsaitaliana.it/borsa/indici/indici-in-continua/dettaglio.html?indexCode=FTSEMIB&lang=en
[Accessed 02 2022].

Borsa Italiana, n.d. *Alfa di Jensen.* [Online] Available at: https://www.borsaitaliana.it/borsa/glossario/alfa-di-jensen.html [Accessed 02 2022].

Bryce Tech, 2022. *Start-Up Space Report 2022.* [Online] Available at: https://brycetech.com/reports [Accessed 07 2022].

Cavezzali, E. & Rigoni, U., 2020. *Corporate Finance & Financial Institutions.* s.l.:McGraw Hill.

Chen, J., 2022. *Systematic Risk.* [Online] Available at: https://www.investopedia.com/terms/s/systematicrisk.asp [Accessed 06 2022].

Congress of Unites States of America, 2015. *Congress.gov.* [Online] Available at: https://www.congress.gov/bill/114th-congress/house-bill/2262 [Accessed 08 2022].

ConsenSys Space, 2022. *Consensys Space.* [Online] Available at: https://www.consensys.space [Accessed 08].

Corporate Finance Institute, n.d. *Cost of Debt.* [Online] Available at: https://corporatefinanceinstitute.com/resources/knowledge/finance/cost-of-debt/ [Accessed 02 2022].

Cottone, N., 2018. Space economy, Battiston: «Dall'integrazione di big data spaziali e terrestri applicazioni sempre più sofisticate». *Il Sole 24 Ore,* 08 06.

Damodaran, A., 2011. *Applied Corporate Finance.* New York: John Wiley & Sons, Inc.

Damodaran, A., 2022. *Aswath Damodaran.* [Online] Available at: https://pages.stern.nyu.edu/~adamodar/ [Accessed 2022].

Damodaran, A., 2022. *Country Default Spreads and Risk Premiums.* [Online] Available at: http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/ctryprem.html [Accessed 03 2022].

Damodaran, A., 2022. *Ratings, Interest Coverage Ratios and Default Spread.* [Online] Available at: https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/ratings.html [Accessed 03 2022].

Deep Space Industries, 2022. *Deep Space Industries - Discover Adapt Enhance.* [Online] Available at: https://deepspace.industries/en/ [Accessed 08 2022].

Eggen, O. J., 2021. *Tycho Brahe Danish Astronomer.* [Online] Available at: https://www.britannica.com/biography/Tycho-Brahe-Danish-astronomer [Accessed 02 2022].

ESA - European Space Agency, 2017. *ESA Euronews: I 60 anni dello Sputnik, il satellite che cambiò il mondo.* [Online] Available at: https://www.esa.int/Space_in_Member_States/Italy/ESA_Euronews_I_60_anni_dello_Sputnik_il_satellite_che_cambio_il_mondo
[Accessed 02 2022].

ESA - European Space Agency, 2019. *A HISTORY OF ASTROMETRY - MAPPING THE SKY FROM ANCIENT TO PRE-MODERN TIMES.* [Online] Available at: https://sci.esa.int/web/gaia/-/53196-the-oldest-sky-maps [Accessed 01 2022].

ESA - European Space Agency, 2019. *A HISTORY OF ASTROMETRY - PART II TELESCOPE IGNITES THE RACE TO MEASURE STELLAR DISTANCES.* [Online] Available at: https://sci.esa.int/web/gaia/-/53197-seeing-and-measuring-farther [Accessed 01 2022].

ESA - European Space Agency, 2019. *A HISTORY OF ASTROMETRY - PART III ASTROMETRY MOVES TO SPACE: THE MAPMAKERS GUIDE TO THE GALAXY.* [Online] Available at: https://sci.esa.int/web/gaia/-/53198-astrometry-in-space [Accessed 02 2022].

ESA - European Space Agency, 2019. *ESA commissions world's first space debris removal.* [Online]
Available at: https://www.esa.int/Space_Safety/Clean_Space/ESA_commissions_world_s_first_space_debris_removal
[Accessed 08 2022].

ESA - European Space Agency, 2020. *The current state of space debris.* [Online] Available at: https://www.esa.int/Space_Safety/Space_Debris/The_current_state_of_space_debris [Accessed 08 2022].

ESA - European Space Agency, 2021. *What is EGNOS?.* [Online] Available at: https://www.euspa.europa.eu/european-space/egnos/what-egnos [Accessed 08 2022].

ESA - European Space Agency, 2022. *About ARTES - Advanced Research in Telecommunications Systems.* [Online] Available at: https://www.esa.int/Applications/Telecommunications_Integrated_Applications/ARTES/About_ARTES
[Accessed 05 2022].

ESA - European Space Agency, 2022. *Europe's Copernicus programme.* [Online] Available at: https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Europe_s_Copernicus_programme
[Accessed 08 2022].

ESA - European Space Agency, 2022. *Member States & Cooperating States.* [Online] Available at: https://www.esa.int/About_Us/Corporate_news/Member_States_Cooperating_States [Accessed 08 2022].

ESA - European Space Agency, 2022. *WHAT IS ASTROMETRY?.* [Online] Available at: https://www.cosmos.esa.int/web/hipparcos/astrometry [Accessed 01 2022].

EUSPA EO and GNSS, 2022. *EUSPA EO and GNSS Market Report 2022,* s.l.: Editor's Special.

Fernando, J., Boyle, M. J. & Clarine, S., 2021. *Dividend Yield.* [Online] Available at: https://www.investopedia.com/terms/d/dividendyield.asp [Accessed 05 2022].

Hayes, A., 2020. *Optimal Capital Structure.* [Online] Available at: https://www.investopedia.com/terms/o/optimal-capital-structure.asp [Accessed 02 2022].

Hayes, A., 2021. *Return on Capital Employed (ROCE).* [Online] Available at: https://www.investopedia.com/terms/r/roce.asp [Accessed 03 2021].

Hayes, A., James, M. & Perez, Y., 2022. *Return on Capital Employed (ROCE).* [Online] Available at: https://www.investopedia.com/terms/r/roce.asp [Accessed 05 2022].

Hayes, A., James, M. & Rathburn, P., 2022. *Dividend Payout Ratio.* [Online] Available at: https://www.investopedia.com/terms/d/dividendpayoutratio.asp [Accessed 03 2022].

Investing.com, 2022. *Investing.com.* [Online] Available at: https://it.investing.com/indices/it-mib-40 [Accessed 02 2022].

Investing.com, 2022. *Italy 5-Year Bond Yield.* [Online] Available at: https://www.investing.com/rates-bonds/italy-5-year-bond-yield [Accessed 2022].

Investing.com, 2022. *Leonardo SpA (LDOF).* [Online] Available at: https://www.investing.com/equities/finmeccanica [Accessed 02 2022].

Investing.com, 2022. *Leonardo SpA (LDOF) - Balance Sheet.* [Online] Available at: https://www.investing.com/equities/finmeccanica-balance-sheet [Accessed 04 2022].

Investing.com, 2022. *Leonardo SpA (LDOF) - Income Statement.* [Online] Available at: https://www.investing.com/equities/finmeccanica-income-statement [Accessed 04 2022].

James Chen, M. J. B. A. C., 2020. *Jensen's Measure.* [Online] Available at: https://www.investopedia.com/terms/j/jensensmeasure.asp [Accessed 02 2022].

Jason Fernando, S. S. P. R., 2022. *Market Capitalization.* [Online] Available at: https://www.investopedia.com/terms/m/marketcapitalization.asp [Accessed 03 2022].

Jones, A. R., 2021. *Ptolemy Egyptian astronomer, mathematician, and geographer.* [Online] Available at: https://www.britannica.com/biography/Ptolemy [Accessed 01 2022].

Kenton, W., Westfall, P. & Belluco-Chatham, A., 2022. *Beta.* [Online] Available at: https://www.investopedia.com/terms/b/beta.asp [Accessed 06 2022].

Leonardo S.p.A., 2020. *Highlights Finanziari - EBIT.* [Online] Available at: https://www.leonardo.com/it/investors/results-and-reports/financial-highlights
[Accessed 03 2022].

Leonardo SpA, 2018. *A legacy leading to the future.* [Online] Available at: https://www.leonardo.com/documents/20142/101046/A_Legacy_Leading_To_The_Future.pdf/cb335a92-1626-11d9-8361-d7ea34abeb8e?t=1562577017592
[Accessed 05 2022].

Leonardo SpA, 2020. *Annual Financial Report 2019,* s.l.: s.n.

Leonardo SpA, 2021. *Integrated Annual Report 2020,* s.l.: s.n.

Leonardo SpA, 2022. *Annual Report 2021,* s.l.: s.n.

Leonardo SpA, 2022. *Bilancio al 31 dicembre 2021 - Quarterly Reports.* [Online] Available at: https://www.leonardo.com/documents/15646808/16736384/Bilancio+integrato+2021+PER+SITO.pdf/bfe13091-99b8-5f28-bac4-d58255209c9b?t=1647598968852 [Accessed 03 2022].

Leonardo SpA, 2022. *Home / l'Azienda / Profilo / Aree di business.* [Online] Available at: https://www.leonardo.com/it/about/profile [Accessed 05 2022].

Leonardo SpA, 2022. *Il nuovo millennio e l'espansione internazionale.* [Online] Available at: https://www.leonardo.com/it/about/history [Accessed 05 2022].

Leonardo SpA, 2022. *Leonardo SpA - Infrastrutture.* [Online] Available at: https://space.leonardo.com/it/infrastructure [Accessed 05 2022].

Leonardo SpA, 2022. *Leonardo SpA - Servizi.* [Online] Available at: https://space.leonardo.com/it/servizi [Accessed 05 2022].

Leonardo SpA, 2022. *Quarterly Reports.* [Online] Available at: https://www.leonardo.com/it/investors/results-and-reports [Accessed 03 2022].

Leonardo SpA, 2022. *Results and Reports - Reports Archive.* [Online] Available at: https://www.leonardo.com/en/investors/results-and-reports [Accessed 06 2022].

Leonardo SpA, 2022. *Spazio - Space Aliance.* [Online] Available at: https://space.leonardo.com/it/home [Accessed 05 2022].

Lerman, R. & Zakrewski, C., 2022. Elon Musk's Starlink is keeping Ukrainians online when traditional Internet fails. *The Washington Post,* 19 03.

Loff, S., 2022. *Apollo 11 Mission Overview.* [Online] Available at: https://www.nasa.gov/mission_pages/apollo/missions/apollo11.html [Accessed 02 2022].

Loth, R., 2020. *Analyzing a Company's Capital Structure.* [Online] Available at: https://www.investopedia.com/articles/basics/06/capitalstructure.asp [Accessed 03 2021].

Loth, R., James, M. & Heller, C., 2022. *Analyzing a Company's Capital Structure.* [Online] Available at: https://www.investopedia.com/articles/basics/06/capitalstructure.asp [Accessed 05 2022].

Messeni Petruzzelli, A. & Panniello, U., 2019. *Space Economy. Storia e prospettive di business.* 2019 ed. s.l.:FrancoAngeli.

Moles, P., Parrino, R. & Kidwell, D. S., 2011. *Corporate Finance.* European Edition ed. s.l.:Wiley.

Morningstar, Inc., 2022. *Leonardo SpA - LDO.* [Online] Available at: https://tools.morningstar.co.uk/uk/stockreport/default.aspx?Site=uk&id=0P00009DKB&LanguageId=en-GB&SecurityToken=0P00009DKB]3]0]E0EXG%24XMIL [Accessed 25 03 2022].

Morningstar, Inc., 2022. *Morningstar, Inc..* [Online] Available at: https://www.morningstar.co.uk/uk/
[Accessed 03 2022].

NASA, 2021. *About the Hubble Space Telescope.* [Online] Available at: https://www.nasa.gov/mission_pages/hubble/about
[Accessed 03 2022].

NASA, 2022. *Artemis I - About the Mission.* [Online] Available at: https://www.nasa.gov/specials/artemis-i/
[Accessed 09 2022].

NASA, 2022. *Gateway - An Overview.* [Online] Available at: https://www.nasa.gov/gateway/overview
[Accessed 08 2022].

NASA, 2022. *Psyche Mission.* [Online] Available at: https://solarsystem.nasa.gov/missions/psyche/in-depth/
[Accessed 08 2022].

Nguyen, J., 2021. *Systemic Risk vs. Systematic Risk: What's the Difference?.* [Online] Available at: https://www.investopedia.com/ask/answers/09/systemic-systematic-risk.asp
[Accessed 06 2022].

OECD Statistics, 2021. *Statutory Corporate Income Tax Rates.* [Online] Available at: https://stats.oecd.org/Index.aspx?DataSetCode=CTS_CIT
[Accessed 25 03 2022].

OECD, 2016. *Space and Innovation.* [Online] Available at: https://read.oecd-ilibrary.org/science-and-technology/space-and-innovation_9789264264014-en#page30
[Accessed 02 2022].

OECD, 2019. *The Space Economy in Figures: How Space Contributes to the Global Economy.* [Online]
Available at: https://doi.org/10.1787/c5996201-en
[Accessed 05 2022].

Petroni, G. & Bianchi, D. G., 2016. *New patterns of space policy in the post-Cold War world.* [Online]
Available at: https://www.sciencedirect.com/science/article/pii/S0265964616300868
[Accessed 02 2022].

Sommariva, A., 2020. *The Evolution of Space Economy: The Role of the Private Sector and the Challenges for Europe.* [Online]
Available at: https://www.ispionline.it/en/pubblicazione/evolution-space-economy-role-private-sector-and-challenges-europe-28604
[Accessed 07 2022].

Space X, 2022. *Falcon 9.* [Online]
Available at: https://www.spacex.com/vehicles/falcon-9/
[Accessed 08 2022].

Space X, 2022. *Fancon Heavy - The World Most Powerful Rocket.* [Online]
Available at: https://www.spacex.com/vehicles/falcon-heavy/
[Accessed 08 2022].

Space X, 2022. *Starlink.* [Online]
Available at: https://www.starlink.com
[Consultato il giorno 08 2022].

Space X, 2022. *Starship SN15.* [Online]
Available at: https://www.spacex.com/vehicles/starship/
[Accessed 08 2022].

Statista, 2022. *Pokémon GO all-time IAP revenue worldwide 2016-2021 Published by J. Clement , Feb 2, 2022 In 2021, Pokémon GO in-app purchase revenues surpassed 904 million*

U.S. dollars worldwide. It was the mobile app's second-most profitable year since launching in. [Online]
Available at: https://www.statista.com/statistics/882474/pokemon-go-all-time-player-spending-countries/
[Accessed 05 2022].

Stiennon , P. J. G., 2018. Disruptive technology in space transportation. *The Space Review - Essays and Commentary About The Final Frontier,* 22 10.

The Editors of Encyclopaedia Britannica, 2022. *National Aeronautics and Space Administration - United States space agency.* [Online]
Available at: https://www.britannica.com/topic/NASA
[Accessed 07 2022].

The Nathalie P. Voorhees Center for Neighborhood and Community Improvement, University of Illinois at Chicago, 2020. *Economic Impact Study - National Aeronautics and Space Administration & Moon to Mars Program,* s.l.: s.n.

Tuovila, A., James , M. & Munichiello, K., 2021. *Corporate Credit Rating.* [Online]
Available at: https://www.investopedia.com/terms/c/corporate-credit-rating.asp
[Accessed 06 2022].

United Nations Office for Outer Space Affairs, 2022. *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.* [Online]
Available at:
https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html
[Accessed 03 2022].

Weinzierl, M., 2018. Space, the Final Economic Frontier. *Journal of Economic Perspectives,* 32(2), pp. 173 - 192.

Westfall, P., Munichiello, K. & Westfall, P., 2020. *Externality: What It Means in Economics, With Positive and Negative Examples.* [Online] Available at: https://www.investopedia.com/terms/e/externality.asp [Accessed 06 2022].

Westman, R. S., 2022. *Nicolaus Copernicus Polish Astronomer.* [Online] Available at: https://www.britannica.com/biography/Nicolaus-Copernicus [Accessed 02 2022].

Wilkinson, F., 2020. *The History of Space Exploration.* [Online] Available at: https://www.nationalgeographic.org/article/history-space-exploration/ [Accessed 02 2022].