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Development of the Global Value Chains in the Space Industry

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Abstract

With a remarkable breakthrough in the high-tech world of the space industry, new competitors, with their disruptive innovations, come on the scene to benefit the utmost portion of this potential economy. Since the space industry has had rapid growth in the last two decades and outreached the investment each year, the critical role of several countries and public and private actors is worth mentioning. Due to the value chain of the space industry, it should notice that main segments, upstream and downstream, passed from traditional space to the new space era. Hence, new business services introduced whose commercialization meets the most ratio in both investment and socio-economic impacts. Satellite services and ground equipment such as positioning, navigation, IoT, Geoinformation, and satellite images assess the farmers to have better use of agriculture 4.0 to enhance precision farming, including profitability, environmental sustainability, and the awareness and the interest of the consumers. The high-ranking position of Italy in the space industry in Europe is that important insomuch as the role of the agricultural industry is not deniable. With a focus on the sample of precision farming start-ups located in northern Italy and considering the fact that indexes indicate the great potential for growth, policymakers play a crucial role in facilitating the transition of innovation technology from the space industry to the agricultural industry.

Investing in research and innovation as long as monitoring space activities are the tasks that governments should take to support start-ups to become more applicable, ingenious, and innovative to create tangible socio-economic impacts.

Key Words: Value Chain, Space Economy, Innovation Technology, Precision Farming, Start-ups, Growth, Policy

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1 CHAPTER ONE

1.1 Introduction

This chapter discusses the background of the study, starting from a more expansive definition of the global value chain and the role of disruptive innovations in value-adding. It follows the broad definition of the Space Economy, including the fields and the applications. The global space economy was expressed, including the total investments in this industry with available forecasts. Also, the Italian space economy was introduced regarding the central institutions working in this sector.

1.2 Literature Review

The new era of life has been started by the globalization. Yet, globalization is not the only material for surviving in the multidimensional world. It is the combination of globalization and technology that become a fundamental driver leading to sustainable development. The co-founder of PayPal, Peter Thiel, stated that "In a world of scarce resources, globalization without new technology is unsustainable" (Thiel & Masters, 2014).

Taking this idea that globalization is a set of actions from one to hundred and technology is a complementary action of globalization from zero to one, the literature review is firstly organized on the globalization part and secondly it will go through technology aspects. Yet, the focus would be on technology aspects including disruptive innovations and its risk assessments.

It is said that when commodity products (such as agricultural commodities, crude oil, or unprocessed minerals) come to the commodity chain process in terms of creating, capturing and sustaining value extract the concept of 'value-added' in global supply chains (Sturgeon, 2008).

Thus, creating, capturing, and sustaining the value will leads to the 'value chain' into the process of the establishing the product or services until delivering the outcome to the end users.

Kogut (Kogut, 1985a) defines the value-added chain as 'the process by which technology is combined with material and labor inputs, and then processed inputs are assembled, marketed, and distributed. A single firm may consist of only one link in this process, or it may be extensively vertically integrated'. On the other hand, activities such as transportation, insurance, telecommunications, quality control, and management specifications are coordinating through service links which are defined as specialized 'production blocks'(Gereffi, 2018).

In terms of the definition, Global Value Chain (GVC) is emphasizing the relative value of those economic activities which are bringing a good or service from conception, adding value, and deliver it to the final consumer (Gereffi & Kaplinsky, 2001).

Adding to the definition, GVC provides top-down and bottom-up approach. The Former is mainly focus on the lead firms and the organization of the global industries and the latter has the particular attitude to the concept of 'upgrading' explaining the strategies implementing by countries, regions, and other economic stakeholders to maintain or improve their positions in the global economy (Gereffi et al., 2011). So, it could be assumed that the economic upgrading leads to the higher-value activities which scale up technology, knowledge, and skills to the higher levels (Gereffi et al., 2005). Thus high-skilled technology-intensive work such as breakthrough innovations in new goods and services, design, marketing, and finance is derived from the GVC approach even though that the overall proportion of knowledge would vary, for instance, in agriculture or in aerospace industry.

Start-ups should find their comparative and competitive advantages through asking this question that where the value-added should be broken across national borders and, what activities and technologies along the value-added chain a firm should concentrate its resources in (Gereffi, 2018). Answers may depend due to their business strategies. It is important to mention that economies of scale (related to an increase in market size); economies of scope (related to an increase in product lines supporting the fixed costs of logistics, control, or downstream links of the value-added chain); and learning (based on proprietary knowledge or experience) belongs to the sources of a firm's competitive advantage which are vital to survive in global markets (Kogut, 1985b).

Dividing firms into top and lead firms, tier 1, and tier 2, helping to identify their characteristics individually and mutually. For instance, top firms are specialized in a system integration role, while in tier 1, the production of major subsystems was outsourced, and tier 2 are suppliers of the smaller sub-systems. In addition, top tiers and tier 1 firms are building sophisticated trans-local pipelines, both intra-firm and inter-firm to build bridges between various industrial clusters as well as they are attractors for other firms and creating hub-and-spoke type industrial cluster (Turkina et al., 2016).

Enterprises are facing a wide range of risks on a day-to-day basis. There are also catastrophic risks from unexpected events such as global economic crises and natural disasters. The most recent ones are Covid-19 pandemic. Acemoglu stated that shocks in one location can easily spread to the rest of the network, generating cascade effects. If the supply network is highly interconnected, low productivity in one sector can potentially affect the entire economy, as downstream sectors will also suffer (Acemoglu et al., 2010).

The rise of the digital economy and its potential impact on trade, productivity, and jobs in both developed and developing countries is a hot topic. Even, the main source of competition between The US and China is interpret as dominant on digital economy and advanced technologies. Hence, new regulations for the players utilizing cutting-edge technologies it seems to be redefined as long as enacting new methods for future of manufacturing, the nature of work, and where and how value is being created and captured in the global economy (Gereffi, 2018).

The increasing digitization of supply chains and the emergence of dynamic internet-based lead firms signals a new era in the global economy**.** Digital revolution brought significant evolutions in space ecosystem. Applying big data analysis, development of the cloud, and using drones and satellites have brought significant advantages. However measuring these impact is not easy on the space ecosystem, yet some applications like precision farming, traffic management, and location-based services have matured and turned into full-fletched commercial services (*The Space Economy in Figures*, n.d.).

As the GVC was mentioned, the concept of value chain is defining as the full range of activities that firms, and workers perform to bring a product from its conception to end use and beyond. This includes activities such as research and development (R&D), design, production, marketing, distribution, and support to the final consumer. Thus, the role of the industrial clusters to provide connection in similar sectoral activities leading to added value is significant(Porter, 1998).

The linking circle between globalization and technology is innovation. Innovation by its general attitude is accelerating movement in both technology and globalization. Hence, the term innovation value chain defines as the process of transforming knowledge into new products and process by exploiting innovation to generate added value (Roper et al., 2008). Innovation value chain is proceeding into three phases of idea generation, conversion, and diffusion.

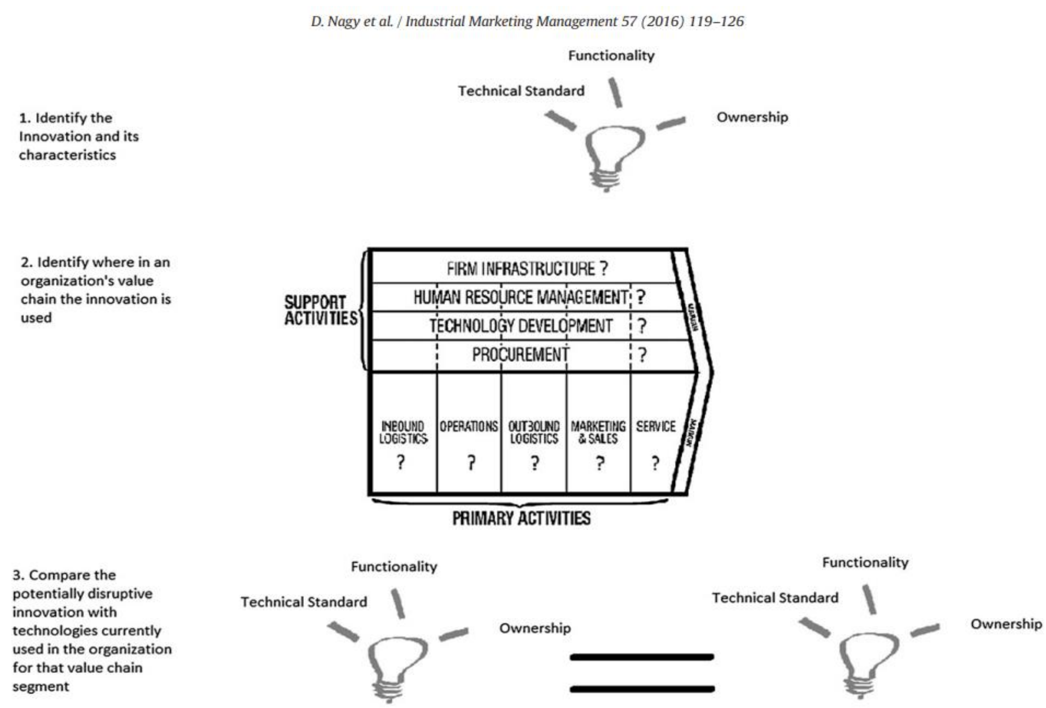
Innovation into the space technology is necessary but it is not solely sufficient factor in the new era of the globalization. New era of globalization and space technology are connecting with disruptive innovations. 'Disruption' describes a process whereby a smaller company with fewer resources is able to successfully challenges established incumbent businesses (Christensen et al., 2016).

Three steps to determine potential disruptive innovations were described as (Figure 1-1):

1. Identify the innovation and its characteristics which has the potential to change the markets with radical functionality, discontinuous technical standards, and an innovation's ownership (Thomond & Lettice, 2002).
2. Identify where in an organization's value chain the innovation is used. In support activities or in primary activities.
3. Compare the potentially disruptive innovation with technologies currently used in the organization for that value chain segment (Nagy et al., 2016)

The distribution of risks and opportunities is closely related to the positioning of an enterprise within a value chain and to the nature of this value chain. Hence, managers should consider about their company position within the value chain to facilitate their decisions on their business strategy. Regarding to the definition of disruptive innovation from Christensen (Christensen et al., 2016), there are two different types of disruptive innovations: new market innovations and low-end innovations. In space industry creating new demand for new technology and, conversely, providing similar characteristics to existing technologies with cost substantially less is still alive

Figure 1-1 Three Steps of determining potential disruptive innovations



and considerably evolving. For instance, the project of Starlink from SpaceX providing space-based broadband internet for a huge potential market without access to the internet. Economists recognize this innovation as a mega disruption. On the other hand, the same from SpaceX, Falcon 9 rocket which is capable to refly, drive down the cost of space access reusing the most expensive parts of the rocket.

Scientific and technological progress go hand-in-hand, and, similar to the science, technological progress is not always sustaining (hence evolutionary or revolutionary) but sometimes disruptive. A sustaining innovation does not significantly affect existing markets, while a disruptive innovation creates a new market by providing a different set of values, which ultimately (and unexpectedly) overtake an existing market (European Investment Bank et al., 2019).

Grimard (*Max Grimard*, n.d., 2012) stated that 'assuring the economical sustainability of space business segment along the full value chain guarantees that part of the money earned at the level of the downstream services to users can circulate backward, to fund the upstream space infrastructures'.

Table 1-1 Types of innovation—from sustaining to disruptive

Innovation Type	Description	Example
Evolutionary innovation	A type of sustaining innovation that improves a product in an existing market in ways that customers are expecting.	Fuel injection for gasoline engines, displacing carburetors.
Revolutionary innovation	A type of sustaining innovation that is discontinuous and/or radical, as well as unexpected, but nevertheless does not affect existing markets.	Automobiles in the late 19th century, being sold in few numbers as an expensive luxury item.
Disruptive innovation	An innovation, which creates a new market by providing a different set of values, which ultimately (and unexpectedly) overtakes an existing market.	Introduction of the lower-priced and affordable Ford Model T, which displaced horse-drawn carriages.

Source: (Christensen, 1997)

Also, the Six types of the business models of the space industry have been considered (*Max Grimard, n.d., 2012*):

- Classical institutional business model
- Government owned, company operated (GOCO)
- The concession model: Paradigm
- The co-ownership model: TerraSar-x
- A mature private business: Commercial Telecoms
- GPS applications, a pure Value-Added Services model

It seems that there are a high potential and a lot of opportunities for all the actors of the space value chain resulting in development for public or commercial market, and often a mix of both (*Max Grimard, n.d., 2012*).

According to the hand-collected dataset on formal firm linkages within and across 52 aerospace clusters in North America and Europe for the periods of 2002-2005, 2006-2009, and 2010-2014, industrial clusters have increasingly specialized in value chain stages over time, leading both an intensification of horizontal linkages within industrial clusters and the trans-localization (offshoring) of vertical linkages across clusters (Turkina et al., 2016).

As it was earlier discussed on this paper, space industry is knowledge-intensive industry which is cumulative accumulation of innovation and R&D. More generally, vertical supply chain relationships with suppliers leads to cost reduction and creates global value chains, while key knowledge is brought up from horizontal partnerships with firms (Turkina et al., 2016).

This OECD reports that how space contributes to the global economy documents emerging trends using original indicators, highlighting the growing importance of space activities for the economy, social well-being, and science. It further offers lessons learned to policymakers on fostering socio-economic impacts (*The Space Economy in Figures*, n.d.).

Comparing the data from the OECD handbook in 2019 and the newly released data is showing that the space economy is growing, and many countries are going to play their role on this matter. Public space budget has reached their largest amounts since the 1960s at $374 Billion in 2020, Even though global economy hit by the Covid-19, the data shows that it has less impact on the total space economy. Space applications, such as telecommunications and earth observation have top benefits include efficiency gains, cost savings and cost avoidances. The share of the women graduate in space engineering remains low in many OECD countries, despite governments and private sector efforts. Also, the past five years have seen exponential growth in the number of launches of very small satellites.

The United States leads in government space spending, with an estimated $48 billion spread among 11 agencies and offices. China follows at $11 billion, with the budget allocated to the military and civil space agency supported by a single contracting entity called China Aerospace Science and Technology Corporation (CASC). The space budget of the European Space Agency (ESA) is about $7 billion. ESA receives contributions from 22 member states, each state contributing funds based on its gross domestic product (GDP) (*Global Space Industry Dynamics*, 2017).

The European commission and the European Investment Bank are significantly considering the emergence of the space industry in Europe and its achievements in space with breakthrough technologies and exploration missions, such as EU space projects: Copernicus — Europe's Earth observation system — or Galileo, the satellite navigation and geo-positioning system (European Investment Bank et al., 2019), consequently bringing a large portion of opportunities for the SMEs and Start-ups in Euro zone. Hence,

The space industry designs, develops, and manufactures spacecraft and launchers, along with the associated ground systems for satellite control and operations. The space manufacturing industry is organized vertically with large and medium system integrators (capable of delivering a complete launcher or spacecraft to the launch pad) providing business to a wide range of equipment and service suppliers (capable of delivering integration ready subsystem, equipment, and components, or providing specialized services and tools supporting system design, integration and test). The industry is highly specialized and capital intensive. The sector is also rather concentrated; despite being distributed across all ESA member states (*Eurospace Facts & Figures*, n.d.).

In terms of innovative activity, Italy highlights a good result, ranking fifth among the main patenting countries, with a share of 4.1% on world patents relating to the Space Economy (years 2013-2018), which is compared with the eleventh position for the total of patents, revealing a good specialization in the activities space, as confirmed by the RTA (Revealed Technology Advantage) index, on values above 2, in the first places among the main economies (*Spazio Nuova Frontiera per Economia e Ricerca, 2021*).

The rapid development of innovation in the field of digital agriculture and agri-food chain, albeit in a chaotic frame of individual proposals, has highlighted an opportunity for a change of paradigm in establishing productivity in farms and of production areas. This has created a link between the production phase and product processing, to finally reaching the consumer (Donatelli & Pisante, 2019).

The final station of implementing space ecosystem disruptive innovations is the aim of this paper which is considering to the precision farming. It could be assumed that the links from space value chain would connect to the agriculture and food value chain through the precision farming. For instance, in the farm to fork strategy the ambitious targets are set into: a 50% reduction of the use and risk of chemical pesticides; at least 50% reduction of nutrient losses to ensure that there is no deterioration in soil fertility; and also enabling digital innovation for all rural areas to have access to fast broadband by 2025 (*Farm to Fork Strategy*, n.d.).

1.3 Space Economy

Space industry has almost always been a field of competition and development. Undoubtedly, space structure was one the main interests of human being from the beginning. There should be no precise data available of when exactly human being became interested into the space yet there are several evidence showings that species above the planet earth became a mysterious point of life for human being as primitive civilization was about to form. Space industry is firstly stablished to find answers to many questions that after millions of years still are remained unanswered such as the formation of the first galaxies. The most newly effort of human being on space was the launch of James Webb Space Telescope in order to investigate on space and collect the information across the fields of astronomy and cosmology in the hope of solving some queries.

Space industry is the fast-growing industry and sometimes is not assessable. Not only the rate of the governments does evolve, but also many new entrants join to this industry. The size of the active countries, companies and employees has been changed during the last decade.

Over the last seven years space industry changed its framework to augmented disruptive innovation industry through introducing new markets such as environmental management, military and security, and agriculture just to name a few. Space industry is a nomenclature which includes all activities residing in different fields of science and technology. Given the chronological background and its cutting-edge innovation of the space industry, this high technology industry should be surveyed under the key aspects of the economy.

The OECD handbook on measuring the space economy defines methodology and indicators into the framework which per se consists of three independent categories, as far as it expresses main objectives. Hence, the explanation of the same division would be absolute:

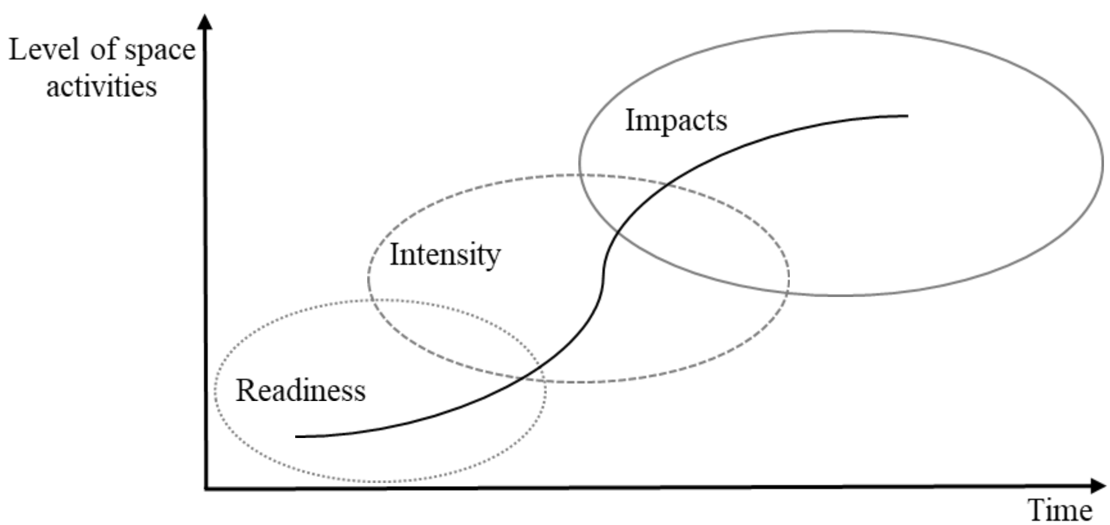
Readiness(input), Intensity(output), and Impacts

The readiness factors of the space economy, which include the different elements that are necessary for the development of space activities. These elements encompass the technical, financial, and social infrastructures that enable the production of space-related hardware or the provision of services, i.e., government budgets for space activities (both for public space programs and for R&D activities) and human capital (*OECD*, n.d., 2012).

The intensity indicators of the space economy, which are constituted by all the diverse outputs (products, services, science) that are produced or provided by the space sector. These outputs are very diverse in nature, from commercial revenues from industry, scientific outputs such as patents, to number of satellites, space missions or space launches (*OECD*, n.d., 2012).

The impacts indicators of the space economy, which include various types of socio-economic impacts derived from the development of space activities. Further work is certainly needed on the social dimensions of the use of space applications (e.g., reduction of the digital divide via satellite communications); they include: the creation of new commercial products and services, productivity/efficiency gains in diverse economic sectors (e.g., fisheries, airlines), economic growth regionally and nationally, and cost avoidances (e.g. floods) (*OECD*, n.d., 2012).

Figure 1-2 Development of the overall space economy



Source: (OECD, 2012a)

Figure 1-2 illustrates the different steps from readiness to impacts. There is a direct tie between the overall size of the space economy growth and the level of the space activities. To simply put, with the minimum of readiness factors dedicated such as government budgets for space activities, intensity of a space program starts to grow, and it finally leads to the more socio-economic impacts.

In comparison with an abundance of data which is available for the readiness factors (e.g., space budget) and the intensity factors (e.g., number of the space missions), there are less data available on impacts (e.g., industry surveys).

Talking about the space economy, it seems significant to consider all corners of the space industry under the lens of a unique framework. Thus, the framework should be the space industry value chain which will be discussed later 2.3).

Since the level of space activities and main concepts of the chain analysis were reviewed, it is time to propose the space economy definition. Still, the concept of space should be defined. A common measure includes everything that lies beyond the Karman Line, e.g., 100 kilometers above the Earth's Sea level (Fédération Aéronautique Internationale (FAI)). However, the U.S. Air Force sets 80 kilometers as a threshold, while the National Aeronautics and Space Administration (NASA) uses 122 kilometers as a re-entry altitude (Institute of Physics, 2010).

It seems that the space economy definition has been developed in align with its industry development. So, it begins with the broad definitions and will be completed with the narrow definition.

NASA has introduced the space economy 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 and utilizing space." (NASA, 2007)

NASA's definition and all similar definitions are not comprehensive due to not considering some important terms like R&D actors, the military fundings as long as they are ignoring scientific and space exploration programs.

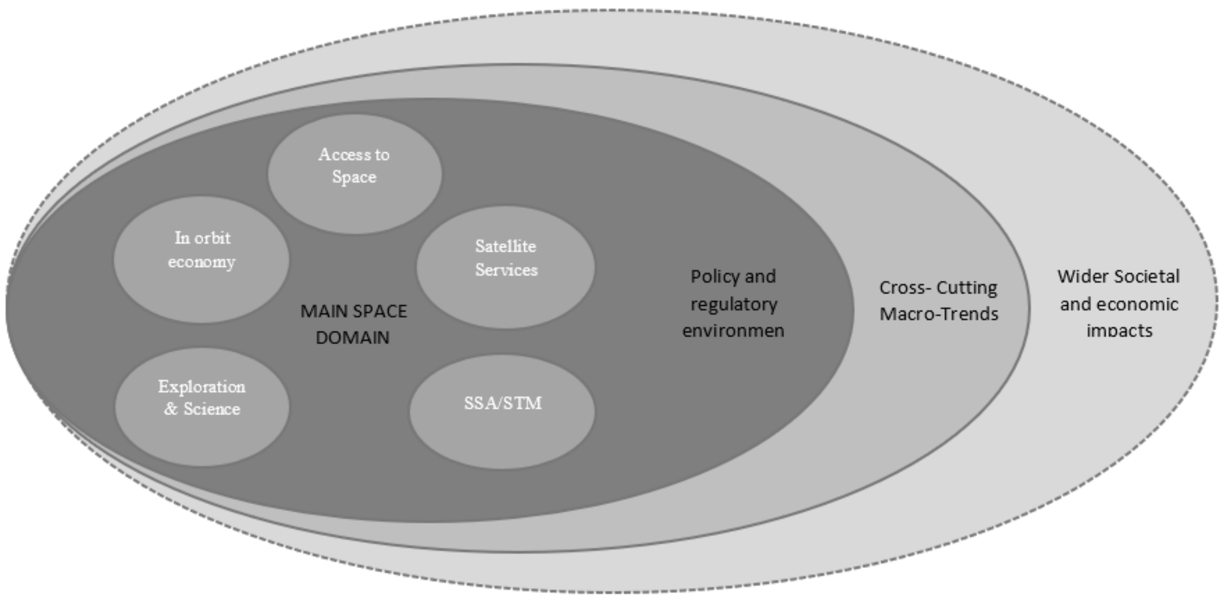
The OECD Secretariat has a narrower definition which is more targeted at value chains:

"The space economy includes: all public and private actors involved in developing and providing space-enabled products and services. It comprises a long value- added chain, starting with research and development actors and manufacturers of space hardware (e.g., launch vehicles, satellites, ground stations) and ending with the providers of space-enabled products (e.g., navigation equipment, satellite phones) and services (e.g., satellite-based meteorological services or direct-to-home video services) to final users." (OECD, 2012b)

Adding to the OECD definition, the socio-economic effects, which consist of both quantitative and qualitative factors, are changing economy and society. These factors are derived from space products, services, and knowledge (Figure 1-3).

Knowing the socio-economic impacts of the space industry are illustrating the route of investment on the space industry, as long as identifying most common benefits on selected economic sectors affected by space-related investments. Also, on the other hand, the more focus on the socio-economic effects, the better deficiencies will be detected. As it was also mentioned on the definition of space economy impacts indicators, it seems necessary to collect more data in terms of the socio-economic impacts of the space industry. Thus, OECD has done research on 77 publications collecting data between the range of 1972 to 2018 (*OECD, 2019*).

Figure 1-3 Space Economy



Source: (Scatteia, n.d.)

Correspondently, there are three main aspects are important to consider.

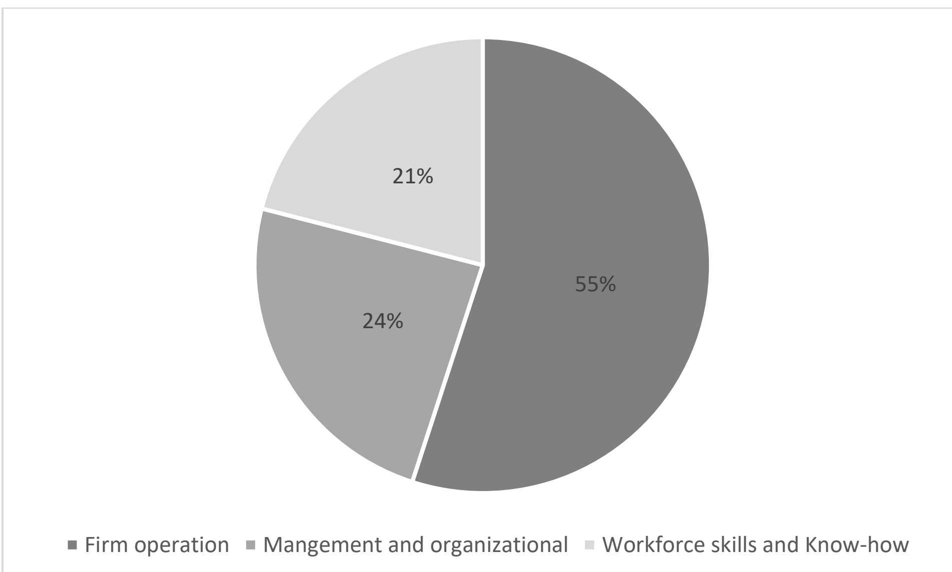
To begin with, Productivity and efficiency gains from space investment are categorized into the three main objectives:

- Firm level (in processes and in operation)
- Workforce (improvement in workers' skills and know-how)
- Managerial level (organizational benefits such as improved co-ordination and co-operation) (Figure 1-4)

In addition, socio- economic impacts derived from space investments also spread its benefits into the different sectors such as Environmental management, Climate monitoring and Meteorology, telecommunication, and agriculture (
Figure 1-5).

Furthermore, the type of positive effects derived from space investments, commercial revenues represent the top category (Figure 1-6). Commercial revenues are followed by effects on employment, with the creation of new jobs being observed. Productivity and efficiency gains represent another fundamental category of benefits. Many studies assess the socio-economic relevance of space activities at the national, regional or local level, taking a macroeconomic perspective (11.5%), assessing impacts on gross domestic product, value added and additional induced taxation (*The Space Economy in Figures*, n.d.).

Figure 1-4 Types of efficiency and productivity gains derived from space investments



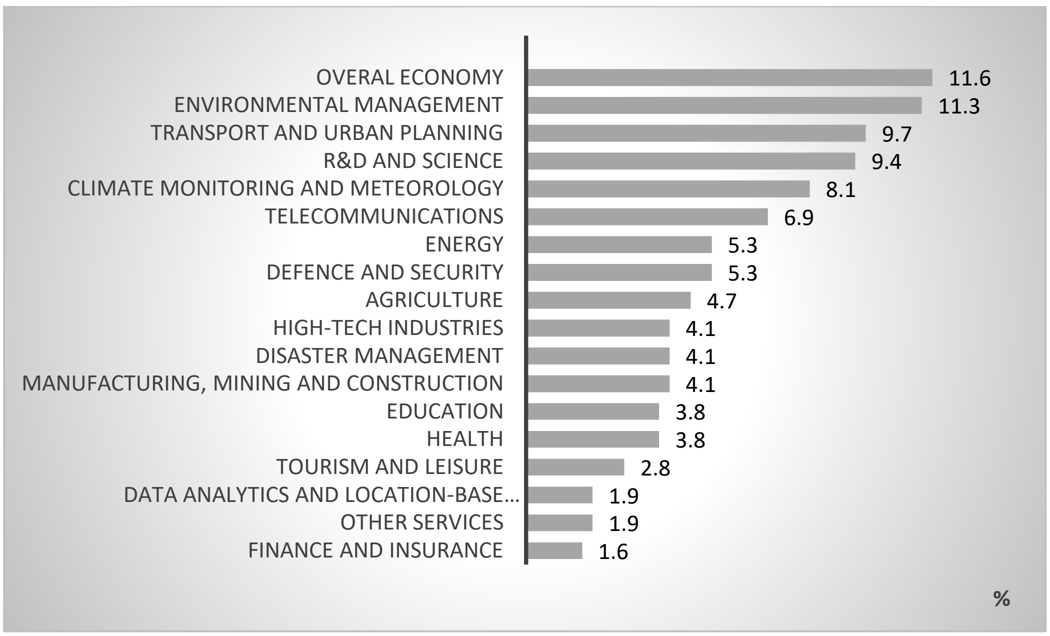
Note: The literature covers 77 impact assessments and program evaluations published between 1972 and 2018. (*The Space Economy in Figures*, n.d.)

Moreover, the benefits from socio-economic impacts of the space industry are not just summarized on space actor, yet they include non-space sectors as well. For instance, around 57% of all cost savings and more than three-quarters of cost avoidance are realized beyond the space sector. Thus, space technologies applications are affecting other fields. The affection is resulted on operating cost reduction (Figure 1-7).

Back to the space economy definition, all mentioned aspects are divided into upstream and downstream segments.

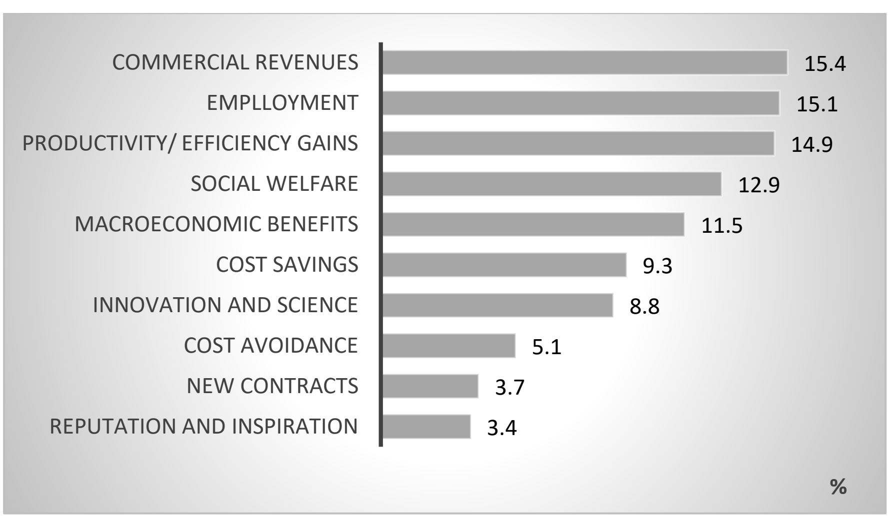
The upstream segment includes research, space manufacturing and ground systems (fundamental and applied research activities, scientific and engineering support activities, material, and components supply, manufacturing of space systems, subsystems and equipment, telemetry, tracking and command stations).

Figure 1-5 Selected sectors that benefit from socio-economic effects derived from space investments



Note: The literature covers 77 impact assessments and program evaluations published between 1972 and 2018. (*The Space Economy in Figures*, n.d.)

Figure 1-6 Types of positive effects derived from space investments



Note: The literature covers 77 impact assessments and program evaluations published between 1972 and 2018. (*The Space Economy in Figures*, n.d.)

The downstream segment includes space operations for terrestrial use, and products and services which rely on satellite technology, signal, data to function (e.g., satellite broadcasting, selected GIS, GNSS-enabled devices).

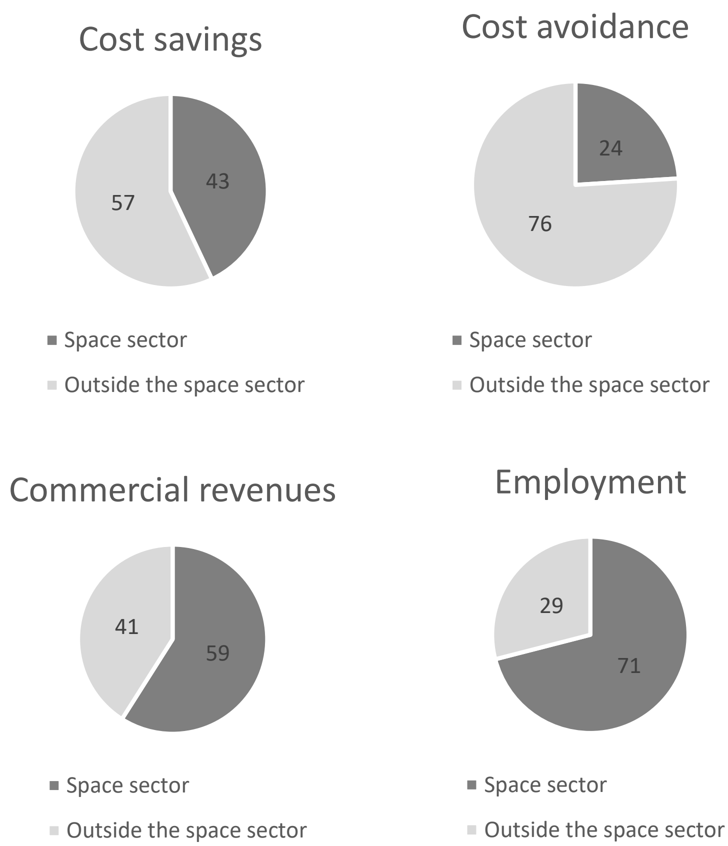
In addition, based on OECD Space forum, there is the third split in which the space-related segment includes space applications, products and services from spin-offs or technology transfer from the space sector, which use satellite technology but do not depend on it (low incorporated quantities of "space" components) (Figure 1-8).

Market forecasts indicate that downstream applications will be the major source of economic growth in the space sector in the coming years (*Space Growth Action Plan*, n.d.). However, strong presence in the upstream sector is essential to secure a 'virtuous circle' of capability across the value chain. For example, mastering the technology for space-based digital payloads allows a direct understanding of satellite operator needs for power and bandwidth flexibility, and being able to optimize this in an upstream design solution can prove decisive in a global competitive environment. Similarly, radar system competence is directly relevant to support delivery user applications related to surveillance, climate change and flood management (*Upstream Space: A Galaxy of Capability - Google Search*, n.d.).

Dividing the space economy into two main up-stream segments and down-stream segments is a lighthouse to provide a clear vision for further research, especially to address space economy value chain.

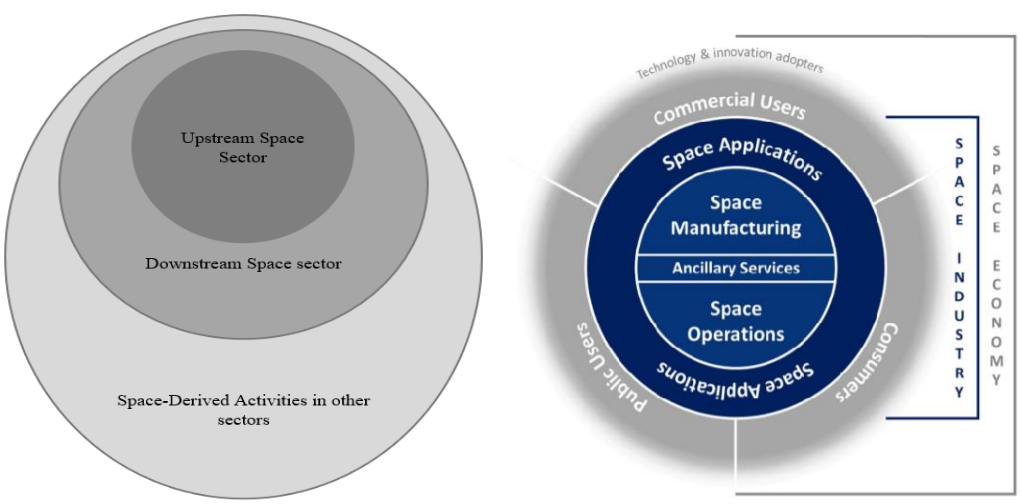
In conclusion, space economy with several definition is expanding its wings into the complex multidimensional framework which is the propulsion system of the market leading to the socio-economic impacts. Space industry has a high-growth scientific and technological progress.

Figure 1-7 Benefits in and outside the space sector derived from space investments



Note: The literature covers 77 impact assessments and program evaluations published between 1972 and 2018. (*The Space Economy in Figures*, n.d.)

Figure 1-8 Main Perimeters of Space Economy



Sources: (*The Space Economy in Figures*, n.d.) (*Upstream Space: A Galaxy of Capability - Google Search*, n.d.)

1.4 Global Space Economy

"The European Space Agency estimates that for every Euro spent in the sector there has been six Euros benefit to society." Dr. Werner Hoyer, President of the European Investment Bank (European Investment Bank et al., 2019).

The beginning of the 21st century with tremendous technological development introduced the new era of globalization. Accordingly, the number of active players in the space industry has boomed due to the governmental enthusiasm to put their flag among other players of this industry. The number of countries with registered satellites in orbit has been increased from 50 in 2008 to 80 in 2018.

Global space economy has been evolving like the other evolutionary paradigms in the world. From the historical point of view, the evolutionary is divided into three eras:

Exploration phase (between the Forties to the Sixties), Experimentation phase (until Nineties), and Exploitation phase (New millennium).

Exploration phase is characterized by the lack of knowledge, high level of risk with significant costs and less returns in the short to the medium run. Hence, private agents are usually not willing to fund activities at this stage and public interventions is required.

Experimentation phase has experienced less risk domain compared to the exploration phase due to the acquisition of knowledge about the environment. However, costs did not reduce as much as the risk. Although public actors remained the key players in the field, private agents began to evaluate the possibility of entering new markets.

Exploitation phase have seen a substantial willing of the private companies to invest on space rather than governments. Environment well defined and technology transformation accesses the actors to play in a low risk and in a low-cost field.

Measuring the global space economy is a complex set of actions due to the variety of angels in the space industry. Thus, there are different numbers are available from different sources. The foremost reason lies into different attitudes to the definition, furthermore, lack of organizational cooperative, and eventually blurry boundaries between space and non-space activities are the main obstacles (Table 1-2).

Table 1-2 Space Market size

Source	Market Estimate
PWC	$371 Bn (2020)
Space Foundation	$423.8 Bn (2020)
Morgan Stanley	$374.3 Bn (2020)
Bryce Space and Technology	$366 Bn (2019)
Euroconsult	$298 Bn (2019)
Morgan Stanley	$355.4 Bn (2019)

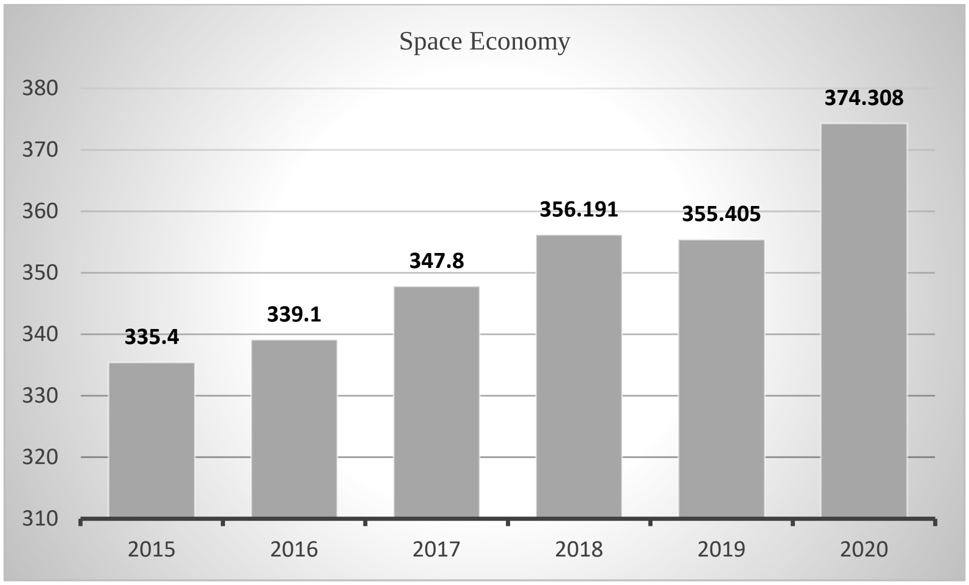
PwC - Space Practice - Luigi Scatteia - (PricewaterhouseCoopers, n.d.)

Over the period of 2015 and 2020, the size of the space economy has been slightly increased. Figure 1-9 shows the size of space economy regarding to the Morgan Stanley datasets between 2015 and 2020. There was a negligible decrease in 2019 due to the less satellite launch and less satellite manufacturing comparing to the previous year. In 2020 the global space economy was worth more than $374 billion in terms of turnover, an increase of almost 5.31% on the previous year and of more than 11.6% with respect to 2015 (Table 1-3). Also, in 2020, the size of the space economy was almost 55% higher than a decade ago.

On the Table 1-3 the average growth rate respect to the previous year was 2.2 %. Moreover, in 2020, even though the world had struggled with the Covid-19, it was a remarkable growth comparing to the previous year and the year 2015, respectively.

Due to the data analysis, Morgan Stanley expects the space economy to hit $1.1 trillion by 2040 (Figure 1-10), while Bank of America Merrill Lynch estimates that the space economy will grow eight times bigger in the next thirty years, reaching $2.7 trillion in 2045. It could be assumed that human being is facing with significant advances on the space ecosystem in the next few decades. The numbers are showing a big potential of the new opportunities for the future investment on the space ecosystems.

Figure 1-9 Space Economy Size during 2015 and 2020



Source: (*Morgan Stanley*, n.d.)

Table 1-3 Space Economy growth rate

Year	Turnover in current price ($ Bn)	Growth rate with respect to previous year	Growth rate with respect to 2015
2015	335.4	-	-
2016	339.1	1.10 %	1.10 %
2017	347.8	2.56 %	3.69 %
2018	356.191	2.41 %	6.19 %
2019	355.405	-0.22 %	5.96 %
2020	374.308	5.31 %	11.60 %

Commercial space activity and government investments are two main factors of the global space economy. Approximately one quarter of the global space economy is enacted by the government budgets and three quarters associated with commercial revenues (European Investment Bank et al., 2019). For instance, in 2016, commercial space activity grew to nearly $260.5 billion which was almost 75% of the total size of the space economy. In contrast, commercial space activity was

$271 billion in 2019. Yet, the share of the commercial space activity was almost 75 % of the total size of the space economy (Figure 1-11).

Figure 1-10 Global Space Economy trends until 2040

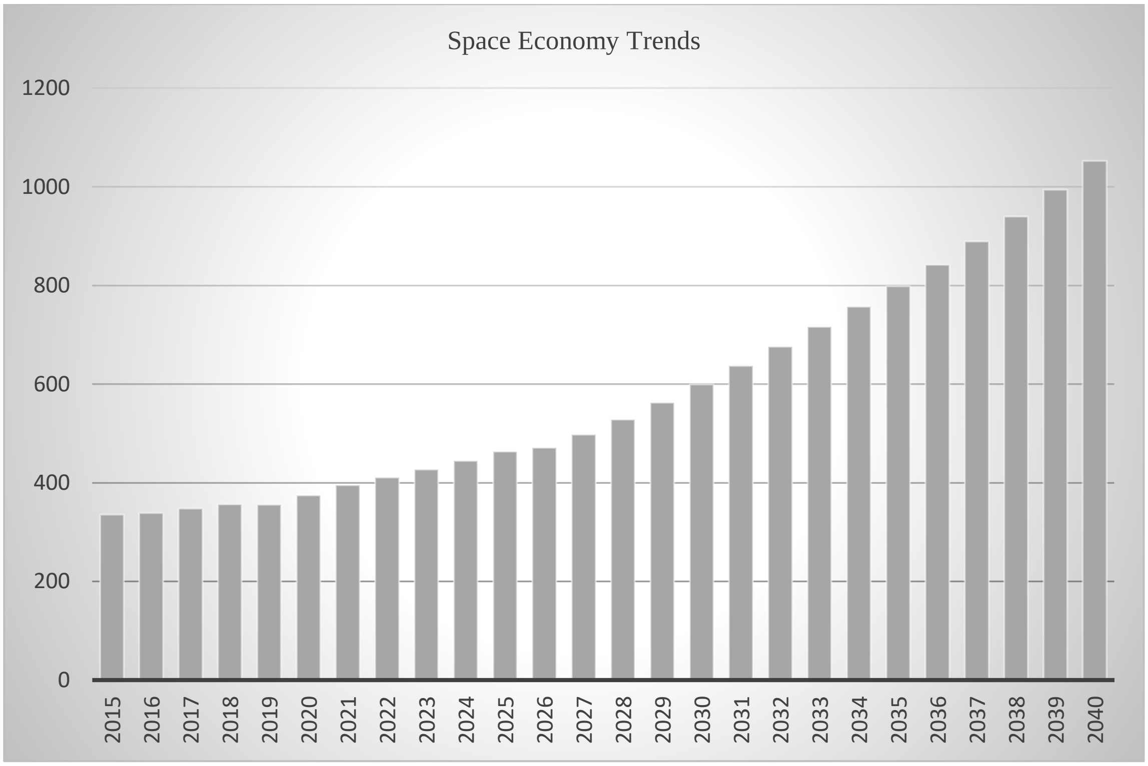
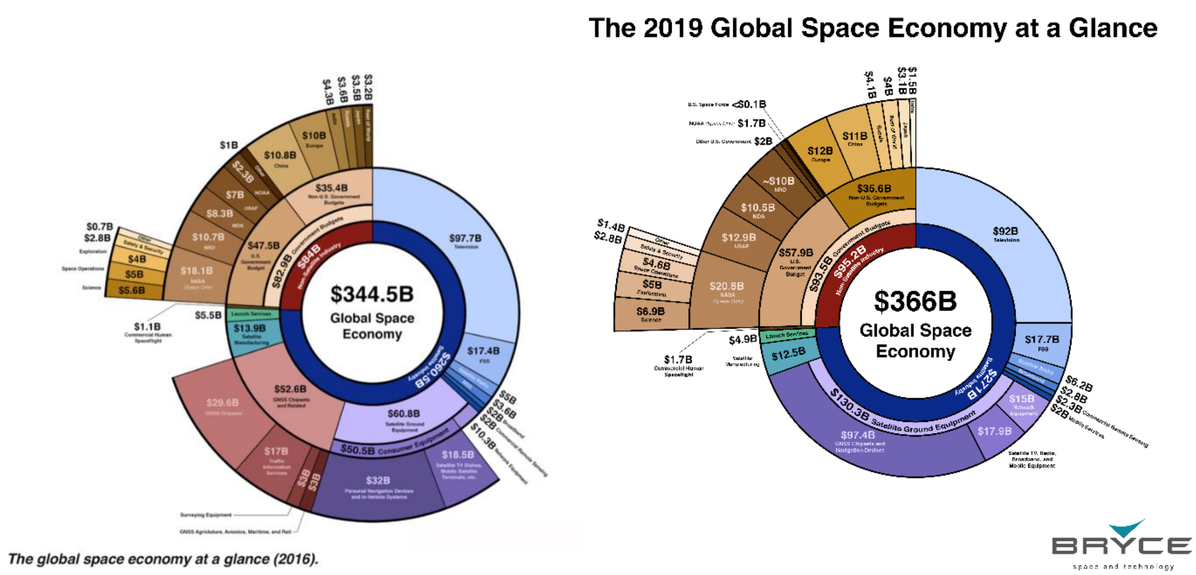


Figure 1-11 Global Space Economy in 2016 and 2019 (BryceTech, *n.d.)*



Government space budgets account for the lion’s share of investments in many space activities, in particular funding traditional activities, such as space science, space manufacturing and launch (*The Space Economy in Figures*, n.d.).

Datasets on space economy gives the top tiers of the space economy showing that in 2020, United States remained at the top of the list by 58% of total activity in space followed by China and European Space Agency (ESA). Collectively, these three entities constituted more than 81% of government space spending in 2020 (*Space Foundation*, n.d.).

This year’s analysis also revealed notable shifts in the global space economy. Japan’s 3% space budget increase in 2020 played opposite Russia’s 37% reduction to make Japan the fourth-highest contributor to the global space economy. France increased its domestic funding by more than 40% in 2020, leapfrogging Germany and India to become the seventh-largest contributor to the global space economy in 2020 after Russia and the European Union. Lastly, Italy’s 37% budget reduction shifted its 2019 ranking of 11 down to 12 in 2020, beneath Canada (*Space Foundation*, n.d.).

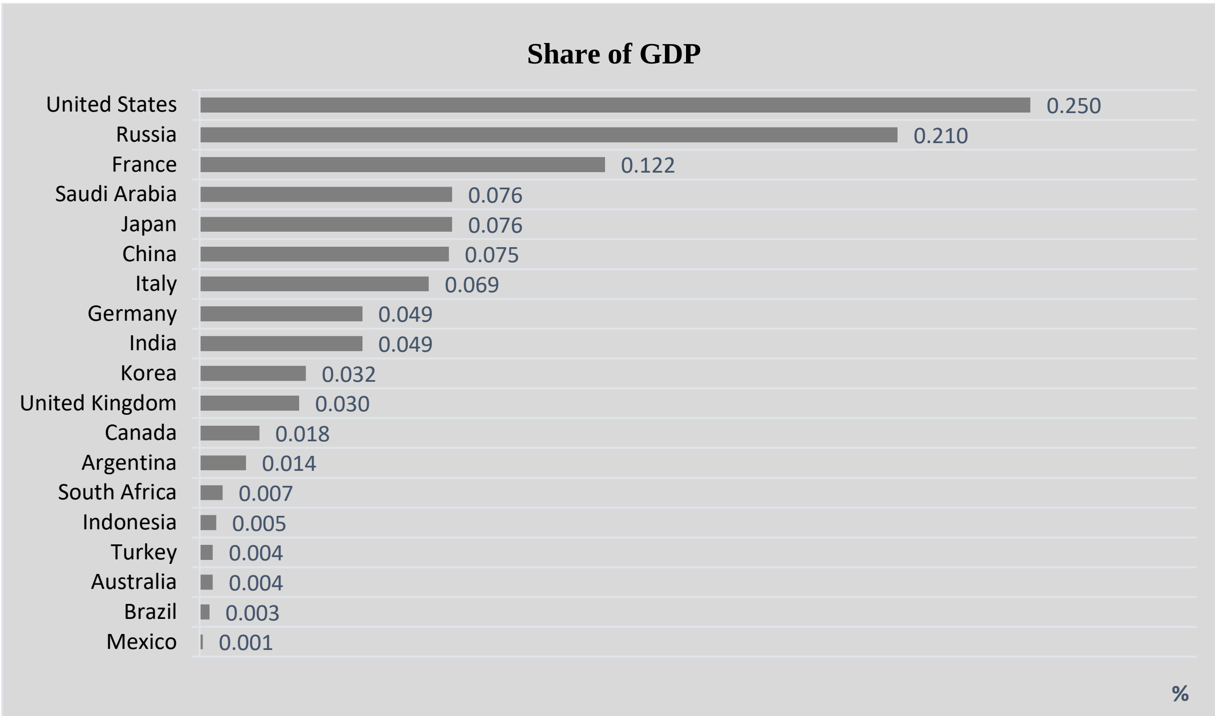
One of the most useful indicators to measure and compare space funding intensity is the ratio of space budget to the national gross domestic product (GDP) (Figure 1-12) (*The Space Economy in Figures*, n.d.).

“Europe- the Member States, the EU, the European Space Agency (ESA), the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)- has achieved many successes in space with breakthrough technologies and exploration missions”. stated Elżbieta Bieńkowska, Commissioner for Internal Market, Industry, Entrepreneurship and SMEs.

EU has the second largest public space budget in the world. Between 2014 and 2020, EU has invested €12 billion in space activities.

Main member states contribute to ESA are Germany with €3.3 billion investment which has 22.9% of the total share in the first place following by France in the second rate with €2.7 billion and 18.8% of the total share and Italy with €2.3 billion and 15.9% of total share keeps a third place.

Figure 1-12 G20 Government Space Budget (2020)



Source: OECD calculations based on government budget sources and OECD databases. (*The Space Economy in Figures*, n.d.)

EU has already had 33 satellites registered in orbit and during its plan for the next 10- 15 years it will be increased to more than 60 satellites. Two of the main programs of the EU are Copernicus program and Galileo.

Considering the results elicit out of the global space economy, seemingly, the space is a reliable industry as it has also proven resilient in the face of economic downturns, including the 2008 global recession.

It was said that three potential incentives are propelling governments toward investing on space activities. Obviously, the reason lies in economic growth and more specifically, in taking advantages of the socio- economic impacts of the space economy.

- Resourcing desired initiatives: which include all funding for space-related developments. Governments are playing key role on this issue, and they have access to the different source of fundings. Private sectors are also boosting their shares on space activities. For example, the European Angel Fund (EAF), with a value of more than $365 million (the exchange rate is considered: €1: $1.14), is an initiative advised by the EIF with the national funds.

Horizon 2020 (Box 1) Space- Related Calls was a program announced by European commission over the period 2014 to 2020, to support ongoing development of the space sector (*Horizon 2020*, n.d.).

- Targeting capabilities: available resources and different capabilities are making different target capabilities for national organizations to encompass the full space value chain. It would be divided into the exploitation of upstream and downstream applications.
- Structuring governance: basically, space governance can take two forms: centralized and decentralized. In a centralized construct, government space functions—development, operations, regulation—are consolidated under a single agency. In a decentralized structure, these functions are the responsibility of different agencies, usually with some degree of coordination. A dedicated space agency is typical, though not an absolute, and is not necessarily indicative of a centralized governance structure (*Global Space Industry Dynamics*, 2017).
- Nine national space budgets (considering Europe collectively) exceed $1 billion: those of the United States, China, Europe (collectively), Russia, India, Japan, France, Germany, and Italy (*Global Space Industry Dynamics*, 2017).

BOX 1. EUROPEAN COMMISION'S HORIZON 2020 SPACE PROGRAM

The main lines of activities in the space sector are:

- Prioritizing the existing two EU Space flagships of European Global Navigation Satellite System (EGNSS) and Earth Observation reaping the benefits they can generate in the coming years and ensuring their state-of-the-art also in the future.
- Ensuring support for the third priority of the EU space policy: the protection of space infrastructure, and in particular the setting up of a Space Surveillance and Tracking system (SST) at European level.
- Ensuring support to EU industry to meet the objectives defined in the Commission communication on Space Industrial Policy, notably to maintain and enhance industry's competitiveness and its value-chain in the global market.
- Ensuring that Europe's investments made in space infrastructure are exploited to the benefit of citizens; as well as supporting European space science.
- Enhancing Europe's standing as an attractive partner for international partnerships in space science and exploration.

1.5 Italian Space Economy

The Italian presence in space has begun at the end of the second world war. Professor Luigi Broglio was the promoter of the San Marco-1 satellite in 1964 from the Sapienza University of Rome. The launch made Italy, after the former Soviet Union and the United States, the third largest country in the world to have launched own satellite (Ministero dello Svilluppo Economico).

Figure 1-13 Telespazio's "Piero Fanti" Space Center in Fucino (L'Aquila) has been active since1963 and is today recognized as the first and most important "teleport" in the world for civil uses.

"Italy, since the inception of the space age, has always had a leading role. Initially acting as a valuable partner of the major world space actors and, over the years, the space industry is a well-established industry that covers the whole space supply chain with excellent results in all application sectors, also thanks to the academic and research community and to the support of the Government and the Italian Space Agency (ASI)" stated by Giorgio Saccoccia, President of ASI | Italian Space Agency ("The Italian Space Industry Catalogue," n.d.).

Italy is a founding member and the third-highest contributor to the European Space Agency (ESA). The Italian Space Agency, Agenzia Spaziale Italiana (ASI), defines, coordinates, and manages national space programs and the Italian participation to European and international space projects, under the supervision of the Ministry of Education, University and Research.

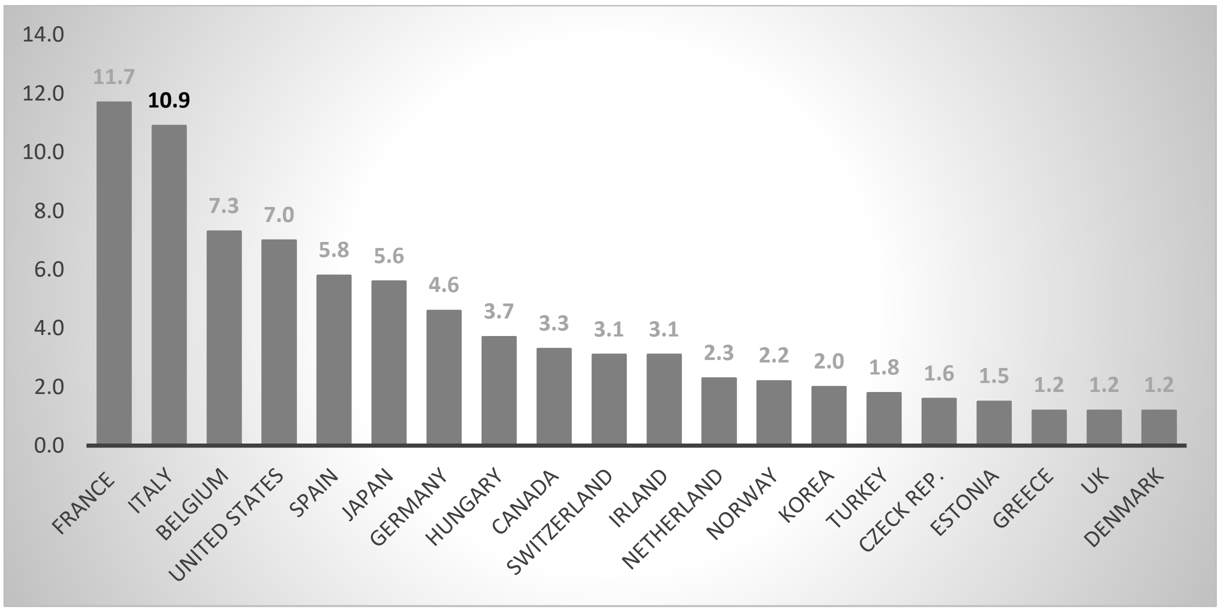
Figure 1-12 indicates that Italy is in seventh position in the international ranking of the space budget based to the national domestic production in 2020 with 0.069 % share of GDP. China with 0.075% share of GDP and Germany with 0.049% share of GDP are located before and after Italy respectively.

Interestingly, the share of the public R&D which is dedicated to exploration and space search shows the high rank of Italy. The data, which was provided by the OECD in 2019, illustrates that

Italy with an average share of 10.9% over two- years period stands in second level, immediately after France and before Belgium with 11.7 % and 7.3% respectively (Figure 1-14).

Figure 1-14 Share of government spending on R&D allocated to research within the Space

(Average% 2018-19)

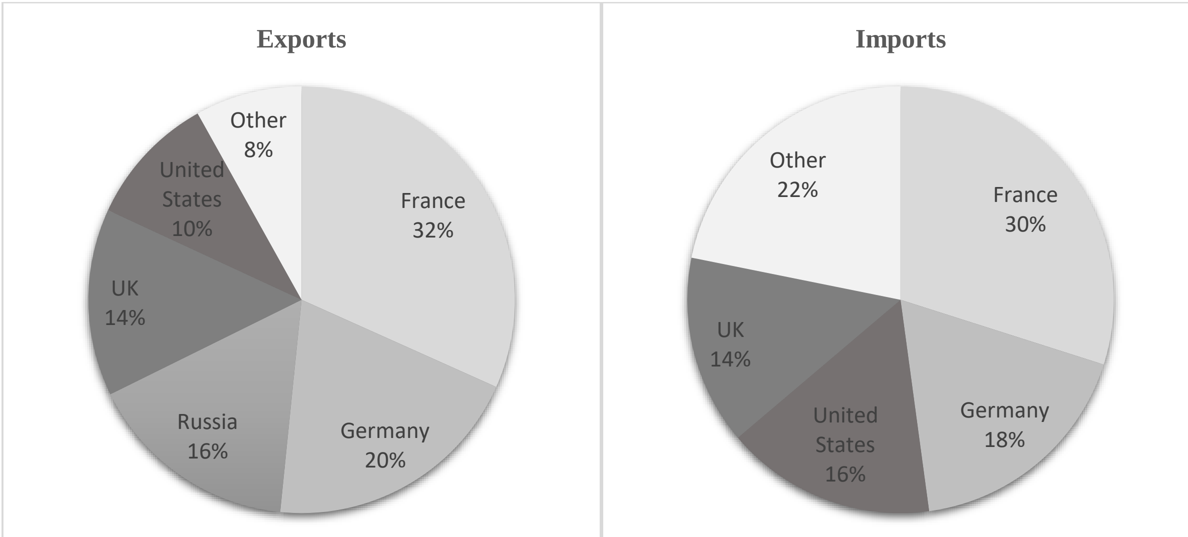


Source: (*The Space Economy in Figures*, n.d.)

Specifically, in Italy the allocations for research and development of the Central Administrations of the Regions and Autonomous Provinces in the context of the exploration and use of Space are amounted to $1.28 million in 2019, up 20% compared to 2018, highlighting a livelier development trend than the total (9.2%). Estimates for 2020 indicate a further increase, reaching $1.74 million. Space represents the second area, after the universities, in public sector R&D appropriations (*The Space Economy in Figures*, n.d.).

The total size of exports in space sector in Italy was worth $490.41 million in 2019 and it was reduced by 21% in 2020 reached at $384.35 million. Imports has also seen decline by 1.1%. The total size of imports was worth $221.26 million in 2019, whereas it was $217.83 million in 2020.

Figure 1-15 Italy Exports and Imports by Main country breakdown



Italian aerospace high-tech industry has formed by the large participation of SMEs, such as a start-ups and spin-offs which can cross-fertilize the whole value chain through their innovations and extraordinary performance. SMEs has made up the 80% of the Italian space landscape of which about 40% are small and medium, and the remaining 60% are micro-enterprises (with a number of employees less than 10 and a turnover below $ 2.28 million). The sectors in which the SMEs are playing a role varies from the elimination of space debris to many applications from using data ranges from agriculture to telemedicine.

The ministry of economic development (Ministero dello Svilluppo Economico) has had the national space plan which includes activities for over $5.36 billion of which 50% private resources. Italy’s space policy guidelines are formulated in the latest Strategic Vision Document for 2016-2025, which puts an increased emphasis on socio-economic returns of space activities, in particular, on the development of downstream activities.

Key priorities of the Italian Space Agency budget include earth observation (30%), launchers and space transportation (26%), and human spaceflight and microgravity (20%).

Table 1-4 Space Economy in Italy

Number of the enterprises with 80% of SMEs	286
Annual Turnover	$ 2.28 million
New jobs for every use generated in Space industry	4
Number of employees (+ 15% in the last 5 years)	7000

"The large participations of Italian SMEs and start-ups in aerospace high-tech industries accomplished with innovations capable of cross-fertilizing the whole value chain. The extraordinary performance of Italian enterprises, from large champions to innovative SMEs and start-ups, paired with the excellence of our Centers of Research and universities, have made Italy the 4th aerospace industry in Europe, and the 8th exporter worldwide, generating 13 billion euro in revenues". Stated by Carlo Ferro; President of ITA | Italian Trade Agency ("The Italian Space Industry Catalogue," n.d.). Moreover, he says that: "The aerospace industry is among the leaders in R&D spending, essential to boost a virtuous cycle of innovation-export-growth that generates new market. It accounts for 15% of turnover, resulting in significant technological innovations and spill-over effects in other technology-intensive industrial fields such as nanotechnology, new materials, microelectronics, defense, communications, and electronics".

On this paper, the focus will be on the space ecosystem in Italy. Yet, it seems necessary to introduce main institutions on the Italy's space ecosystem and later, the space clusters in Italy will be introduced.

ASI- Italian Space Agency

The Italian Space Agency (ASI), which was born in 1988, is a national public body steered and supported by the *"Interministerial Committee for Space and Aerospace Policies"* (COMINT) ("The Italian Space Agency in short," n.d.)

Over 30 years working in the space and aerospace sector, ASI has three main objectives:

- Innovate and support Research
- Promote the development and use of space services and applications
- Consolidate the country's role at the international level

ASI is being still supervised by the ministry of University and Research and taking its steps according to the Government directions with the aim of making progress on:

- National Space Policy Strategic Document (DSPSN: Documento Strategico di Politica Spaziale Nazionale)
- Space Strategic Vision Document (DVSS: Documento di Visione Strategica per lo Spazio)

Later on, the importance of the Earth observation will be noticed, yet ASI with the Constellation of Small Satellites for the Mediterranean basin Observation (COSMO-SkyMed) (Table 3-6), which consist of four satellites equipped with Synthetic-Aperture Radar (SAR) sensor, provides applications that are useful in seismic hazard analysis, environmental disaster monitoring and agriculture mapping.

AIAD- Italian Industries Federation for Aerospace Defense and Security

The Italian Industries Federation of Aerospace, Defense and Security was funded in 1947. It includes almost all the national enterprises that operate with advanced technology in the design production, research and services activities for the civil and military aerospace, military navy and army sectors.

AIPAS- Association of Italian Space Companies

AIPAS is a non-profit association born in 1998 aiming at protecting the interests of Italian Space Small and Medium Enterprises. Since 2007, AIPAS has also allowed Large Enterprises to participate in the Association, becoming an example of good collaboration between Large Enterprises and SMEs, including Startups, aiming at developing a favorable eco-system for all space enterprises regardless of their dimension.

AIPAS members are active both in the upstream and the downstream covering all the space value chain. Nowadays, AIPAS has 52 members, among which 4 large companies, 1 consortium and 47 SMEs. (The list of the members is available at: aipas.it/en/members/)

AIPAS is co-founder and operational secretariat of SME4SPACE, the European representative Organization of Space SMEs.

ASAS- Association for Space-based Applications & Services

ASAS was stablished in 2004 by the significant Space industries whose mission is to develop and enhance applications and services based on space, to bring technologies and capacity ‘from Space to Earth’.

ASAS promotes space applications and technologies as a powerful tool to develop knowledge and innovation, support wellness and quality of life and contrast natural disaster and critical emergencies.

To date, ASAS has 34 members among large companies and SMEs, some of them being the Italian branch of large multinational Corporations, all focused on Space-based Services and Applications.

CTNA (Cluster Tecnologico Nazionale Aerospazio)

The CTNA is a PPP (Public Private Partnership) born in 2012 from the aggregation of the main regional technological districts, industrial and research players in the aeronautical and space sectors, the ASI and AIAD, with the aim of implementing a strategy based on research and innovation for the competitiveness of the Italian aerospace sector. The association is recognized by MUR as a driver of sustainable economic growth in all the regions of the national economic system, as it fosters the innovation and specialization of Italian manufacturing systems.

The CTNA Action Plan defines the road maps and priorities for actions in the aeronautics and space sectors, in accordance with the relevant EU and national policies.

2 CHAPTER TWO

2.1 Introduction

This chapter introduces the space economy value chain and its segments. Also, the leading innovative technology trends affecting the space ecosystem and space economy market segments' risk assessment discussed. It follows the Europe funding channels and the obstacles to funding with recommendations to tackle the problems. The main satellites used in Europe, especially Earth Observation, were mentioned. Finally, Italian space clusters acknowledged the reasons for the focus on northern Italy regarding the aim of this paper.

2.2 Traditional and New Space Business Services

As discussed before, the pace of evolvement in the space industry has seen a rapid growth during the last decade, and it has become an engine to push many other industries to get involved under the umbrella of its industry. However, the space industry is not solely able to bring all necessities, hence frontier technologies especially in artificial intelligence, science technology, nano and biotechnology, mechanical engineering, etc., are accelerating the development in this vast industry.

Moreover, the rate of new entrants and private institutions are going high due to, firstly, the progress of the frontier technologies, secondly, movement from governmental to non-governmental private actors, and thirdly, the new source of opportunities. Private-sector funding in space-related companies topped $10 billion in 2021—an all-time high and about a tenfold increase over the past decade (*McKinsey*, n.d.).

Thus, the emergence of an early wave of startup innovation creates commercial opportunities in space exploration and exploitation which is leading to create value on Earth with technology in space.

The so-called "New Space" trend thrives upon technology and business model innovations that permit a significant reduction in cost, the provision of new products and services and a broadening of the customer base (European Investment Bank et al., 2019).

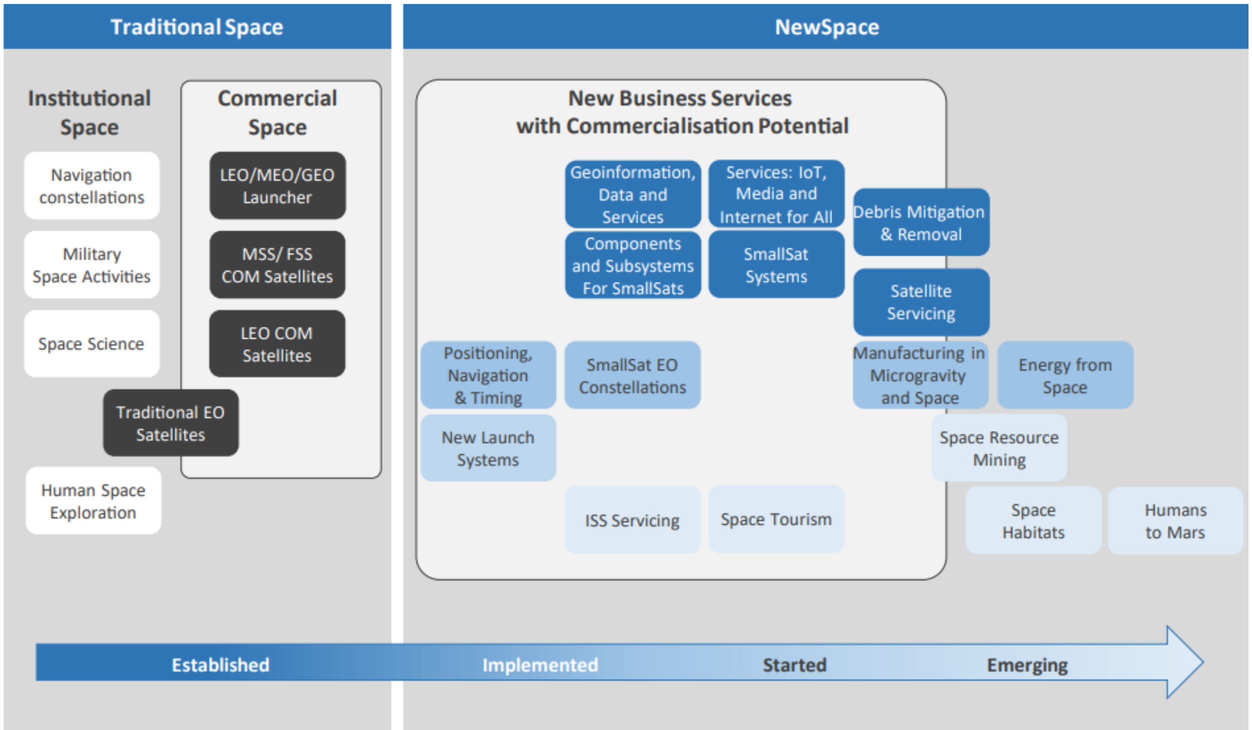
In terms of the formulating of the new space economy, it seems that the Orbital Circular Economy Framework (OCEF) has well defined its characteristics and it is well contributed to the new space economy, even if the definition expands and become more practical in the future (Brennan & Vecchi, 2020). As it was said previously on the global space economy, new entrants on space industry are willing to invest on the exploitation phase because of its specific characteristic. Exploitation phase and new space under OCEF application indicates that how private companies take advantage of cost reduction, the development of a self-sustaining organizational innovation and creativity engine, as well as significant cross-savings production which leads to the sustainable competitive advantage. The space companies have shown a radically different vision by endorsing a much more proactive approach "flash deep" that ultimately yields many tangible benefits that are all well-beyond mere cost-savings stemming from recycling and reuse (Brennan & Vecchi, 2020).

OCE implementation (flash deep) in comparison by the traditional CE implementation (Skin Deep) is significant into:

- Proactive Approach
- Return for reuse is taken to next level by using a step-by-step approach that drives organizational learning
- Circular suppliers, replacing single life-cycle inputs, resource recovery where resources are recovered from disposed products and product life extensions
- Blue Ocean strategies that rely on creativity and innovation that lead to new capabilities and new horizons, and the development of new business models that could provide sustainable competitive advantage (Brennan & Vecchi, 2020).

For instance, considering the private companies like SpaceX, Blue Origin, and the Spaceship, OCEF is well fitted. Adding to the formulation, when it refers to the commercialization, space missions serving B2B and B2C business models.

Figure 2-1 New Space



Source: (European Investment Bank et al., 2019)

Figure 2-1 illustrates the boundaries of the traditional space and new space economy from the establishment to business emerging. In despite of the lower risk, and lower cost of the productions and services thanks to the disruptive innovations, new space era is based on the sustainable growth. It could be said that all the new space activities are commercial space activities. Activities of new space actors are better characterized by the ‘‘accumulation relationship’’ attempting to satisfy two conditions simultaneously: the pursuit of a common, nongovernmental goal (e.g., safe human space flight) and the accumulation of necessary industry infrastructure resources to become fully independent (Davidian, 2020). New Space Economy is a real cultural revolution that it redefines the public/private relationship.

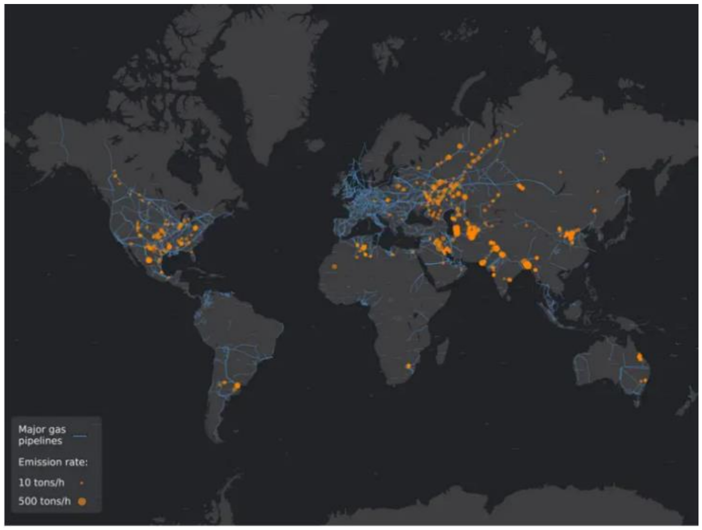
In this sense, ‘space ecosystem’ has the broader concept of the space industry when it goes to identify the new space economy. Hence, the development of the space ecosystem is capable to connect startups, universities, and research centers with big businesses.

Morgan Stanley divided new space economy into five key themes (*2021*, n.d.):

1. Climate change
2. Capital formation
3. Mitigating orbital debris

4. Space and security
5. Telecoms a Near-Term focus

Figure 2-2 Methane emission captured by satellite



Blue lines show the main gas pipelines. Orange dots depict sources of methane emissions. © Kayrros Inc., Esri, HERE, Garmin, FAO, NOAA, USGS, OpenStreetMap contributors, and the GIS User Community

Climate change, security, and telecoms have seen the highest rate of progress in the new space economy. Satellite technology is almost in common between all five key themes especially when it expands its boundaries including transportation and logistics efficiency, natural resource management, precision agriculture, environment, and climate change monitoring.

Satellite images are accessing investors focusing on Environment, Social, and governance (ESG) with key data. For instance, for the first time, newly released satellite photos of the methane emissions lead to observe a map of the one the main global warming reasons (Figure 2-2). If the emissions could be cut, the result would be saving money. In the US, ultra-emitters could save $250 per ton of methane if they eliminate routine leaks, the researchers calculated (McFall-Johnsen, n.d.)

Also, in 2020, despite covid 19, the space ecosystem has seen the biggest private investment in space to date. SPACs (Special Purpose Acquisition Companies) may be a potentially well-suited mechanism to attract capital for long-horizon business models in space (*2021*, n.d.).

Thus, new space economy, is an ecosystem which is well fitted into the OCE framework to steer traditional space economy towards new sustainable space economy through applying breakthrough

innovations by both entrepreneurial actors and large main actors. Hence, it could be seen that new space economy is targeting three main problems that human being struggling with:
Global warming, water, and food.
Satellites are divided into three categories based on their altitude:
LEO (Low Earth Orbit), MEO (Medium Earth Orbit), GEO (Geostationary Equatorial Orbit).
Figure 2-1 also indicates the importance of the satellite broadband constellations in new business services. Almost over 80 countries have registered satellites in orbit. There are 3,372 active artificial satellites orbiting the Earth as of January 1, 2021, 1,897 belong to the United States. This is by far the largest number of any single country, with their nearest competitor, China, accounting for only 412. It is followed by Russia, UK, Japan, India, European Space Agency, Canada, Germany, and Luxembourg.
Table 2-1 shows the number of satellites with their main purpose of operation.

Table 2-1 Number of satellites and main target plan

Number of satellites	Main purpose
1832 satellites	Communication purpose
906 satellites	Earth Observation
350 satellites	Technology development and demonstration
150 satellites	Navigation and positioning
104 satellites	Space science and observation
20 satellites	Earth science
10 satellites	Other purposes

Source: (*How Many Satellites Are Orbiting the Earth in 2021? - Geospatial World*, n.d.)

Between 2003 and 2018, and 2018 to 2033, cycle 4 and cycle 5 of space development introduced, respectively. The main characteristics of these cycles are digitalization (strong rise of downstream activities), new generation of space systems such as small satellites which is provided by bundle of knowledge in micro-electronics, computers, and material sciences. Satellites infrastructure outputs (signals, data) have seen the growth, recently, in use of mass-market products and global monitoring of treaties such as land, ocean and, climate thanks to the new telescopes and robotic missions.

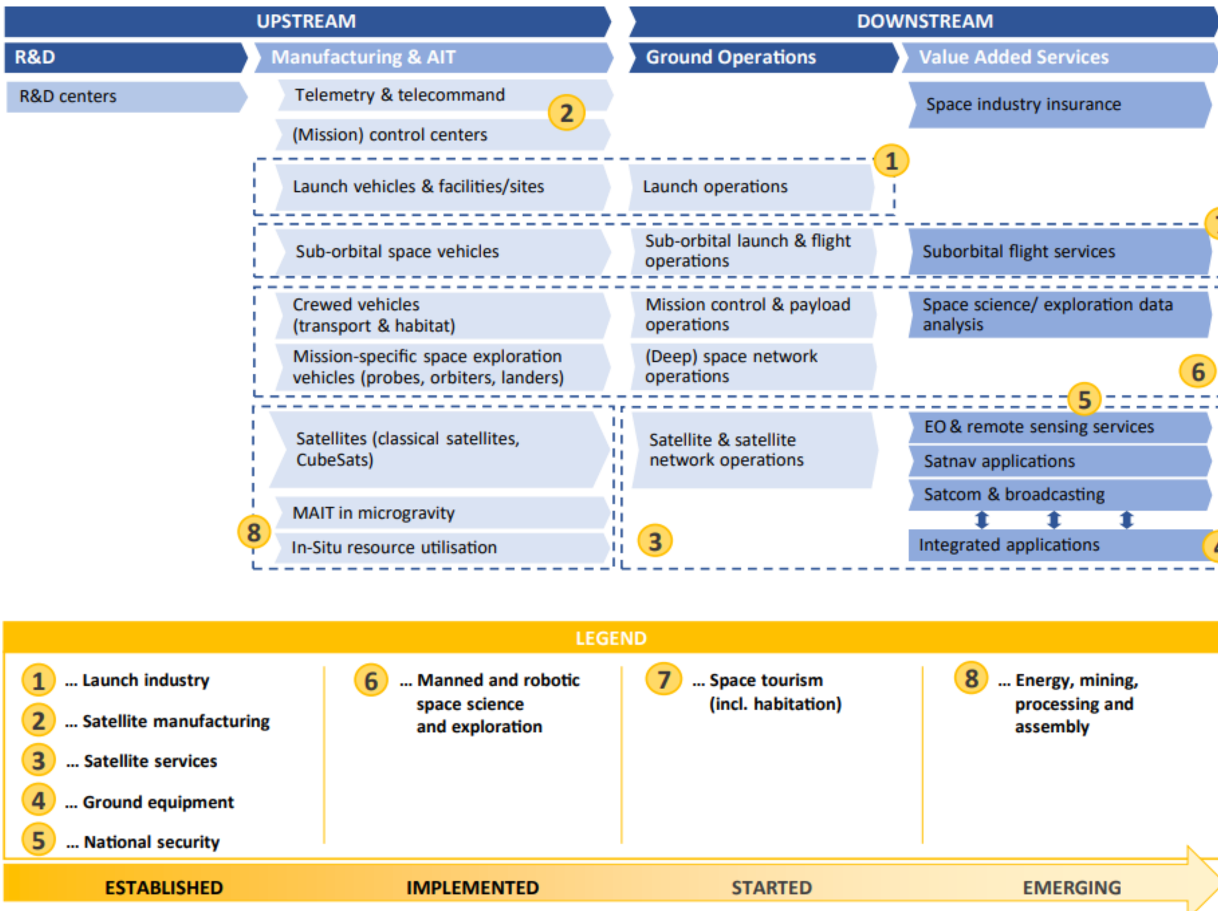
Increased development of small satellite and cubesat constellations influence the management of space manufacturing supply chain. Hence, the vertical integration of production and increased internationalization of supply chains, with a growing reliance on off-the-shelf components can be identified.

The increased reliance on serial production and automation lowers the cost of production and reduces the need for outsourcing. For instance, ArianeGroup, the joint venture of Airbus and Safran, which is producing the future European Ariane 6 and the small launcher Vega-C with Arianespace, is also consolidating its production supply chain, previously spread across 25 different European industrial sites, by focusing more on-site specialization and mass production of standardized parts and components (*The Space Economy in Figures*, n.d.).

2.3 Space sector value chain and market domain

It was previously mentioned on the literature review that space economy is divided into the two segments of the upstream and downstream. Also, the definition and the interrelations between the two segments were discussed. Here, the target is introducing the space sector value chain, market domains, market segments and sub-areas. More, specifically the satellites will be surveyed and their effects on the future agriculture will be discussed. The space sector value chain is referred to the new space ecosystem. Hence, the market domains whether included into the traditional space economy, the route has been changed to the new space economy especially when new private actors are joining to each domain.

Figure 2-3 Space sector value chain



Source: (European Investment Bank et al., 2019)

Figure 2-3 indicates space sector value chain. The whole space economy is subdivided into the four sub-areas which is beginning with the fully established and ending with the emerging market. Fully established market domain is important due to the highest rate of the investment, several governmental and non-governmental actors and applying new technologies especially on satellites. Hence, as it was discussed earlier, this market domain is obsessed with great portion of the commercialization.

The second market domain is featuring by the 'Manned and robotic space science and exploration'. This segment has taken new steps in the last decade thanks to the new technologies especially in the areas in which applying robotics facilitating deep learning of space. Perseverance Mars rover is the one of the last inventions on this sector.

The most recently developing domain has just started into space tourism. Some histories have already made by Richard Branson's Virgin Galactic, Jeff Bezos' Blue Origin, and Elon Musk's

SpaceX. A seat on a SpaceshipTwo of Virgin Galactic costs $ 450,000 (*How Much Is a Seat on Virgin Galactic?*, n.d.). More, Axiom Space's Ax-1 mission, is bringing the next with the first all-private crew to ever visit the International Space Station (ISS), ushers in a new era of accessibility, commercialization, and increased science on the orbiting laboratory (*Axiom Space Releases Patch for Ax-1 Crew, First Private Crew to ISS*, n.d.).

These examples were made due to getting familiar with the impact of the new space economy through space value chain. Also, as a matter of fact, for example, Richard Branson, Jeff Bezos and Elon Musk are introduced as Entrepreneurs. Notwithstanding, the idea, the passion, and more importantly, the investment has made them to become frontier in this segment.

Emerging sector of the space economy will become more in competence in the future due to the great potential of the pure resources in the space.

Table 2-2 is giving more details about the eight market domains on the space value chains.

Table 2-2 Space market segments with descriptions and primary technology trends

Business model segment	Business model	Description	Primary technology trend(s)
Launch industry	Launch vehicles & facilities/sites	Companies that develop launch vehicles and facilities to provide access to near and outer space. These companies also provide launch services, sometimes complemented by rockets sourced from other suppliers (e.g., Soyuz being launched by Arianespace). With the advent of smallsats this domain has received a new impetus to develop micro launchers such as Electron.	• Evolved expendable/reusable launcher systems: • Cheaper and more frequent access to space • Enlargement of the space market • New business models in space
	Launch operations		
Satellite manufacturing	Satellites (classical satellites, CubeSats)	Companies that develop and build satellites for satellite applications and services for commercial, civilian and military users. With the advent of the CubeSat standard, small, mini, micro and nano satellites complement classical—big— satellites.	• Agile development and industrial standard implementation and • Miniaturization and nanotechnology: • Flexible designs • Minimum viable product strategies • Staggered rollout sequences • Cheaper and smaller systems • Stiffer and highest performing structures • Self-repairing and self-replicating systems
Satellite services	Satellite & satellite network operations	Companies that provide satellite services by single satellites or constellations, in low Earth orbit (LEO), medium Earth orbit (MEO), geostationary orbit (GEO) or any other orbit deemed appropriate. Typical services involve satellite communication, Earth observation, satellite navigation and integrated applications.	• Artificial Intelligence (AI)/Man-Machine Interface (MMI) and • Change detection and data fusion: – Autonomous operations – Better management of onboard resources
	EO & remote sensing services		

	Satnav applications Satcom & broadcasting Integrated applications		– Higher performance – Easier and faster data interaction with computer systems – Cost-effective observation and analysis of specific points of interest – Correlation of images and time sequences with other data
Ground equipment	Telemetry & telecommand (Mission) control centers EO & remote sensing services Satnav applications Satcom & broadcasting Integrated applications	Companies that develop hardware and software for mission control centers, telemetry and telecommand systems (e.g., Deep Space Networks), as well as GNSS receivers and communication terminals (e.g., VSAT).	• Acceleration of generation change/obsolescence, • Micro- and nanoelectronics/ advanced telemetry and telecommand, • Digital transformation and convergence, • Agile development and industrial standard implementation, • Artificial Intelligence (AI)/Man– Machine Interface (MMI): – Shorter generation cycles – Better performance – Reduced costs – Holistic observation – Control of processes – Health monitoring – Predictive maintenance – Data archiving – Easier search within and comparison of data sets – Lower entry hurdles to data processing, manipulation, and visualization – Flexible designs – Minimum viable product strategies – Staggered rollout sequences – Easier and faster data interaction with computer systems
National security	Mission control & payload operations EO & remote Sensing services Satnav applications Satcom & broadcasting Integrated applications	Companies that provide services and applications in the interest of national security, including satcom, Satnav, Remote Sensing and Space Situational Awareness. This domain is more concerned by service availability than cost.	• Change detection and data fusion, • Optical and ubiquitous communications: – Autonomous operations – Better management of on-board resources – Higher performance – Easier and faster data interaction with computer systems – Cost-effective observation and analysis of specific points of interest

			– Correlation of images and time sequences with other data – Ubiquitous communication – Secure Machine to machine data exchange – Holistic insights into events ongoing worldwide
Crewed and robotic space science and exploration	Crewed vehicles (transport & habitat)	Companies that manufacture specific crewed and robotic exploration vehicles such as probes, orbiters and landers, support the operation of these vehicles and/or perform the retrieval and processing of the data acquired during the science or exploration mission. With the renewed interest in crewed exploration beyond LEO (e.g., cis-lunar space), new players emerge, often originating from space tourism ambitions or incentive prices (Google Lunar X-Prize).	• Advanced manufacturing technologies/3D printing, • Agile development and industrial standard implementation, • Evolved expendable/reusable launcher systems and • Optical and ubiquitous communications – Reduced complexity costs – Manufacturing in space and on other celestial bodies – Flexible designs – Minimum viable product strategies – Staggered rollout sequences – Cheaper and hence more frequent access to space – Enlargement of the space market – New business models in space – Deep -space communication with high data rates – Secure Machine to machine data exchange
	Mission-specific space exploration vehicles (probes, orbiters, landers)		
	Mission control & payload operations		
	(Deep) space network operations		
	Space science/ exploration data analysis		
Space tourism (incl. habitation)	Sub-orbital space vehicles	Companies that manufacture and operate space vehicles as well as habitats in space, providing access to space for everyone that can afford the ticket and is fit enough for flight. So far space tourism has focused on suborbital flight, but once this step has been successfully reached orbital flight will certainly follow. NASA is supporting the development of this domain by its ISS cargo resupply contracts and commercial crew awards.	• Advanced manufacturing technologies/3D printing and • Evolved expendable/reusable launcher systems: – Reduced complexity costs – Manufacturing in space and on other celestial bodies – Cheaper and hence more frequent access to space – Enlargement of the space market – New business models in space
	Sub-orbital launch & flight operations		
	Suborbital flight services		
Energy, mining	MAIT in microgravity	Companies that aim to manufacture goods in space, building upon resources in space (e.g.,	Advanced manufacturing technologies/3D printing,

	In-situ resource utilization	solar energy), on the moon, asteroids or on Mars. While asteroid mining has attracted some interest, space-based energy harvesting is waiting for the first serious start-ups.	• Agile development and industrial standard implementation, • AI/MMI, • Change detection and data fusion, • Evolved expendable/reusable launcher systems, • Miniaturization and nanotechnology, • Optical and ubiquitous communications

Source: (European Investment Bank et al., 2019)

The technology is vastly applying in the new space ecosystem. Some of these technologies have outweighed the others in which disruptive innovations are the main identification. At this section, regarding to the introduction of the eight market segments of the space economy, introducing these main technologies due to positioning each of them into the most related segment could be helpful for further research and analysis.

Table 2-3 is showing the main technologies in the new space economy respecting to their market domain.

Table 2-3 Technology trends impacting business model segments

	Launcher Industry	Satellite Manufacturing	Satellite Services	Ground Equipment	National Security	Crewed and robotic Space Science and Exploration	Space Tourism (incl. Habitation)	Energy, Mining, Processing and Assembly
Acceleration of generation change/obsolescence	○	○	○	●	○	○	○	○
Advanced manufacturing technologies/3D printing	○	○	○	○	○	●	●	●
Micro- and nanoelectronics/advanced telemetry and telecommand	○	○	○	●	○	○	○	○
Agile development and industrial standard implementation	○	●	○	●	○	●	○	●
Artificial intelligence (AI)/Man–machine interface (MMI)	○	○	●	●	○	○	○	●
Change detection and data fusion	○	○	●	○	●	○	○	●
Digital transformation and convergence	○	○	○	●	○	○	○	○
Evolved expendable/reusable launcher systems	●	○	○	○	○	●	●	●
Miniaturisation and nanotechnology	●	●	●	●	●	●	●	●
Optical and ubiquitous communications	○	○	○	○	●	●	○	●

Source: (European Investment Bank et al., 2019)

It could be seen that the major parts of the technology trends are related to the Emerging Market domain. Next to the Energy, Mining, Processing, and assembly, the technology trends were applied mostly in Established market domain (Ground equipment). Hence, the technology trends are deployed both in downstream and upstream segments of the space value chain bringing some parallel approach to develop the market domains. To clarify the previous sentence, the technology trends is not just centralized on one market domain. There were dispersed through all eight market domains.

From technology point of view, Miniaturization and nanotechnology is applied to the whole value chain. This technology is vastly applicable in the satellites development which are building the main bricks of the new space economy. Yet, it affects both upstream and downstream segments of the space value chain.

Considering that technology trends are divided into the three main innovation type:

Evolutionary innovation, Revolutionary innovation, and Disruptive innovation (and combination of them) (Table 1-1), better understanding of each technology trend would be important due to firstly knowing the critical technologies in space ecosystem and secondly highlighting them for public or private actors on their future approach.

Table 2-4 Acceleration of generation change/obsolescence

Element	Assessment
Affected market segments	1–8, strong driver for 4 (Figure 2-3)
Enabling	Shorter generation cycles, better performance, reduced costs
Innovation type	Sustaining–evolutionary (Table 2-3) (Table 1-1)
Specific financing needs	Limited (electronics can be easily sourced from multiple suppliers; as long as the access to a free and open market is guaranteed, there is no specific need to set up a dedicated financing tool

Source: (European Investment Bank et al., 2019)

According to the Moore's Law which predicts that transistor density on a very large-scale integration (VLSI) chip is doubling on two to three years' basis, it leads to ever-increasing capabilities and reducing costs of electronics and microprocessors. Today, the obsolescence of electronic components is one of the most significant issues for any long-term program (European Investment Bank et al., 2019).

Thus, faster generation change and obsolescence trend affecting many industries in which space industry is not, of course, exemption. The aerospace sector features a cycle of the order of seven to ten years, approximately five times slower than that of the ICT sector, (European Investment Bank et al., 2019) from the accessibility of space assets (e.g., space qualification or launcher cost), which is the very costly segment, to maintenance activities (e.g., Hubble Space Telescope (HST), and International Space Station (ISS)), the procedure of performing the system has already changed to the faster generation change and obsolescence with cheaper access.

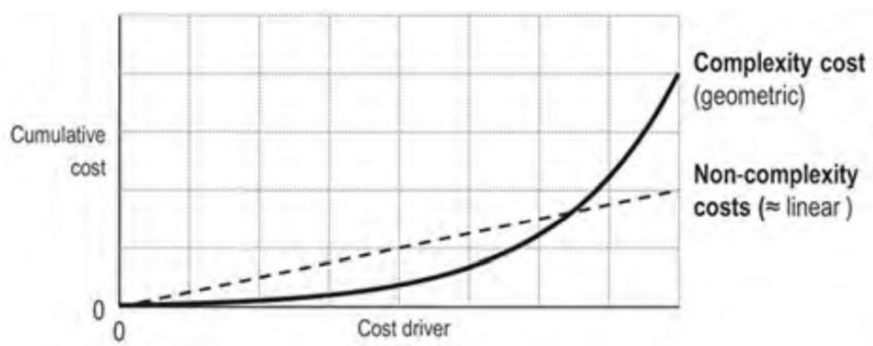
Table 2-5 Advanced manufacturing technologies/three-dimensional printing

Element	Assessment
Affected market segments	1–8, game changer for 6–8 (Figure 2-3)
Enabling	Reduced complexity costs, manufacturing in space and on other celestial bodies
Innovation type	Disruptive (Table 2-3) (Table 1-1)
Specific financing needs	Medium (R&D and bridge financing to further develop and commercialize space-qualified printers)

Source: (European Investment Bank et al., 2019)

Whether it is space, aviation, automotive, software or any other sort of industry, according to Stephen Wilson and Andrei Perumal, "Complexity costs are the single biggest determinant of your company's cost competitiveness" (Company, n.d.).

Figure 2-4 Moore's Law



Source: (Company, n.d.)

The further reducing the complexity of products, the further is reducing the cost of products. Thus, this strategy will increase the reliability and maintainability of the products affecting the whole system especially on those which need to be commercially competitive (Frischauf, 2014).

The key to the reduction of the complexity of the technical systems is transferring of functionality from hardware to software, hence the advent of advanced manufacturing technologies/three-dimensional (3D) printing has provided engineers with a powerful tool to reduce complexity even further, as one can now design and manufacture complex systems in one piece without the need to combine and fasten elements together (European Investment Bank et al., 2019).

Table 2-6 Micro- and nanoelectronics/advanced telemetry and telecommand

Element	Assessment
Affected market segments	1–8, game changer for 4 (Figure 2-3)
Enabling	Holistic observation, control of processes, health monitoring, predictive maintenance
Innovation type	Disruptive for the IoT-element of it (Table 2-3) (Table 1-1)
Specific financing needs	Limited (electronics can be easily sourced from multiple suppliers)

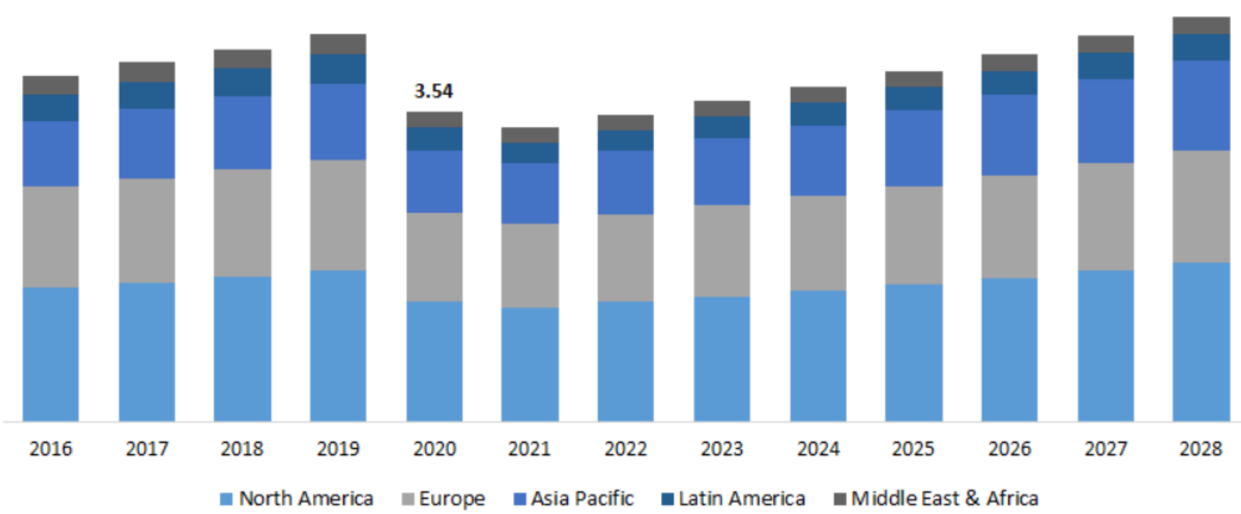
Source: (European Investment Bank et al., 2019)

Nonetheless, CPUs, microprocessors and computer systems are directly affected by the Moore's Law (Figure 2-4), sensors have exceeded the previous numbers and they have seen drastic improvements by Moore's Law. Both boosting performance and the miniaturization of components are related to the concerning improvements. Today, a suite of sensors is available to observe a plethora of processes, providing a wealth of data, which can be used for health monitoring and predictive maintenance of systems (European Investment Bank et al., 2019).

The global aircraft sensor market was valued at USD 3.54 billion in 2020 and is expected to grow at a CAGR of 4.7% during forecast period (Figure 2-5) (*Aircraft Sensors Market | 2021-28 | Industry Size , Growth Report*, n.d.).

Nowadays, the remarkable effect of the IoT especially in 'Industry 4.0' has convergence with the progress in advanced telemetry and telecommand algorithms (European Investment Bank et al., 2019).

Figure 2-5 Aircraft Sensor market size, by region, 2016- 2028, USD billion



Source: (*Aircraft Sensors Market | 2021-28 | Industry Size , Growth Report*, n.d.)

Table 2-7 Agile development and industrial standard implementation

Element	Assessment
Affected market segments	1–8, high impact on 2, 4, 6 and 8 (Figure 2-3)
Enabling	Flexible designs, minimum viable product strategies, staggered rollout sequence
Innovation type	Sustaining–Revolutionary (Table 2-3) (Table 1-1)
Specific financing needs	Limited (it is more business philosophy than classical engineering)

Source: (European Investment Bank et al., 2019)

Agile development is an approach from the IT sector, which has recently seen its introduction into space along with the New Space trend (*SpaceTec Partners*, n.d.).

It represents an approach to software development under which requirements and solutions evolve through the collaborative effort of self-organizing cross-functional teams, their customer(s)/end users(s) (*Collier K.*, n.d., 2011) and it always becomes flexible to response any changes immediately.

Table 2-8 Artificial intelligence/man–machine interface

Element	Assessment
Affected market segments	1–8, high impact on 3, 4 and 8 (Figure 2-3)
Enabling	Autonomous operations, better management of on-board resources, higher performance, easier and faster data interaction with computer systems
Innovation type	Sustaining–revolutionary for weak AI/disruptive for strong AI (Table 2-3) (Table 1-1)
Specific financing needs	Medium to high (R&D and strategic investments to build up a whole industry sector)

Source: (European Investment Bank et al., 2019)

Two types of AI are known: weak AI and strong AI. Weak AI, also known as narrow AI, focuses on performing a specific task, such as answering questions based on user input or playing chess. It can perform one type of task, but not both, whereas Strong AI can perform a variety of functions, eventually teaching itself to solve for new problems (*IBM*, 2021). Self-driving cars and virtual assistants, like Siri, are examples of Weak AI (*IBM*, 2021).

Although AI still lacks the reliability and adaptability in which new software require (*Artificial Intelligence in Space*, n.d.), AI and ML are used through the Satellites, spacecrafts and Mars rovers for their positioning, communication, EO data, and telemetry data.

The German Aerospace Center (DLR) is set up an institute of Artificial Intelligence Security in 2021 [ESA]. The AIDA (Artificial Intelligence Data Analysis) project, funded under the European Horizon 2020 framework, using ESA and NASA data to develop an intelligent service over our Solar System (*Artificial Intelligence in Space*, n.d.).

The Japanese Space Agency (JAXA), French Space Agency (CNES), UK Space Agency (UKSA), and the Italian Space Agency (ASI) are also working through this area.

The operational costs of performing AI algorithms can range from 4 % to 32% (*McNeill, Jr., J.*, n.d., 2014), two-digit savings in satellite operations costs might be possible (European Investment Bank et al., 2019).

Table 2-9 Change detection and data fusion

Element	Assessment
Affected market segments	1–8, game changer for 3, 5 and 8 (Figure 2-3)
Enabling	Cost-effective observation and analysis of specific points of interest, correlation of images and time sequences with other data (also from ground and other sources)
Innovation type	Sustaining–Revolutionary (Table 2-3) (Table 1-1)
Specific financing needs	Medium to high—it is not so much a technology topic but more a matter of whether Europe wants to have its own player(s) that can provide this service, which is highly relevant for security

Source: (European Investment Bank et al., 2019)

With computers becoming increasingly powerful and accessible with every new generation (cloud computing), the processing of power-intensive data algorithms such as change detection and data fusion becomes more feasible (European Investment Bank et al., 2019).

Table 2-10 Digital transformation and convergence

Element	Assessment
Affected market segments	1–8, game changer for 4 (Figure 2-3)
Enabling	Data archiving, search within and comparison of data sets, lower entry hurdles to data processing, manipulation, and visualization
Innovation type	Disruptive, as showcased by global information storage capacity (Table 2-3) (Table 1-1)
Specific financing needs	Limited to medium (electronics can be easily sourced from multiple suppliers; the development of specific software may not be easily outsourced and requires skilled personnel)

Source: (European Investment Bank et al., 2019)

Technology convergence is defined as a trend or process describing the evolution of technology services and industry structures in such a way that several different technological systems sometimes evolve towards performing similar tasks (European Investment Bank et al., 2019).

Concerning the space industry, digital transformation and convergence is lowering the entry barriers by processing the most available data through strong computers as long as make it cheaper by employment of the skilled personnel.

Table 2-11 Evolved expendable/reusable launcher systems

Element	Assessment
Affected market segments	1–8, game changer for 1, 6, 7 and 8 (Figure 2-3)
Enabling	Cheaper and hence more frequent access to space; enlargement of the space market; new business models in space
Innovation type	Disruptive, as it will extend humanity’s sphere of influence beyond LEO and into space (at least the near solar system) (Table 2-3) (Table 1-1)
Specific financing needs	Medium to high (building a rocket requires high upfront investment, dedicated safety analysis; a competitive launch platform; synergies with advanced materials (e.g., carbon fibre), which withstand higher temperatures, high density power systems; improved control algorithms can reduce rocket and launch costs significantly)

Source: (European Investment Bank et al., 2019)

The launcher system is still one the most expensive part of the space ecosystem. Yet, miniaturization and CubeSats reduce the total cost of the launch due to the reduction on total mass. Also, it was not the only reason for cost reduction, new entrants such as SpaceX, Rocket Lab, Blue Origin, Virgin Galactic, and Vector space systems are playing the key role competing with Arianespace, ULA, ILS, and others to decrease the cost by reusable missiles.

Table 2-12 Miniaturization and nanotechnology

Element	Assessment
Affected market segments	1–8, nanotechnology is a game changer for everything (Figure 2-3)
Enabling	Cheaper and smaller systems, stiffer and highest performing structures, self-repairing and self-replicating systems
Innovation type	Sustaining–evolutionary for miniaturization (Table 2-3) and Disruptive for nanotechnology (Table 1-1)
Specific financing needs	Limited to high (miniaturization is mostly thriving on Moore’s Law and some advances in new materials, while nanotechnology does still require a considerable amount of R&D to develop the “universal assembler”, miniature power control and distribution unit (PCDU), nanoscale energy storage systems, nanoscale control systems and computers, etc.)

Source: (European Investment Bank et al., 2019)

Several types of the nanotechnology are being used in the space such as nano-medicine, nano-based computers and robotics, nano-material, and advanced materials. As it was mentioned on the assessment above, nanotechnology is disruptive innovation which has an impact on the whole space value chain.

Table 2-13 Optical and ubiquitous communications

Element	Assessment
Affected market segments	1–8, high impact on 5, 6 and 8; however, space is more the enabler and not so much the benefactor (Figure 2-3)
Enabling	Ubiquitous communication, machine-to-machine data exchange, holistic insights into events ongoing worldwide
Innovation type	Disruptive, as it is at the root of mobile Internet (Table 2-3) (Table 1-1)
Specific financing needs	Medium to high (R&D and bridge financing need to be provided to further develop and commercialize space-based optical communication systems)

Source: (European Investment Bank et al., 2019)

Optical and ubiquitous communications are crucial due to the response of the future demands of the fast-growing space commercialization.

While NASA, ESA (European Data Relay System (EDRS), (**Error! Reference source not found.**) and JAXA (Japanese Data Relay System) have set up space optical systems, R&D efforts are still ongoing, and standards are yet not entirely harmonized (e.g. wavelengths of 1550nm and 1064nm) and a network of ground stations is yet to be built (European Investment Bank et al., 2019).

Business model building for carrying out the new space activities, should established on the following pillars:

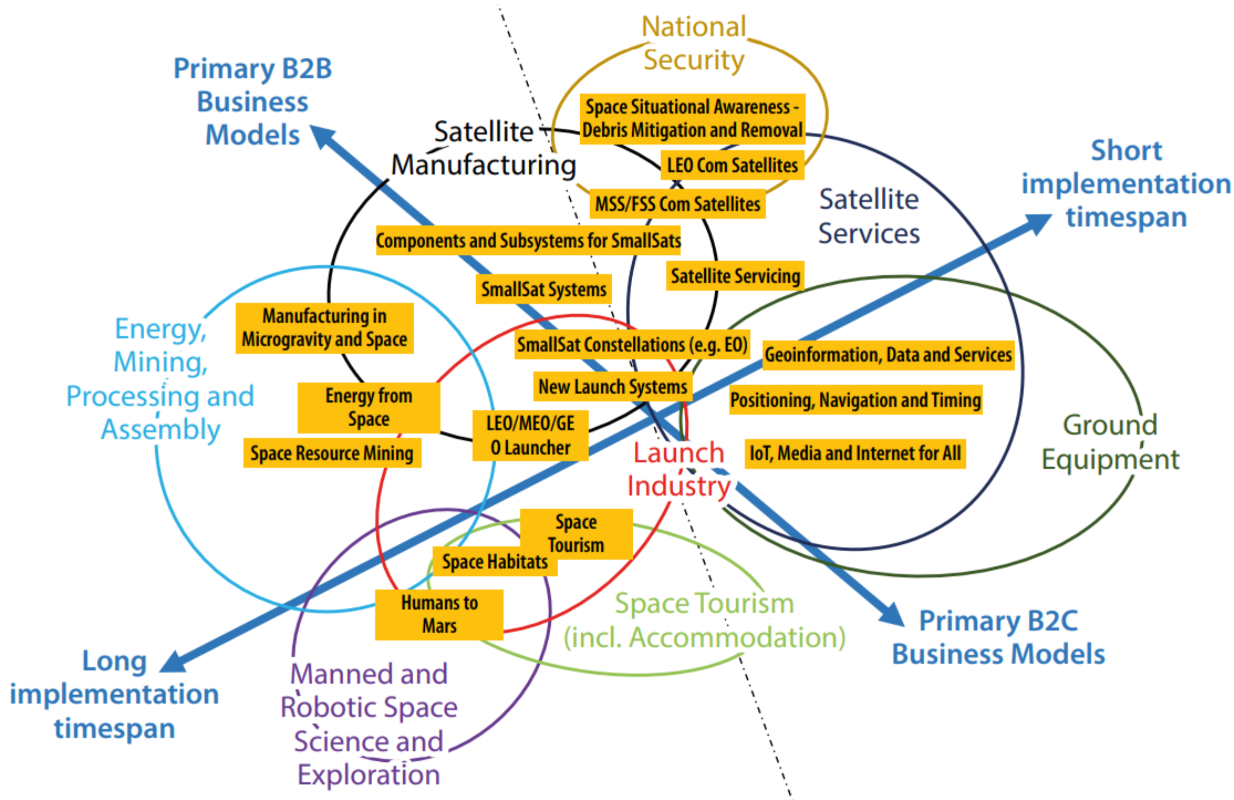
- Space is not a destination.
- Space is an enabler for a variety of business verticals.
- Space accelerates and expands business verticals by providing new, disruptive ways of doing business that are faster, cheaper and better (European Investment Bank et al., 2019).

Optical and ubiquitous communications trigger novel commercial sector. Hence, governments should meet all fundamental requirements to benefit the utmost advantages of this disruptive innovation.

2.4 Risk assessment of the space ecosystem

Figure 2-3 shows eight different business model segments and Figure 2-1 illustrates different business services. Considering two dimensions of the timespan (short implementation, long implementation) and business character (B2B, B2C), Figure 2-6 indicates the risk assessments of these dimensions as long as their interdependencies with business model segments and business services.

Figure 2-6 A landscape of space business services, business models and segments



Source: (*Space Tec Partners*, n.d.)

Acknowledging that market opportunities are, in general, more favorable in a B2C dominated sector and that entry hurdles are lower in business segments where projects and business models may be realized within short time frames or where it is possible to thrive on short generation cycles, we can infer that the associated business models are less risky on the upper right-hand side of Figure 2-6 and come along with higher risk levels on the lower left-hand side (European Investment Bank et al., 2019).

As a result, it could be said that the Ground Equipment, Satellite Services, and National Security are located into the low-risk zone with the higher market opportunities. Adding to this, Satellite manufacturing could also be partially seen into this area, but it needs both higher sort of R&D and investment. In contrary, Energy, Mining, Processing and assembly as long as the Manned and Robotic Space Science and Exploration are located into the high-risk zone.

The highly successful pure-play commercial space companies such as ViaSat, Intelsat, Inmarsat, SES and Eutelsat, as well as most of the successful New Space ventures like Spire, Planet, Orbcomm, OneWeb, ISIS—and to a certain extent SpaceX, Blue Origin, Rocket Labs are concentrated in the upper right corner (European Investment Bank et al., 2019).

Another aspect of the risk assessment is based on the comparing the technology trends and the space business models. It was previously mentioned that the technology trends are affecting space ecosystem, and ‘space is experiencing an ever-increasing technology flow (“spin-in”)’ (European Investment Bank et al., 2019). Table 2-2 is also comparing the technology trends and space business models providing innovative process respected to the market segments.

The five defined set of risk such as product/technology, assets, demand, competition, and regulation are leading to an assessment to the space market segments. Table 2-14 is giving the general overview of the risk assessment related to each segment of the space ecosystem. Comparing Table 2-14 and Figure 2-1 in which new space economy was depicted, it could assume that as much as the market segments are going to become closer to the new space economy, the general risk is high and it is in contrary with the established segment of the space economy in which that the general risk is low. It was due to the implementation of timespan. However, the launch industry is still located on the high-risk zone of the space ecosystem due to its over complicatedness of actions even with all the development in the technology during several decades.

Table 2-14 Risk assessment of market segment and business models in space ecosystem for five discriminators

Legend: ○ Low Risk ● High Risk

	Launch industry	Satellite manufacturing	Satellite services	Ground equipment	National security	Manned space science and exploration	Space tourism	Energy, mining, processing, and assembly
Product/Technology	◑	◔	◑	◑	◑	◑	◕	●
Assets	●	◕	◑	◔	◑	●	●	●
Demand	◑	◔	◔	○	◔	◕	◕	●
Competition	◑	◑	◔	◕	◔	◑	◕	◑
Regulation	◕	◑	◕	◔	◑	◑	◕	◕
Summary	◕	◑	◑	◔	◑	◕	◕	◕

Source: (European Investment Bank et al., 2019)

Risk assessments of space ecosystem regarding the predefined five discriminators are following as the same behavior of the space ecosystem regarding the short and long implementation of the timespan. Comparing both satellite services and ground equipment with the other segments due to the low level of risks and high implantation of the technology trends (Table 2-3) is leading to the high opportunity for the actors involving on these sectors and of course, the result would be the great dominant of affection even on the other industries.

Following tables are showing the risk assessment with five discriminators for all the eight segments of the space ecosystem.

Table 2-15 Launch industry

Product/technology	◑	The principal design of rockets is unaltered, innovation is geared towards reducing specific launch prices, increasing the flight rate, as well as building up the highest possible success rate, Space-X and Blue Origin are trying to (re)introduce reusable rockets
Asset intensity	●	High upfront costs for machinery, test stands, launch ports (mostly subsidized); extensive testing required, limited COTS components available, but 3D printing reduces complexity

Demand	◑	Increasing demand from the New Space sector and for smallsat and CubeSats constellations (micro launchers)—synergies with space tourism, new business models in space
Competitive landscape	◑	Triopoly for commercial launches (Arianespace/ SpaceX/ILS), new players incoming has to show high success rate
Regulation	◕	New regulation for toxic propulsion systems (REACH) upcoming; return of rocket stage (space debris?)
Risk summary	◕	

Source: (European Investment Bank et al., 2019)

Table 2-16 Satellite manufacturing

Product/technology	◔	Well-known systems, limited innovation (besides CubeSats), smallsats as pilots for technology try-outs (esp. agile development, miniaturization and industrial standard implementation)
Asset intensity	◕	Expensive manufacturing (clean room) and testing systems required, more and more COTS components reduce costs
Demand	◔	Altered consumer behavior (IPTV versus analogue TV) might slow down demand for big Telco-Sats, increasing demand for small to medium sats/constellations with short generation cycle
Competitive landscape	◑	Players mostly known with some new actors in the smallsat sector; high upfront costs and reliability requirements limit competition for
Regulation	◕	New regulation for toxic propulsion systems (REACH) upcoming; so far, voluntary actions to reduce space debris
Risk summary	◑	

Source: *(European Investment Bank et al., 2019)*

Table 2-17 Satellite services

Product/technology	◑	New services (New Space) building upon constellations, new sensors and algorithms allow for cost-effective and market extensions, shorter generation cycles allow swifter innovation introduction
Asset intensity	◑	The advent of powerful computers has allowed increased autonomy and is making the operations less expensive, COTS and outsourcing reduce costs further
Demand	◔	Altered consumer behavior (IPTV versus analogue TV) might slow down demand for big Telco-Sats; however, several new space services, e.g., ADS-B and AIS form space/M2M communications, IoT; in addition, EO is seeing high demand
Competitive landscape	◔	Limited competition: however, novel services provide opportunities for new players to enter this restricted segment (New Space)
Regulation	◕	Limited space and frequencies for certain orbits; satcom frequencies under pressure by terrestrial networks (WiMax); so far voluntary actions to reduce space debris; constellations may not get launched as intended, due to restrictions of space and frequencies
Risk summary	◑	

Source: (European Investment Bank et al., 2019)

Table 2-18 Ground equipment

Product/technology	◑	New products evolving, building upon new powerful algorithms, Moore's Law, digital transformation and convergence
Asset intensity	◔	Digitalization and the shift from hardware to software has significantly reduced the upfront costs
Demand	○	Satnav and Earth Observation services see high demand, satcom will be indispensable for IoT and M2M
Competitive landscape	◕	High; several players compete on this market and the entry costs are relatively low
Regulation	◔	Industrial standards and RF regulations are the dominant factors
Risk summary	◔	

Source: (European Investment Bank et al., 2019)

Table 2-19 National security

Product/technology	◑	New change detection algorithms lead to the merging of a few big high-res satellites with a constellation of low-res EO sats, strong R&D in cryptography
Asset intensity	◑	The requirements for high reliability and security limit sourcing and increase costs
Demand	◔	Unpredictive actors within a multipolar world have triggered a bigger security demand (institutional market)
Competitive landscape	◔	Limited competition due to institutional market and demands for high reliability and service continuity
Regulation	◑	Military systems are often exempted from certain regulations; however, ITAR and similar regulations are taken very seriously
Risk summary	◑	

Source: (European Investment Bank et al., 2019)

Table 2-20 Crewed and robotic space science and exploration

Product/technology	◑	Conservative segment due to high safety constraints (crewed), data transfer operations over long distances and/or with high data rates will require specific equipment (e.g. big dishes and/or Laser Communication Terminals (LCT))
Asset intensity	●	Expensive manufacturing (clean room) and testing systems required, the utilization of COTS components is limited, ECSS standards apply
Demand	◕	Limited institutional market but with renewed interest in crewed exploration beyond LEO (e.g., cis-lunar space), in the future crewed vehicles will leave LEO and venture further into deep space (Cis-lunar space, L1/L2, moon, asteroids, Mars)
Competitive landscape	◑	New players, often engaged in space tourism or in incentive prices like the one initiated by Bigelow start to enter the field
Regulation	◑	ECSS and similar standards, as well as ITU/RF regulations, are the dominant factor
Risk summary	◕	

Source: (European Investment Bank et al., 2019)

Table 2-21 Space tourism (incl. habitation)

Product/technology	◕	Space tourism companies try old and new designs, such as gliders and rocket (Virgin Galactic, XCOR, Sierra Nevada, Blue Origin), SpaceX and Blue Origin are trying to (re)introduce reusable rockets
Asset intensity	●	High upfront costs for machinery, test stands, launch ports (mostly subsidized), etc., extensive testing required, limited COTS components available, but 3D printing reduces complexity
Demand	◕	Space tourism (incl. Habitation) activities have started, however the market has not been tried yet, a catastrophic failure might lead a halt to the segment, NASA is supporting the development of this domain by its ISS cargo resupply contracts and the commercial crew awards
Competitive landscape	◕	Several players compete on this market, which has not been tried yet and is currently very limited in size
Regulation	◕	In the US the FAA has eased up the certification regime by using the spaceport approach, acknowledging that a full-fledged licensing/ certification process as used in aviation would likely kill the market segment due to very high upfront costs; situation in Europe is unclear
Risk summary	◕	

Source: (European Investment Bank et al., 2019)

Table 2-22 Energy, mining, processing, and assembly

Product/technology	●	First trials on manufacturing, assembly, integration and testing of systems and goods in space based on the ISS experience and on experiments on board, ISRU, etc. have not been tried yet, lots of technologies still to be developed
Asset intensity	●	Very high upfront costs (launch, space qualified components, subsystems and systems), challenging operation
Demand	●	AMF serves as first commercial 3D-printer in space; asteroid mining has attracted some interest; spacebased energy harvesting is waiting for the first serious start-ups
Competitive landscape	◑	Very limited; few companies such as Planetary Resources, Deep Space Industries and the Shackleton Energy Corporation
Regulation	◕	Outer space and moon treaty prevail, which pose a significant risk; what might and can be done? In addition, ECSS and similar standards, as well as ITU/RF regulations, are the dominant factors
Risk summary	◕	

Source: (European Investment Bank et al., 2019)

2.5 Funding Channels in Europe

Due to the comprehensive information which was provided by European Investment Bank interviewing 40 space and space application companies (European Investment Bank et al., 2019), the result is generalized to the current situation in Europe. Thus, the most important aspects of the result regarding the aim of this paper were introduced only and more analysis about the funding channels, of course, need further research and concentration. Also, more importantly, the obstacles hindering the European space Small and Medium Enterprises to scale-up phase would introduce as long as proposing the recommendations to overcome the hurdles. Also, knowing the private or public funding channels are important due to the giving assess to the start-ups when strategists are paving the route for their business plan.

First and foremost, access to the venture capital/private equity is much preferable for the companies. The reasons are mostly lies into:

- Ease of access
- Volume of funding
- Speed of funding.

Venture capital, by its definition is going to fund start-ups, early-stage, and emerging companies ("Venture Capital," 2022) that are believed to have long-term growth potential (*Investopedia*, n.d.). So, expectedly, not only the companies should look for venture capital investors, it seems that also venture capital firms are interested to invest on these companies in exchange for equity, or an ownership stake ("Venture Capital," 2022). Again, the same as "Unicorns" in which venture capitalist provide strategic advice to the firm's executives on its business model and marketing strategies ("Venture Capital," 2022), space investors highlight the importance of the management when selecting their investments (European Investment Bank et al., 2019).

The second important source of funding coming from public instruments, mostly through the channel of R&D grants. However, the reason which attracts companies to the public funding were introduced as better conditions due to the non-dilutive nature (European Investment Bank et al., 2019).

As it was also previously mentioned about Horizon 2020 (see Box 1) which is managed by European Commission, the Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME) program, and the European Structural and Investment Funds (ESIF) program are also under supervision of the European Commission (European Investment Bank et al., 2019). The successor program of Horizon 2020 is called 'Horizon Europe' which is an over seven-year period project (from Jan 2021 till Dec 2027). The proposal is €95.5 ($110.34) billion Euro, 25 billion Euro investment more than Horizon 2020 program. Under Horizon 2020 program, InnovFin Space Equity Pilot (ISEP) is an example of the EIF to support space SMEs and mid-caps (European Investment Bank et al., 2019).

The European Investment Bank (EIB) Group consists of the EIB itself and the European Investment Fund (EIF) (European Investment Bank et al., 2019) are also funding elements for the space sector. For instance, the European Fund for Strategic Investments (ESFI) is a joint initiative of the European Commission and the EIB group addressing private finance for strategic investment.

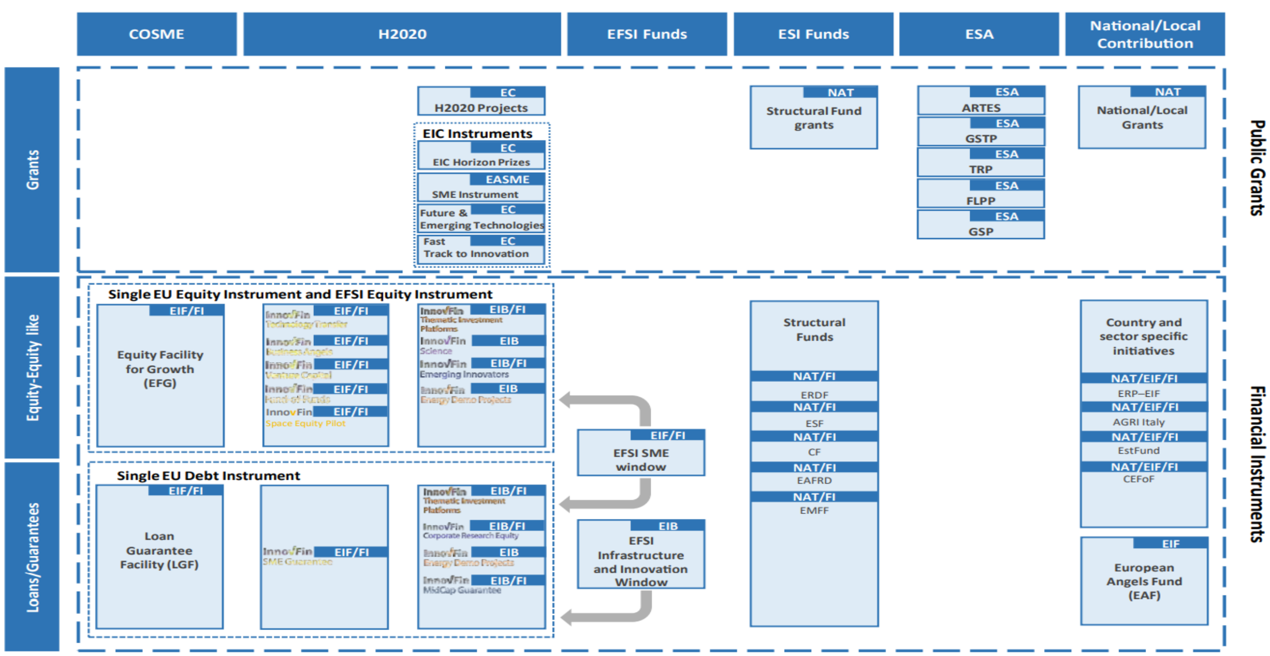
The European Space Agency (ESA) is another major actor when it comes to investment in space-related R&D in Europe. The ESA funds a wide range of different R&D programs aiming to foster a high level of competency in the European space sector and it includes mandatory programs and optional programs (European Investment Bank et al., 2019).

For instance, beginning of 2021, European Commission (EC), European Investment Bank (EIB), and European Space Agency (ESA) have shown strong willing to support space start-ups, SMEs and mid-caps on areas which includes Climate change solutions, transformative digital services, safety and security over the next 3 or 7 years (*Financing SMEs*, n.d.).

Figure 2-7 illustrate an overview of the public funding schemes in Europe. It should be added that whether the fundings are general, they are directly or indirectly relevant for small and medium-sized enterprises (SMEs) in the space sector (European Investment Bank et al., 2019).

Besides, National ministries and regional/ local authorities (NAT), and Financial Intermediaries (FI) are arranging additional funds for R&D in Europe.

Figure 2-7 Existing European financing programs/instruments for SMEs and mid-caps

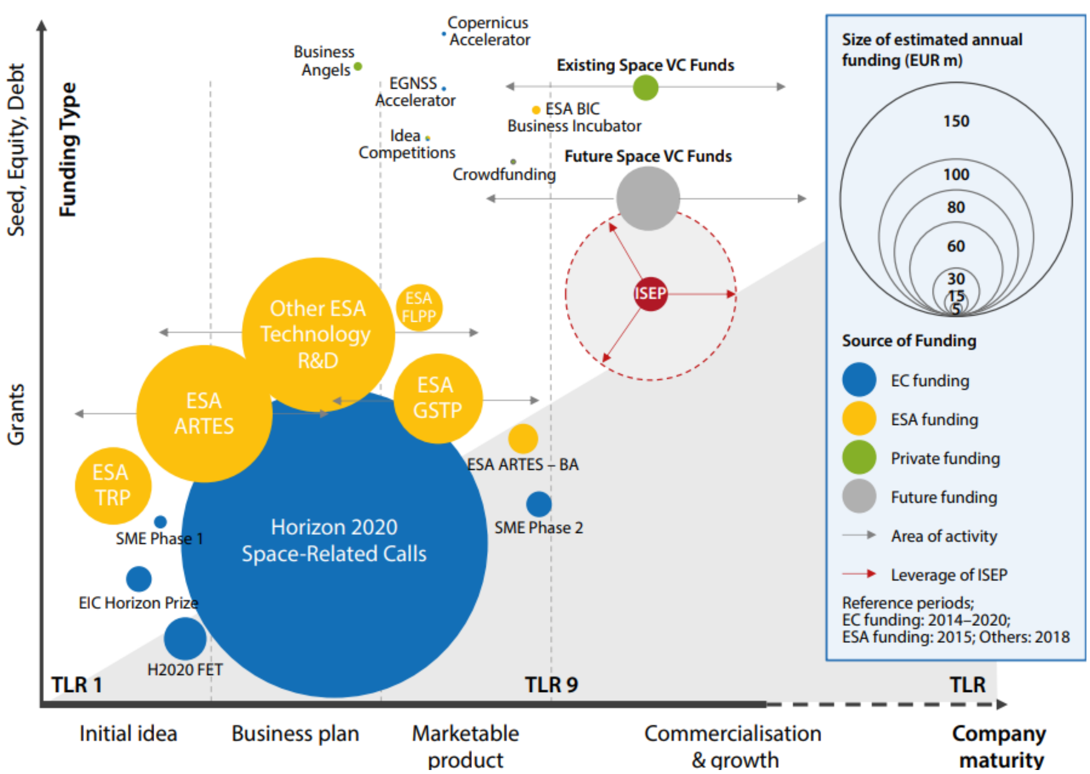


Source: (European Investment Bank et al., 2019)

The infographic in Figure 2-8 shows a synthesis of the estimation of all available funding instruments, per year, for SMEs in the European space sector, and their relative importance (European Investment Bank et al., 2019). Looking into the Figure 2-8 gives these important aspects:

- Horizontal elements show the development phases of a product from the initial idea to a company maturity which is based on the technology readiness level (TRL) (Figure 1-2) in a scale of 1 to 9 referring the maturity of a technology.
- Vertical elements indicate the funding channels for the space ecosystem in Europe divided into the Grants and Seed, Equity, Debt.
- Main source of the funding in Europe is coming from the EC and the ESA.
- While the accumulation of the investment is seen on the business plan stage providing by EC and ESA, private financiers, who make funding available in the form of equity, debt or hybrid products (European Investment Bank et al., 2019), mostly, are filling the gap on the commercialization and growth stage.

Figure 2-8 Overview of space-focused financial instruments in Europe and estimated annual funding volume



Source: (European Investment Bank et al., 2019)

Table 2-23 Horizon 2020 Grants

Summary	• Objective: to enable the European space research community to develop innovative space technologies and operational concepts "from idea to demonstration in space", and to use space data for scientific, public or commercial purposes. • Number of space projects funded to date: 231. • Total space funding: EUR 1479 million (to date—also used for procurement, infrastructure & in-orbit demonstration/ validation (IOD/IOV) activities). • Funding amount per project: EUR 2.3 million (average).

Source: (*Horizon 2020*, n.d.)

Table 2-24 EIC Horizon Prize

Summary	• Objective: to solve a major challenge facing society and to boost breakthrough innovation. • Number of space projects funded: two dedicated to space. • Total space funding: EUR 10 million for the Low-Cost Space Launch prize and EUR 5 million for the Early Warning for Epidemics prize. • Funding amount per project: EUR 5–10 million.

Source: (*European Innovation Council*, n.d.)

Table 2-25 Horizon 2020 FET Open instrument

Summary	• Objective: to turn Europe's excellent science base into a competitive advantage. • Number of space projects funded: 11. • Total space funding: approximately EUR 40 million over the period 2014–2017. • Funding amount per project: from EUR 100 000 to several EUR million

Source: (*Horizon 2020*, n.d.)

Table 2-26 ESA TRP Program

Summary	• Objective: to research basic principles observed from actual system completion to experimental proof of concept. • Number of space projects funded: 150 contracts per year. • Total space funding: EUR 50 million per year. • Funding amount per project: EUR 50 000–150 000.

Source: (*Shaping the Future*, n.d.)

Table 2-27 ESA ARTES Program

Summary	• Objective: to develop innovative satcom products, services, systems and partnerships. • Number of space projects funded: over 100 contracts per year. • Total space funding: approximately EUR 110 million per year. • Funding amount per project: EUR 0.5 million–1.5 million for core competitiveness, EUR 0.6 million–2 million for business applications.

Source: (*ESA TIA*, n.d.)

Table 2-28 ESA FLPP

Summary	• Objective: to develop future launchers with low development and production costs. • Number of space projects funded: approximately 14 contracts per year. • Total space funding: ca EUR 30 million per year. • Funding amount per project: up to several million euro.

Source: (*FLPP Preparing for Europe's next-Generation Launcher*, n.d.)

Table 2-29 ESA GSTP

Summary	• Objective: the development of new technologies and projects. • Number of space projects funded: approximately 70 contracts per year. • Total space funding: EUR 60 million per year. • Funding amount per project: EUR 150 000–EUR 1 million.

Source: (*Shaping the Future*, n.d.)

Table 2-30 Copernicus Hackathon Program

Summary	• Objective: creation of innovative business ideas based on Copernicus EO data. • Number of space projects funded: 20 hackathons every year for two years. • Total space funding: total funding pool of EUR 1.2 million. • Funding amount per project: no cash prize-winners enter the Copernicus Accelerator.

Source: (*Homepage | Copernicus*, n.d.)

Table 2-31 GSA Hackathons

Summary	• Objective: to look for passionate coders who want to shape the future of location-based services and GEO–IoT. • Number of space projects funded: 11 winners selected per year. • Total space funding: yearly prize pool of EUR 3000, plus additional prizes provided by technical partners. • Funding amount per project: EUR 1000.

Source: (*EU Agency for the Space Programme*, n.d.)

Table 2-32 Farming by Satellite

Summary	• Objective: to promote Europe's GNSS and EO services in agriculture. • Number of space projects funded: three winners selected per year. • Total space funding: yearly prize pool of EUR 8000 • Funding amount per project: between EUR 1000 and EUR 5000.

Source: (*Farming by Satellite || Farming by Satellite*, n.d.)

Table 2-33 Copernicus Masters

Summary	• Objective: creation of innovative products & services based on Copernicus EO data. • Number of space projects funded: 15 winners selected per year. • Total space funding: EUR 1.5 million of cash prizes and non-financial support (2017). • Funding amount per project: cash prizes between EUR 5000 and EUR 10 000 plus non-financial support.

Source: (*Home*, Copernicus Masters n.d.)

Table 2-34 European Satellite Navigation Competition (ESNC)

Summary	• Objective: to award the best services, products and business ideas using satellite navigation in everyday life. • Number of space projects funded: 26 projects per year. • Total space funding: yearly prize pool of EUR 1.3 million (2017). • Funding amount per project: up to EUR 10 000.

Source: (LAMPARTE, 2019)

Table 2-35 Copernicus Accelerator

Summary	• Objective: to turn promising ideas into reality and successfully enter them into the market. • Number of space projects funded: 50 participants from the Copernicus ecosystem. • Total space funding: yearly funding pool of EUR 250 000 (2017). • Funding amount per project: EUR 5000 for mentor.

Source: (*Home*, Copernicus Masters, n.d.)

Table 2-36 E-GNSS Accelerator Program

Summary	• Objective: to enable the winners of the ESNC to accelerate their business ideas and start real commercial ventures. • Number of space projects funded: the top three winners of the ESNC selected per year. • Total space funding: yearly prize pool of EUR 186 000. • Funding amount per project: EUR 62 000 of non-financial support.

Source: (LAMPARTE, 2019)

Table 2-37 Copernicus Incubation Program

Summary	• Objective: to turn the most innovative and commercially promising ideas into reality and successfully enter the market. • Number of space projects funded: 20 European start-ups from the Copernicus ecosystem. • Total space funding: yearly funding pool of EUR 1 million. • Funding amount per project: EUR 50 000 of non-financial support.

Source: (*Home*, Copernicus Masters n.d.)

Table 2-38 ESA Business Incubator Centers (BICs)

Summary	• Objective: to work with and inspire entrepreneurs to turn space-connected business ideas into commercial start-up companies. • Number of space projects funded: 140 start-ups in 18 European BICs funded per year. • Total space funding: EUR 7 million per year. • Funding amount per project: approximately EUR 50 000 of grants and non-financial support.

Source: (*Business Incubation | ESA Space Solutions*, n.d.)

Table 2-39 Crowdfunding

Summary	• Objective: to build a bridge between new space investors and space entrepreneurs. • Number of space projects funded: unknown. • Total space funding: unknown. • Funding amount per project: variable.

Source: (European Investment Bank et al., 2019)

Table 2-40 Business Angels

Summary	• Objective: to provide the capacity to invest, bringing both finance and experience to small businesses. • Number of space projects funded: unknown. • Total space funding: unknown - angels invested EUR 6.7 billion across industries (2016).87 • Funding amount per project: typically, between EUR 25 000 and EUR 100 000.

Source: (*HOME*, Business Angels Europe, n.d.)

Table 2-41 Horizon 2020 SME Instrument

Summary	• Objective: to support highly innovative SMEs with close-to-market activities though a phased approach. • Number of space projects funded: approximately 20 per year in phase 1 and 10 per year in phase 2. • Total space funding: EUR 14–16 million per year. • Funding amount per project: EUR 50 000 (phase 1) to EUR 2.5 million (phase 2).

Source: (*Horizon 2020*, n.d.)

Two important divisions into these tables should be consider. Firstly, these grants are concentrating into the innovations which is coming from R&D in Europe in space business ecosystem. Next, these grants and seeds are also instruments to support star-ups in Europe. However, following problems have been shown on Table 2-42 in Europe financing system:

Table 2-42 Summary of the financing problems in Europe

	Key finding	In detail
	Financing challenges	
1	The European space sector experiences funding hurdles similar	• Not only is the volume of European VC investment lower, but also venture capitalists invest with smaller tickets, and growth capital is particularly hard to find

	to those of other tech companies, particularly at scale-up phase	• Business loans from commercial banks are nearly inaccessible
2	Companies in both the upstream and downstream sectors of the industry struggle with access to finance, but for different reasons	• Upstream companies face long development cycles, are capital-intensive and operate in a limited market with many businesses risks • Downstream companies sell to emerging markets (with predominantly governmental buyers) and to unsophisticated customers
3	The space ecosystem lacks investors with a space background and space investment expertise	• It will still take years for the European space sector to exploit the full potential of the mobility of people between the triangle of corporate, entrepreneurship and investment roles
4	European space entrepreneurs feel there is a lack of private financing sources and keep an eye on the US	• Most space entrepreneurs are looking for private capital outside of the EU • The wave of New Space investments in the US, with larger funding rounds and investors with greater risk appetite, are enticing to European firms
	Market maturity and sector risks	
5	Space innovations have a longer development cycle than general tech	• The space hardware development cycle is considerably longer than in general tech; however, New Space is closing the gap
6	Investors are mostly concerned by market maturity	• Immature markets with questionable demand, technology risks and high capital needs are the key risks from the perspective of space investors
7	Investors do not see the exit opportunity (yet)	• Large system integrators do not yet have a tradition to invest in external innovation • Investors perceive the lack of exits as a sign of new or failing markets and therefore a risk for financial returns
8	The lack of follow-on finance has led to a number of early initial public offerings (IPOs)	• Europe has seen a few small space IPOs over the last two years despite a decline in the overall small IPO market • IPOs are seen by the entrepreneurs as a sizable funding source but also as a scalable funding source
	Role of the public sector	
9	European public innovation instruments play an important role in unlocking private capital for the space sector	• 40 % of the companies seek public funding as it is a precondition for private investment • Public funding serves as a seal of approval in the market
10	The landscape of space sector support mechanisms is rather fragmented, and procurement is	• Entrepreneurs find it hard to navigate through the different possible funding options

	geared towards the traditional value chain	• The traditional European upstream space industry is used to a large institutional market of traditional public procurement and R&D grant programs • Industry associations and entrepreneurs in both the upstream and downstream sectors indicate a lack of public anchor tenants to stimulate the sector
11	Public authorities around the globe are stimulating the setting-up of venture capital funds dedicated to the space industry	• France, Luxembourg and Japan are examples of governments initiating VC funds to bridge the funding gap for space companies

Source: (European Investment Bank et al., 2019)

More, Table 2-43 is recommending some solutions to tackle the problems.

Table 2-43 Financial Recommendations

SUPPORT FOR THE ECOSYSTEM 1. Strengthen the ecosystem of public support mechanisms by introducing more flexibility and more commercial orientation
INNOVATIVE PULL MECHANISMS FROM THE PUBLIC SECTOR 2. Develop and deploy innovative pull mechanisms from the public sector (e.g., innovative procurement and industrial policies) to stimulate technology development and its commercial uptake 3. Adopt a strengthened European defense policy as a driver for market development across all space business segments
ACCESS TO FINANCE 4. Increase the volume of risk capital and catalyze additional private investment into the sector
ADVISORY AND SOFT MEASURES 5. Establish a “finance for space” forum with representatives from the finance community, academia, policymakers and industry to bridge the information gap and develop innovative financing solutions for the space sector

Source: (European Investment Bank et al., 2019)

3 CHAPTER THREE

3.1 Introduction

This chapter introduced satellites that have the most impact on precision farming made in the EU. Also, the connection of space and agriculture through precision farming and their technology trends and value chains regarding the aerospace clusters in Italy were discussed. More, the reasons why northern Italy is the main focus of the study were explained. Finally, global policy and Italy's policy towards space economies were reviewed.

3.2 Introduction of main EU satellites

A large part of space-specific funding by the European Union and the ESA is associated with the three European space programs: Galileo, Copernicus and EGNOS (European Investment Bank et al., 2019), hence it seems essential to introduce these programs. Some preliminary information was discussed about the satellites at the beginning of chapter two; however, Galileo, Copernicus, and EGNOS programs will be under discussion, especially. Before going through the programs, it should say that the technical part of the satellites is no issue for this paper.

Galileo is European Union's own global navigation satellite system (GNSS), providing a highly accurate, guaranteed global positioning service under civilian control (*Galileo*, n.d.).

The Galileo program was created to answer Europe’s strategic need of a reliable European satellite navigation signal, and to foster the development of economic and societal benefits (European Investment Bank et al., 2019).

Four significant characteristics of the Galileo program are described as (European Investment Bank et al., 2019):

1. Open Service: Free of charge to users, providing positioning and synchronization information for high-volume navigation applications
2. High Accuracy Service: More secured and precise service delivered through encrypted signal for applications such as safety-of-life
3. Public Regulated Service: Restricted to government-authorized users, for sensitive applications requiring a high level of service continuity, free of charge for European institutions and MS
4. Search and Rescue Service: Contributing to COSPAS-SARSAT, Galileo will offer a unique link alert informing the sender that their distress message has been received

The estimated budget allocated to the Galileo and EGNOS program is €9.1 ($12.74) billion over the period of 2021-2027 ("EU Space Program 2021-2027," 2020).

Table 3-1 Satellite Navigation Value chain

Upstream	Midstream	Downstream	End users
Space system development and launch • Satellite system manufacturing • Provision of launch service	**Operations** • Satellite operations • GNSS service provision	**Receiver manufacturing and system integration** • Design development and production of receivers and chipsets • Receiver and component integration Navigation data exploitation • Software development • Provision of services to institutional, industrial, public and private users	Drones Agriculture Road transportation Rail Manned Aviation Consumer solutions Emergency response Maritime Critical infrastructures Geomatics

Source: (*PwC*, n.d.)

One of the most important innovations is the Galileo Navigation system. A joint team of the engineers from Italy, Germany, and France, which are the main contributors of the ESA, come together with an idea to compete with military-oriented navigation systems of the USA (GPS), Russia (GLONASS), and China (BeiDou) for primarily civilian use ("Galileo (Satellite Navigation)," 2022).

Galileo has a huge potential to be employed in different industries, from energy to transportation, from agriculture to finance with an accuracy of less than 10 cm in positioning (*ASI | Agenzia Spaziale Italiana*, n.d.).

The Copernicus Program is a complex earth satellite observation program which is a part of the broader GEOSS (Global Earth Observation System of Systems) project ("COPERNICUS," n.d.). Same as the Galileo project, Copernicus program is providing autonomy to the European Union.

The Copernicus program is collecting data from the space through a set of six types of the UE-owned satellites called "the Sentinels".

Sentinel-1: Produce interferometric radar data includes day and night radar imaging for land and ocean in all-weather conditions

Sentinel-2: Optical satellites for multispectral observation includes high resolution optical imaging for land services (useful in Precision farming)

Sentinel-3: Conduct oceanographic and terrestrial observations

Sentinel-4: Monitor the atmospheric components

Sentinel-5: Monitor the atmosphere's chemical composition

Sentinel-6: Study the surfaces of the seas and oceans for climatological purposes ("COPERNICUS," n.d.)

Another set of Copernicus program is currently being studied by ESA to fulfill deficiencies and improve service to the users. This set includes:

Sentinel-7: Anthropogenic CO_2 emissions monitoring (CO2M)

Sentinel 8: High Spatio-temporal Land Surface Temperature (LSTM)

Sentinel 9: Copernicus Polar Ice and Snow Topography Altimeter (CRISTAL)

Sentinel 10: Copernicus Hyperspectral Imaging Mission for the Environment (CHIME)

Sentinel 11: Polar Imaging Microwave Radiometer (PIMR)

Sentinel 12: Radar Observing System for Europe – L-band SAR (ROSE-L)

The sectors in which Copernicus added value are (*Copernicus Europe Eyes on Earth.Pdf*, n.d.):

- Agriculture
- Forestry
- Urban Monitoring
- Coastal and Marine Exploitation and preservation
- Oil & Gas
- Renewable Energies
- Air Quality Management
- Management of Natural Disasters
    - Insurance for Natural Disasters
    - Response to Natural Disasters
- Security

Figure 3-1 A-68A giant iceberg

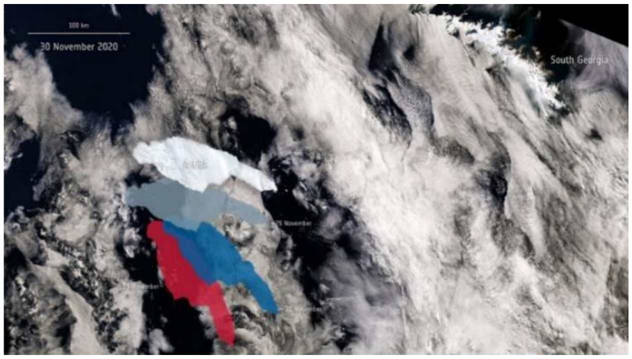


Figure 3-2 Effects of the locked-down city of Venice

Figure 3-1 is Sentinel-2 images showing one of the effects of the locked-down city of Venice, in northern Italy. The top image, captured 13 April 2020, shows a distinct lack of boat traffic compared to the image from 19 April 2019 (*Sentinel Data Access*, n.d.).

Figure 3-2 shows A-68A giant iceberg's movements across the Southern Ocean over the 15 days in November 2020 using data from the Copernicus Sentinel-1 and Sentinel-3 missions (*Sentinel Data Access*, n.d., 2020).

Figure 3-3, captured on 31 March 2020 from Sentinel-3, shows the Ganges Delta – the world's largest river delta (*Sentinel Data Access*, n.d.).

Figure 3-4, using data from the Copernicus Sentinel-5P satellite, show the average nitrogen dioxide concentrations from 13 March to 13 April 2020, compared to the March-April averaged concentrations from 2019. The percentage decrease is derived over selected cities in Europe and has an uncertainty of around 15% owing to weather differences between 2019 and 2020 (*Sentinel Data Access*, n.d., 2020).

Figure 3-3 Ganges Delta

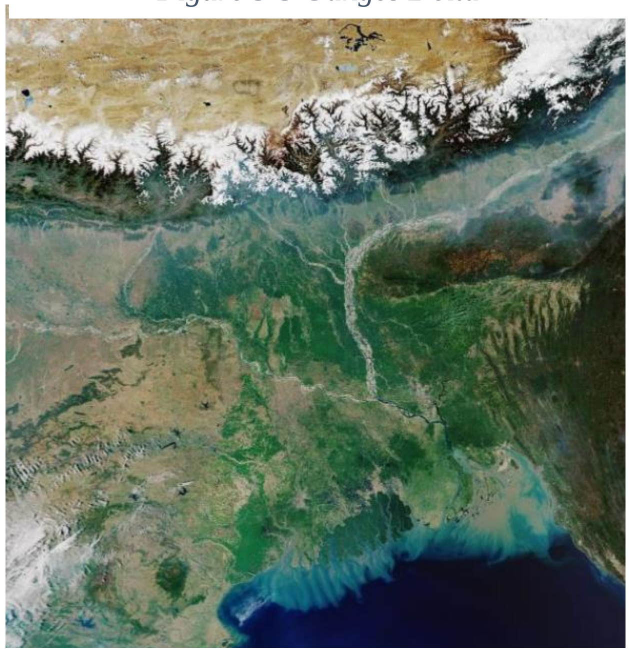
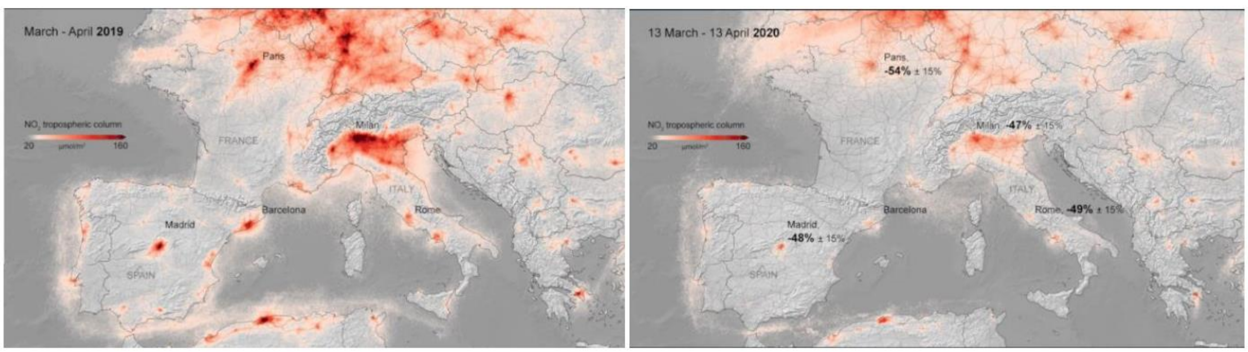
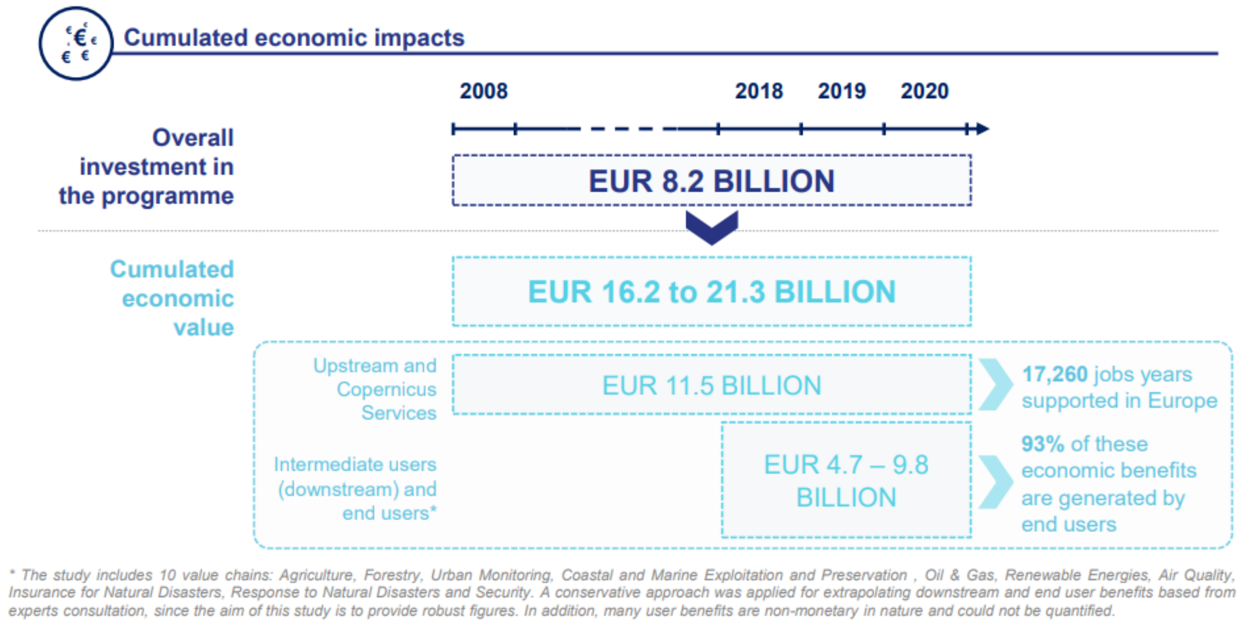


Figure 3-4 The average nitrogen dioxide concentrations



The total investment in the Copernicus program was almost reached at EUR 8.2 ($11.48) billion, over the period of 2008 and 2020 (PwC., 2019). The economic value was created through the value-added creation in the upstream segment, downstream suppliers, and Copernicus-enabled products by end users which measured between EUR 16.2 ($22.7) and 21.3 ($29.8) billion. Comparing the investment and economic benefits indicates that the size of the investment has more than doubled when it becomes on economic benefits, more interestingly, the intermediate and end user's benefits have only calculated between 2018 and 2020. Figure 3-5 illustrates the summary of the economic results of the Copernicus program.

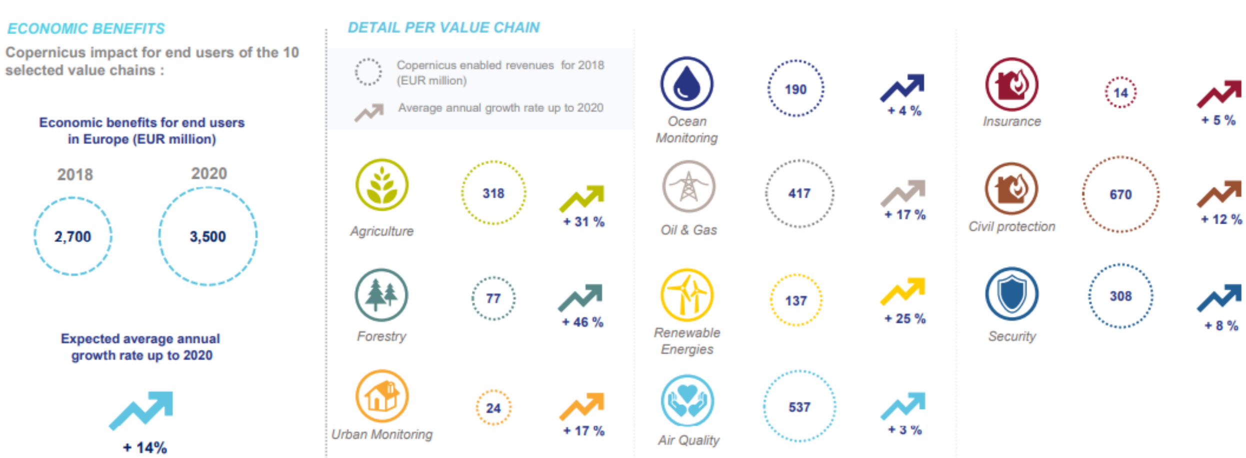
Figure 3-5 Overview of Copernicus program benefits



Source: (European Commission. Directorate General for Internal Market, Industry, Entrepreneurship and SMEs. & PwC., 2019)

Satellite images of the Copernicus are linked to the end users through the intermediate users. Although end users have direct access to the data, they have more desire to pay EO products generated by intermediate users. Figure 3-6 is showing the benefits providing by Copernicus program for the end users due to the large market and significant benefits especially on the agriculture sector.

Figure 3-6 Overview of end user' benefits



Source: (European Commission. Directorate General for Internal Market, Industry, Entrepreneurship and SMEs. & PwC., 2019)

It was previously mentioned that Copernicus program offers information services that draw from satellite Earth Observation and in-situ (non-space) data (*Copernicus*, n.d.)**.** Remote sensing technologies is useful on EO. When data (images) gathered, they were analyzed to serve different aspects of applications and industries. It is important to note that different types of the sensors are leading to different resolutions. Optical or thermal sensors, and Radar sensors are providing Spatial resolution, Temporal resolution, and spectral resolution (Figure 3-7).

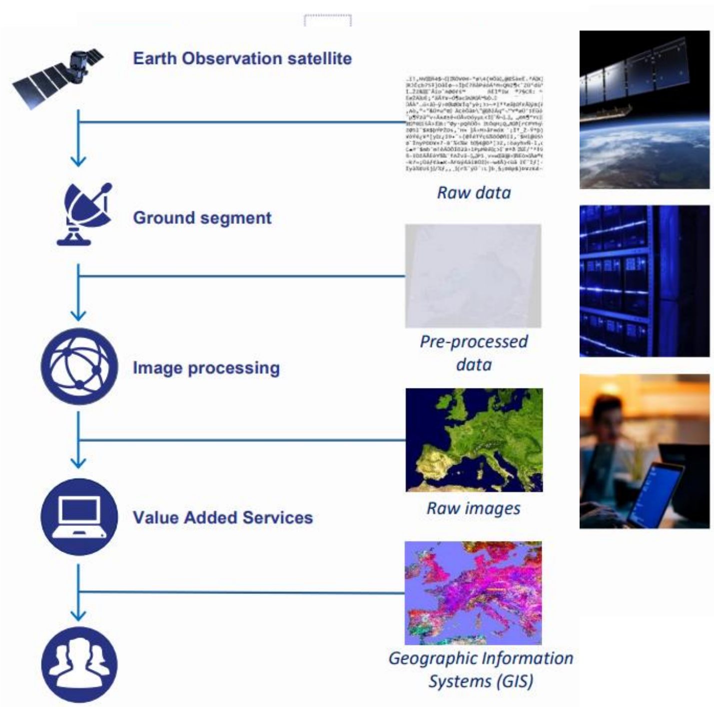
Three stages of the EO value chain are in upstream segment, downstream segment, and end users. In comparison by 2015, Global revenues of the EO upstream and downstream segment had risen 39 % and 12% reached at EUR 7 ($9.5) billion and EUR 2.8 ($4) billion respectively in 2019. Figure 3-8 shows the EO value chain on three stages. If consider upstream segment as hardware part of the value chain, software part of the EO value chain is on downstream segment in where processing data and the creation of Value-Added Services (VAS) exist.

The European Geostationary Navigation Overlay Service (EGNOS) is Europe's regional satellite-based augmentation system (SBAS) that is used to improve the performance of global navigation satellite systems (GNSSs), such as GPS and Galileo (*EGNOS*, 2011).

The advantages of the EGNOS system include applications in several market segments such as precision farming, civil aviation, vehicle traffic management, maritime, and mountain rescue.

Figu

Figure 3-8 The Earth Observation value chain



Source:(*Copernicus Europe Eyes on Earth.Pdf*, n.d.)

For instance, ASI has applied EGNOS satellite technologies in programs dedicated to railway traffic control and info mobility, in particular in collaboration with the Sardinia Region ("Egnos," n.d.). One the most significant advantages of the EGNOS system is become the utmost level of accuracy when it combines with Galileo system. EGNOS is accessing farmers through free subscription service improving reliability and accuracy of GPS system finally leading to the considerable financial impact. Around Thirty stations in over twenty countries are observing data arriving from the GPS satellites, then the data uplink to three fixed point or Geostationary European Satellites which transmit these data to the users back on the ground.

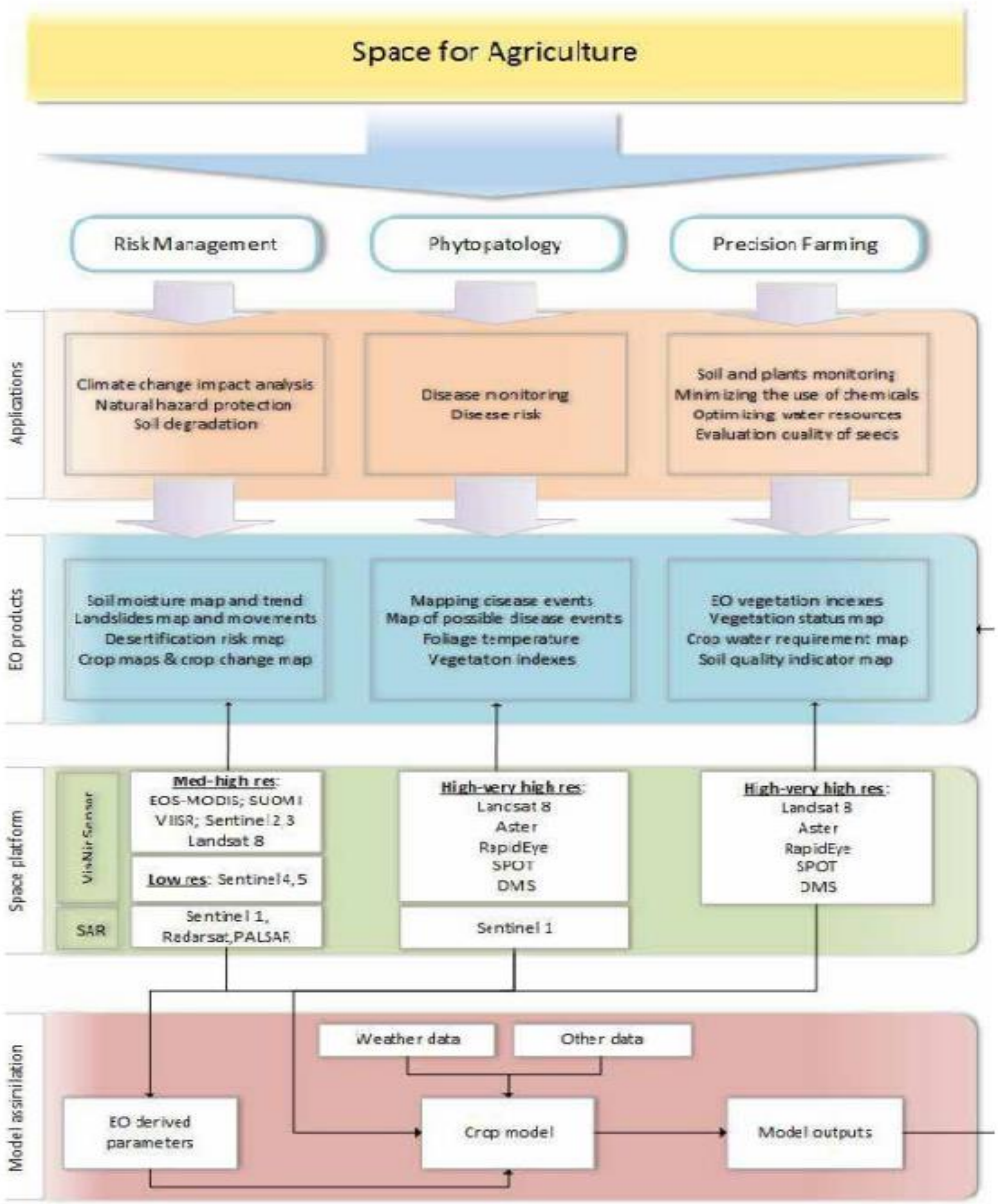
3.3 Space and Agribusiness

The linking ring between space ecosystems and agriculture is EO and remote sensing. Broadly, agriculture is applying applications rendered from the downstream segment of the space ecosystem to become sustainable. However, upstream segments in satellite manufacturing have also indirectly fed the agriculture sector with disruptive innovations to develop the quality of remote sensing and EO.

It is also worth mentioning that the concept of the "Agribusiness", which is the combination of the agriculture (fields, crops), livestock and their application and products has more synergy with the user's target. More specifically, on Agribusiness, technologies which are also currently use in the space ecosystem transferred to the applications in which agriculture value chain affected by. Also, it assumes that in terms of sustainable agriculture, space ecosystem employed disruptive technologies that facilitate flow of added value into the agriculture value chain. Here is the place that 'earth-space-earth' technology cycle was defined. Yet, the technology transformation would continue with such as 'The Farm to Fork' strategy or 'AgriDigit' project as a next steps or steps align with precision farming to finally profound respect for people, food, environment, and climate.

European Innovation Partnership for Agriculture productivity and Sustainability (EIP-AGRI) is an initiative leading to competitive and sustainable agriculture.

Figure 3-9 Space for Agriculture



Source: (Cuca et al., 2016)

3.4 Precision Farming

"Precision farming is a management approach that focuses on (near real-time) observation, measurement, and responses to variability in crops, fields, and animals. It can help increase crop yields and animal performance, reduce costs, including labor costs, and optimize process inputs.

All of these can help increase profitability. At the same time, precision farming can increase work safety and reduce the environmental impacts of agriculture and farming practices, thus contributing to the sustainability of agricultural production" (HOYE, 2018).

The European Parliament's report defines precision Agriculture as: "a modern farming management concept using digital techniques to monitor and optimize agricultural production processes" in which optimizing dosage of fertilizers, being cost-effective, and reducing environmental impacts have been emphasized (European Parliament.et al., 2016).

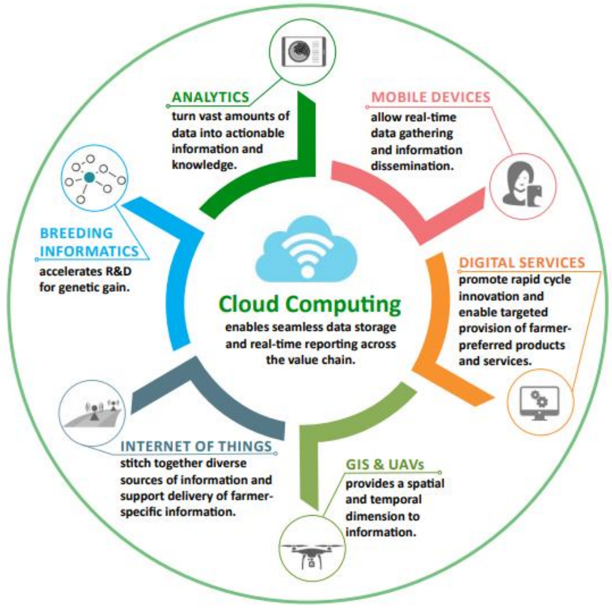
Applying precision farming is removing the gaps intra-farms and increasing the productivity inter-farms and finally is leading to the 'Agriculture 4.0'. It is important to mention that there are 13% reduction in cost/ha and 30% reduction in the use of water, fuel, fertilizers, pesticides, and in terms of environmental sustainability, a 15% reduction in the carbon footprint of crops are recorded due to the digital technologies supporting 'Agriculture 4.0' (Scuderi et al., 2022). Also, the global value generated by 'Agriculture 4.0' is about $7 billion, 30% is the share of Europe and Italy represents only 4% of the global market. In Italy, 'Agriculture 4.0' market has had rapid growth in recent years and become five times bigger from €100 ($140) million in 2017 and reached at €540 ($756) million in 2020 (Scuderi et al., 2022).

Moreover, 80% of the market was due to offers from established players in the sector such as suppliers of agricultural machinery and equipment and about 20% is generated from start-ups as emerging players proposing innovative digital systems and technology consulting services (Ge & Brewster, 2016).

3.5 The main technology trends in Precision farming

Precision farming derives from the digital agriculture. The emergence of the integrated data sets with a combination of the evolution of satellite imagery and weather and soil data maintains farm management. To address digital technologies shaping the digital transformation in the agriculture and agri-food supply chain, Internet of Things (IoT), Machine Learning (ML) techniques, SmartApp and WebServices, and blockchain are taking place in the value chain they enable the development of 'Agriculture 4.0'. Thus, Agriculture 4.0 is created by

Figure 3-10 Digital Agriculture



Source: (*Digital Agriculture: Pathway to Prosperity – ICRISAT*, n.d.)

precision farming solutions, which are applying IoT sensors, mobile devices, smart tractors, robots, drones, and satellites, and smart farming solutions which are management software, analytics, cloud (Scuderi et al., 2022).

Internet of Things (IoT): Physical objects, sensors, data, and internet connections are the main features of the IoT. The combination of IoT with drones and satellites images as well as remote sensing providing real-time field data accessible in cloud (Donatelli & Pisante, 2019). More, mobile devices, smart tractors, and robots are the 'things' to name.

Machine Learning (ML) is applying Artificial Intelligence (AI) and assessing crop models with reliable predictions (Donatelli & Pisante, 2019).

SmartApp and WebServices are the management part of the precision farming's definitions which support farmers on their decisions (Donatelli & Pisante, 2019).

And finally, blockchain tools guarantee the food safety and quality by implementation prototype in forestry. Hence, the whole process of the food supply chain could track electronically via IoT devices and develop a certified distributed control system that newly become one of the significant issues for the consumers.

3.6 Italian Space Clusters

The importance of the clusters is clear to everyone when accompanied with the innovation and globalization through value chains bringing social and global economic benefits. Successful clusters have significantly increased their global reach- attracting people, technology and investments, serving global markets, and connecting with other regional clusters that provide complementary activities in global value chain, therefore clusters are as drivers of competitiveness and prosperity in global economy (Corò, n.d.).

Regarding the importance of the clusters in the value chain, it seems necessary to introduce main space clusters in Italy. The introduction of each group provides by the Italian Trade Agency (ITA), ASI, AIAD, AIPAS, and ASAS.

Also, it is worth mentioning that more than 21 start-ups, more than 120 SMEs, and 27 large companies directly connect to the Italian space ecosystem. Table 3-2 introduces all. However, this data was published in 2021-2022 and would need to be reviewed again and again.

Table 3-2 List of the Start-ups, SMEs, and Large Companies of Space industry related in Italy

Start-ups		
AIKO	ANTECK SPACE	ARCA DYNAMICS
CENTRALE VALUTATIVA	COLOMBOSKY	ECHOES
GERICO SECURITY	GERMANI ENTERPRISE	IN QUATTRO
LATITUDO40	NABLAWAVE	S2G TECHNOLOGIES
SAFE STRUCTURES COMPANY	SIDEREUS SPACE DYNAMICS	SIHEALTH PHOTONICS
STELLAR PROJECT	STUDIOMAPP	THINKQUANTUM
UNIVERSO ENERGIA	WISE ROBOTICS	YETITMOVES
Small and Medium Enterprises		
AREA	AGT	ALFAMECCANICA
APR	ARESCOSMO	ALMA SISTEMI
ARESYS	ARGOTEC	ASTRA
AVIOTEC	BERCELLA	BLU ELECTRONIC
B-OPEN SOLUTION	BRIGHT AEROSPACE	BRIGHT SOLUTIONS
CBL ELECTRONICS	COMPOLAB	CONSORZIO DI RICERCA HYPATIA
CRISEL	D-ORBIT	DAVI PROMAU
DIGIMAT	DTM	ECOR INTERNATIONAL
EICAS AUTOMAZIONE	EIE GROUP	ELLENA

ETS SISTEMI	EURO STAMP 1	EURO.SOFT
FLYSIGHT	G&A ENGINEERING	GEM ELECTRONICA
GEO-K	GEOMATICS RESEARCH & DEVELOPMENT (GRED)	G-NOUS
GP ADVANCED PROJECTS	GTER	GUIZZO SPACE
HTT	I-EM	IMT
INFORMATION TECHNOLOGIES SERVICE-ITS	INGENIARS	INNOVA CONSORZIO PER L'INFORMATICA E LA TELEMATICA
INTELLIGENTIA	ITALCONSUL	ITALSPAZIO
KAYSER ITALIA	KELL	LABORMET DUE
LEAD TECH	LEAF SPACE	LEN
LMA	LTG ELECTRONICA	MBI
MEC	MEDIA LARIO	METASENSING
METEOROLOGICAL ENVIRONMENTAL EARTH OBSERVATION- MEEO	MTM PROJECT	NADIR-PLASMA & POLYNERS
NANORACKS SPACE OUTPOST EUROPE	NCM TECHNOLOGY	NEMEA SISTEMI
NEXT ENGEGNERIA DEI SISTEMI	NHAZCA	NHOE
NURJANA TECHNOLOGIES	OBO SPACE	OFFICINA STELLERE
ON-AIR CONSULTING & SOLUTIONS	OPENET TECHNOLOGIES	OPTEC
PASQUALI MICROWAVE SYSTEMS	PICOSATS	PLANTEL ITALIA
PROESYS	PROGEM	PROGETTI SPECIALU ITALIANI
PROGRESSIVE SYSTEMS	REDCAT DEVICES	RF MICROTECH
RGM	SAB AEROSPACE	SAB LAUNCH SERVICES
SATE- SYSTEMS AND ADVANCED TECHNOLOGIES ENGINEERING	SICILSAT	COMMUNICATIONS
SOCIETA AEROSPAZIALE MEDITERRANEA- SAM	SOPHIA HIGH TECH	SPACE DYNAMICS SERVICES
SPACE LAB	SPACE TECHNOLOGY FOR INNOVATION	SPAECEARTH TECHNOLOGY
SPACEEXE	SPAZIOFUTURO	STAM
SURVEY LAB	T4I- TECHNOLOGY FOR PROPULSION AND INNOVATION	TAIRUS SOFTWARE ITALIA
TEC EUROLAB	TECHNO SYSTEM DEVELOPMENTS	TEMIS
TESI TECNOLOGIE E SERVIZI INNOVATIVI	TIBERLAB	TRANS-TECH
TYVAK INTERNATIONAL		
Large Companies		
AIRBUS ITALIA	ALTEC	AVIO

BEAMIT	BLUE ENGINEERING	BUSINESS INTEGRATION PARTNERS
CAPGEMINI ENGINEERING	CESI	SGI ITALIA
CISTELAIER	DASSAULT SYSTEMS ITALIA	E-GEOS
EXPRIVIA	INTECS SOLUTIONS	LEONARDO
LOCCIONI	NPC SPAEMIND	OHB ITALIA
RHIENMETALL ITALIA	RINA CONSULATING	SABLET
SERCO ITALIA	SITAEL	STMICROELECTRONICS
TELESPAZIO	THALES ALENIA SPACE ITALIA	VIROCISET

Figure 3-11 Italian Aerospace Clusters

Source: ("The Italian Space Industry Catalogue," n.d.)

Figure 3-11 shows the main active aerospace clusters in Italy. The main features of each cluster will be introduced into following tables.

Table 3-3 Cluster Tecnologico Nazionale Aerospazio (CTNA)

Region: Lazio	Headquarter: Rome
Description	**Space Highlight**
• Public Private Partnership (PPP) organization • Cluster of technological, industrial, research and innovation • Driver of sustainable economic growth in all regions of the national economic system	• Defining the road maps in upstream (enabling technologies) and in downstream (enabled space products and services) segments. • Advanced data acquisition • Transmission and processing systems • APS • New materials • Processes and components • Robotics technology • Technology for big constellation • Integrated service and applications • New design and production methodologies

Source: ("The Italian Space Industry Catalogue," n.d.)

Table 3-4 Dominio ICT Aerospazio Abruzzo (DICTAS)

Region: Abruzzo	Headquarter: Coppito
Description	**Space Highlight**

• Collaboration between Telespazio s.p.a and the University of L'Aquila	• Enabling Space Technologies
	• Innovative enabling products and services
	• Mostly focus on downstream segment supply chain
	• Future guidelines are defined for:
	  ◦ Unmanned/Air/Space Traffic Management
	  ◦ Earth Observation
	  ◦ Access to Space
	  ◦ Space exploration
	  ◦ Satellite navigation
	  ◦ Satellite communication
	  ◦ Geo-Information

Source: ("The Italian Space Industry Catalogue," n.d.)

Table 3-5 Distretto Tecnologico Aerospaziale della Campania - DAC S.c.a r.l.

Region: Campania	Headquarter: Napoli
Description	**Space Highlight**
• Stimulation collaboration between research centers, universities, and companies in the Campania. • 24 large companies, 19 Research Centers, and 133 SMEs are included in the cluster. • Directing Smart Specialization Strategy • Vocational training and high education • Technology transfer and communication • Duality and internationalization	• MISTRAL satellite and its reentry capsule project • PM3 multi-mission satellite • MISENO application project • Nano and microsatellite operating system • Satellite subsystems enhancement • Machine Vision techniques (AI) • Enabling of the technology of the small E2E satellites

Source: ("The Italian Space Industry Catalogue," n.d.)

Table 3-6 Lazio Aerospace Technology District (DTA)

Region: Lazio	Headquarter: Rome
Description	**Space Highlight**
• Established by Memorandum of Understanding (MoU) between Italy Ministry of Research and Lazio Region • Leading international role in Aerospace and security in terms of R&D, manufacturing, hi-tech value-added services • Supporting space through European Structural Investment and Equity Financing to Start-ups/ SMEs	• Launchers (Vega, solid rocket motor for Ariane) • EO, NAV & TLC SATs manufacturing and services • Micro Nano SAT Constellation • Space Surveillance and Tracking (SST) • Manned and Unmanned Space Exploration (incl. ISS) • Safety & Security; Homeland/ Cyber Security • Cooperation with NASA ESA and ASI • Playing a leading role in EU space programs (COSMO-SkyMed, ESA-VEGA launcher)

Source: ("The Italian Space Industry Catalogue," n.d.)

Table 3-7 SIIT Scpa

Region: Liguria	Headquarter: Genova
Description	**Space Highlight**
• Create an integrated system among large industries, SMEs, the University of Genova, public institutions, research and finance to develop industrial research and technology transfer activities	• Presence of the oldest aircraft manufacturing • Safety and Cyber Security • Complex automation systems • Industry 4.0 • ICT platform and technologies • Territory monitoring • Critical infrastructures

	• Modeling and simulation • Decision support systems • Application of AI-Big data • IoT

Source: ("The Italian Space Industry Catalogue," n.d.)

Table 3-8 Lombardia Aerospace Cluster (LAC)

Region: Lombardy	Headquarter: Varese
Description	Space Highlight
• 220 companies, 16500 employees, € 6 ($8.5) billion turnover, € 1($1.4) billions of exports • 3 complete supply chain in 3 flight platforms: • Fixed wing • Rotary wing and vertical flight • Satellites, parts for space use, scientific payloads for EO and space exploration • Urban Air Mobility	• Complete supply chain of satellites focusing on EO and space exploration • Strong integration of producers with land infrastructure and downstream services

Source: ("The Italian Space Industry Catalogue," n.d.)

Table 3-9 Distretto Aerospaziale Piemonte (DAP)

Region: Piemonte	Headquarter: Torino
Description	Space Highlight
• 70 members • Long-term vision for public and private investment in technological innovation	• Large System Design, Development, Assembly, Integration, Post-Delivery Support • Pressurized Structures • Mechanical components and processes • Habitability and Environmental Control Systems • Thermo-Fluidic Systems and Components • Software, Avionics Component/Electrical Ground Support Equipment • Guidance, Navigation and Control • Mechatronics/Artificial Intelligence applications • Digital twins • CubeSat and micro sat

Source: ("The Italian Space Industry Catalogue," n.d.)

Table 3-10 Distretto Tecnologico Aerospaziale (DTA s.c.a.r.l.)

Region: Puglia	Headquarter: Brindisi
Description	**Space Highlight**
• Technological cluster • Creating infrastructures for research and innovation at national and EU level • Over 80 companies, 7000 employees, € 561.6 ($786) million exports, turnover € 738 million ($1 B) • The most competitive Italian regions in the aerospace sector	• Design and building of satellites • EO application • Navigation and integrated applications • Industry 4.0 technologies for aerospace industry (Advanced materials, additive manufacturing, augmented reality, cyber security, Big) • UAS/RPAS: Aerial platform development • UAS/RPAS applications in service provision: precision farming, emergency management • Space technologies: Application of GNSS and SATCOM services to unmanned transports • Aerospace propulsion system • Microsatellites: satellite platform and avionic modules, propulsion systems, innovative EO services • Testing of UAVs in partnership with Aeroporti di Puglia (AdP), the 'Grottaglie Test Bed'.

Source: ("The Italian Space Industry Catalogue," n.d.)

Table 3-11 Distretto AeroSpaziale della Sardegna (DASS Scarl)

Region: Sardegna	Headquarter: Cagliari
Description	**Space Highlight**

• Owned by five public and twenty-four private shareholders with a capital share of € 95112 ($133,157) (fully paid-up)
• Undertake initiatives suitable for the development of an aerospace technological district
• Support its scientific and technological expertise
• Attract investment in high-technology production sector
	• Owner of 100% of the rights to the patent families of:
	  • "Fabrication process of physical assets for civil and/or industrial structures on the surface of Moon, Mars and/or asteroids", Patent 10453PTWO, 28/07/2011
	  • "A process for the production of useful materials to sustain manned space missions on Mars through in-situ resources utilization", Patent PCT/IB2012/053754, 24/07/2012

Source: ("The Italian Space Industry Catalogue," n.d.)

Table 3-12 Disretto Regionale Toscano 'Advanced Manufacturing 4.0'

Region: Toscana	Headquarter: Pisa
Description	**Space Highlight**

• Network of SMEs, research centers, and laboratories is made of three participants:
  ◦ GATE SpA
  ◦ ERRE QUADRO SRL
  ◦ Industria Servizi
• Managing all the activities related to:
  ◦ Dissemination of knowledge about I4.0 technologies and their application
  ◦ The organization of both one-to-one and plenary initiatives
  ◦ Matching between demand/supply of technology
  ◦ Funding opportunities
• System integrator in order to:
  ◦ Fill the technology value chain
  ◦ Amplify business opportunities
  ◦ Improve the competitiveness of the affiliated companies
• Benefitted from the financial support of 'Programma operativo regionale (POR) FESR 2014-2020'
• Over 150 SMEs, Departments from 3 Universities and CNR, over 20 labs/ research centers
	• Over 20 SMES from aerospace in the district
	• Leading Research Centers in Tuscany
	• Partner of the National Aerospace Cluster (Cluster Tecnologico Nazionale Aerospazio, CTNA)
	• Organization or participation to sector specific dissemination and matchmaking initiatives for aerospace SMEs

Source: ("The Italian Space Industry Catalogue," n.d.)

Table 3-13 Umbria Aerospace Cluster (UAC)

Region: Umbria	Headquarter: Perugia
Description	**Space Highlight**

• Cluster companies can supply:
  ◦ Mechanical engine and structural components
  ◦ Electromechanical and hydraulic actuation systems
  ◦ Equipment, aerostructures, electronic and control systems
  ◦ Fittings, production and testing systems
• Professional skills and technological processes include:
  ◦ Heat treatment
	• High precision machining, design and manufacturing of custom environmental test chambers and equipment
	• Test program development
	• Board testing and reliability test support
	• Space simulators
	• Design and manufacturing of custom embedded systems
	• Propulsion systems
	• Actuators
	• 3D digitizing systems

• Electroplating • Painting • Welding • Qualified services in non-destructive tests, cabling, assembly, and inspection	• Structural design and stress analysis • Metal surface treatments • Thermo-mechanical analysis and design • Design and prototyping of microwave satellite communication systems • Satellite systems development and simulation • Satellite software applications

Source: ("The Italian Space Industry Catalogue," n.d.)

3.7 Geographical focus of the study

Before introducing the selected start-ups working on precision farming (**Error! Reference source not found.**), the reasons for choosing northern Italy to search for these start-ups will discuss.

It could be possible to mention several reasons; however, two main facts are available to discuss. The first reason comes from data related to the farms in north Italy, and the second reason is the number of start-ups located in northern Italy.

Considering the data related to the farms, Table 3-14 outlines the main features in which the comparison with another part of Italy is also available.

This data presents the period between 2015 and 2018. The data collected based on FADN sample. There are 40,408 farms in the sample. Northwest and northeast Italy, with 17,140 farms, are the most significant number of farms compared to the other locations. The Utilized Agriculture Area (UAA) is about 43.6% in Northern Italy, higher than in other parts of Italy. More, 56 % of the added value produces in northern Italy. Also, the number of family work employment is roughly in line with the number of farms. Although the purchase and use of feed are related to livestock, the data shows the more significant number in northern Italy, with about 80% of the full feeds. This data regarding the total water and groundwater shows higher numbers in northern Italy compared to other regions. It is worth mentioning that the FADN database classified pesticides based on their degree of toxicity. This group includes toxic and very toxic (I), harmful (II), and irritants (III and IV). Finally, there is a whole group of unclassified pesticides (0). As a result, it could conclude that northern Italy is a critical zone for investing in precision farming due to the geographical and altimetric levels. Several characteristics are mentioned, and due to sustainable agriculture, it seems necessary to focus on northern Italy.

Table 3-14 Geographical area and altimetric level in Italy

	Italy	Northwest	Northeast	North	Center	South	Islands
Farms (n°)	40,408	8070	9070	17140	7286	11,507	4475
UAA (KHA)	1254	302	244	546	246	272	190
Added Value (MM €)	3384	846	1047	1893	531	715	246
Family labor (kh)	73,115	11,906	18,647	30,553	13,780	21,141	7609
External labor (kh)	23,151	2395	4903	2595	10,837	2421	11,297
Feeds (Ktons)	2076	830	821	1651	159	204	62
Total Water (kmc)	360,250	115,756	100,728	216,484	23,009	86,653	34,101
Groundwater (kmc)	72,115	5805	16,096	21,901	6765	35,853	7596
Mineral fertilizer (tons)	190,190	57,105	57,430	114,535	27,638	33,038	14,980
Manure (tons)	253,731	64,507	102,083	166,590	20,907	44,362	21,873
Pesticides classified (tons)	4451	1891	1421	3312	359	677	103
I	445	86	174	260	86	87	13
II	842	142	477	619	77	132	14
III- IV	3165	1664	771	2435	196	458	76
Pesticides unclassified (tons)	4802	2758	768	3526	437	706	132

Source: (*Farm to Fork Strategy*, n.d.)

The second reason to choose northern Italy to focus on start-ups working on precision farming is coming from the fact that the innovative start-ups located in northern Italy shows more significant numbers in comparison with the center and the south of Italy (Table 3-15). Thus, it was expected that looking for start-ups working on precision farming would be much more accessible than in other regions.

Table 3-15 innovative start-ups divided by territorial division and regions

	2019		2020		Var. %
	n°	%	n°	%	2019/2020
Piemonte	613	5.6 %	662	5.5 %	8.0 %
Valle d'Aosta	22	0.2 %	22	0.2 %	0.0 %
Lombardy	2,927	26.9 %	3,244	27.1 %	10.8 %
Liguria	190	1.7 %	187	1.6 %	- 1.6 %
Total Northwest	3,752	34.4 %	4,155	34.3 %	9.7 %

Trentino-Alto Adige	266	2.4 %	290	2.4 %	9.0 %
Veneto	892	8.2 %	973	8.1 %	9.1 %
Friuli-Venezia Giulia	231	2.1 %	251	2.1 %	8.7 %
Emilia-Romagna	931	8.5 %	942	7.9 %	1.2 %
Total Northeast	2,320	21.3 %	2,456	20.5 %	5.9 %
Toscana	424	3.9 %	544	4.5 %	28.3 %
Umbria	187	1.7 %	196	1.6 %	4.8 %
Marche	344	3.2 %	343	2.9 %	- 0.3 %
Lazio	1,229	11.3 %	1,397	11.7 %	13.7 %
Total Center	2,184	20.0 %	2,480	20.7 %	13.6 %
Abruzzo	215	2.0 %	216	1.8 %	0.5 %
Molise	80	0.7 %	75	0.6 %	- 6.3 %
Campania	899	8.3 %	1,060	8.8 %	17.9 %
Puglia	431	4.0 %	506	4.2 %	17.4 %
Basilicata	104	1.0 %	110	0.9 %	5.8 %
Calabria	265	2.4 %	254	2.1 %	- 4.2 %
Sicilia	514	4.7 %	551	4.6 %	7.2 %
Sardegna	129	1.2 %	160	1.3 %	24.0 %
Total South	2,637	24.2 %	2,932	24.5 %	11.2 %
Total Italia	10,893	100.00 %	11,983	100.00 %	10 %

Source: (*Startup e PMI Innovative, in Parlamento la relazione annuale*, n.d.)

3.8 Policy of Space Economy

The ever-growing role of the private actors in transforming digitalization from the space ecosystem to other industries such as agriculture raises multiple issues for the governments. Enabling industry competitiveness, encouraging further growth and innovation, and ensuring returns on investments in publicly funded space programs would fail if strategic shifts in government policy and project management, mainly focusing on commercialization and industry partnerships, were not applied. The necessity of the policy and legal framework to develop transfers from the space sector to other fields is crucial. Policymakers should encourage coherence between information and provide legal certainties such as defining clear property rights and strengthening R&D networks using research grants to promote the role of technology transfer intermediaries, including innovation centers, incubators, and technology parks. It could succeed through mentoring and networking programs as long as supporting start-ups. Strong R&D focus with pre-existing portfolios of technologies, facilities, and expertise, space agencies could support start-ups. Also, mentoring programs would encourage space-related start-ups and strengthens the relationship with private and academic actors.

All these could happen if flexible producers for procurement of commercial space products and services are set up, accelerate access to funding, and facilitate the path of start-ups. Moreover, private actors unladen the costs over governments by applying co-funding arrangements for R&D and technology development, including different types of public-private partnerships. For instance, the European Space Agency has a great experience using PPPs in satellite communications.

Industrial policies and geographical distribution have significant effect on the clearance for the future attitudes on enabling space applications in the earth leading to sustainability. Hence, the role of the European Commission, ESA, and ASI also become significant to pave the way. Besides, the end-user's willingness to pay for the applications provided by the start-ups in precision farming could be the one the most important challenges of the start-ups. Yet, the interests between farmers are increased during the last years.

One of the main objectives of the ESA is to increase the competitiveness of European industry on the international market. Hence, ESA applied principles for boosting the technological and research activities in such that the 'fair return' is an example to develop co-ordination between European and national space activities. On this matter, Article VII extracting from convention of the ESA relating to Industrial Policy designed to:

1. Meet the requirements of the European space program and the coordinated national space programs in a cost-effective manner;
2. improve the world-wide competitiveness of European industry by maintaining and developing space technology and by encouraging the rationalization and development of an industrial structure appropriate to market requirements, making use in the first place of the existing industrial potential of all Member States;

3. ensure that all Member States participate in an equitable manner, having regard to their financial contribution, in implementing the European space program and in the associated development of space technology; in particular the Agency shall for the execution of the programs grant preference to the fullest extent possible to industry in all Member States, which shall be given the maximum opportunity to participate in the work of technological interest undertaken for the Agency;
4. exploit the advantages of free competitive bidding, except where this should be incompatible with other defined objectives of industrial policy (*Industrial Policy and Geographical Distribution*, n.d.).

To address more policies in the space economy, the essential Strategic orientation 'Horizon Europe' plan is investing in research and innovation, in which 6 clusters are affected. Cluster 4 of 'Horizon Europe' is dedicated to the digital and industrial technologies, including in space, addressing the high necessity of new technologies deployment to support Green Deal by 'New Industrial Strategies for Europe' and in the Circular Economy Action Plan, digital strategies are 'Shaping Europe's Digital Future', 'Data', 'Artificial Intelligence', 'White Paper', and 'Space strategy for Europe'.

Figure 3-12 Horizon Europe

Cluster 4 will support in particular the following two Horizon Europe key strategic orientations and impact areas associated to them[28]

KEY STRATEGIC ORIENTATIONS FOR R&I	**KSO A: Promoting an open strategic autonomy by leading the development of key digital, enabling and emerging technologies, sectors and value chains**	**KSO C: Making Europe the first digitally enabled circular, climate-neutral and sustainable economy**
IMPACT AREAS	Competitive and secure data-economy Industrial leadership in key and emerging technologies that work for people Secure and cybersecure digital technology	Climate change mitigation and adaptation Circular and clean economy
EXPECTED IMPACTS	**16.** Industrial leadership and increased autonomy in key strategic value chains with security of supply in raw materials **17.** Globally attractive, secure and dynamic data-agile economy **18.** Open strategic autonomy in digital technologies and in future emerging enabling technologies **19.** Open strategic autonomy in developing, deploying and using global space-based infrastructures, services, applications and data **20.** A human-centred and ethical development of digital and industrial technologies	**15.** Global leadership in clean & climate-neutral industrial value chains, circular economy and climate-neutral digital systems and infrastructures

Source: (*Horizon Europe*, n.d.)

To implement policy dialogues is necessary to emphasize these goals on:

- Material safety methodologies and standards in which EU partners could measure and test chemicals and materials including safe-by-design approach
- Circular economy and climate-neutral technologies in which EU could strengthen sustainability
- Enhancing EU's technological sovereignty while sustaining productive relations with EU strategic partners reducing dependency on third countries of technology value chains.
- Common standards and interoperability which includes the regulatory on manufacturing technologies, digital technologies and Artificial Intelligence.
- Promoting a human-centered Internet in aims of attracting internet talents and contributing to standards with bided cooperation with the third countries
- On space, dialogues are held on a regular basis with a number of countries. Copernicus has developed a number of agreements for mutual data exchange and promotes R&I collaboration with these international cooperation partners(*Horizon Europe*, n.d.).

In Italy, public-private partnerships will play a central role in the national Space Economy Strategic Plan, as one of the main instruments for space technology development in satellite telecommunications, Galileo, Copernicus and exploration (*(OECD*, n.d.).

R&D support programs encouraging entrepreneurship, or university-industry collaboration, thus developing targeted R&D grants contribute to other policy goals beyond technology development such as promoting innovation in small and medium enterprises.

The latest Strategic Vision Document for 2016-2025 is Italy's space policy guidelines are formulated into four primary goals (*STRATEGIC VISION DOCUMENT 2016-2025*- n.d.). This strategic macro-objective is to build a system able to collaborate and compete in space globalization. ASI as long as universities, research centers, industries, public administrations defining domestic policy in the space sector which leads to optimize and extend the space value chain.

Strategic Goal 1: Promote the development of services and applications for the Space Economy

Strategic Goal 2: Promote the development and use of infrastructures for the Space Economy

Strategic Goal 3: Accelerate and support scientific and cultural progress (science diplomacy)

Strategic Goal 4: Raise the country's international prestige (Space Diplomacy)

Figure 3-13 Strategic Vision Document 2016-2025

Source: (*STRATEGIC VISION DOCUMENT 2016-2025*, n.d.)

According to the Interreg Europe, for instance, in Veneto Region, which is characterized by an agricultural sector that produces on average 6,1 gross billion per year, namely the 11% of total national production, and generates an added value of 3 billion euros, implanting of the precision farming on production chains is still on the moderate or at the primary level (*D.T1.1.2-Precision-Farming-Policy--Economic-Review-IT.Pdf*, n.d.). The farmers also use parallel guidance systems, ISOBUS ready tractors, or weather stations; however, taking advanced precision farming is still low. Moreover, besides the farmers' interests as the precision farming applicants' end-user, lack of experience, low-skilled people in precision farming, and high costs hindered the investments in this sector. Hence, EAFRD (European agricultural fund for rural development) has made measures to invest in precision farming.

Policy adopted by the Italian government to take advantage of these measures would promote the technology advancement, which finally leads to increased yield and quality of production. 'Industry 4.0' and 'ISMEA' are among the national ambitions to facilitate the digital transformation of high technology innovations strengthening farm competitiveness and revenues, preserving, valorizing and restoring the ecosystems, reducing CO2 emissions, and incentive the efficient use of resources (*D.T1.1.2-Precision-Farming-Policy--Economic-Review-IT.Pdf*, n.d.).

Two approaches were recommended in order to assess better and apply the growth of space activities as well as improve returns on public investments:

1. Governments, as long as the private actors can take more advantage of the commercial services for their specific tasks. Since institutional space budgets still make the key driver for commercial space activities and provide capabilities of the growth for the private actors, governments also can increase their sophisticated tasks in the use of commercial space services.
2. Investing on mapping national space economies along the value chain to benefit the space sector's global value chains.

4 CHAPTER FOUR

4.1 Introduction

This chapter introduced start-ups that were found during the research in northern Italy. Start-ups were compared with their technology trends and services, location, number of employees, revenues from sales and service, total asset rates, founder's prior experience, and the connections with R&D centers.

4.2 Start-ups

This section introduces all the start-ups with a geographical focus on northern Italy. Previously, the reasons leading to selecting northern Italy were discussed. Finding the start-ups was begun through the European Space Agency (ESA) and Italian Space Agency (ASI), Italian incubators, the Strategy Innovation, and the Spin-off of the Ca 'Foscari University Venice.

The keywords were about the start-ups working on precision farming or those producing information related to precision farming on their payoff. However, the research on the mentioned sources was not enough, and the research went through incubators working on the precision farming in Italy with the same keyword and additional information about precision farming and space economy. The target regions were Emilia-Romagna, Lombardy, Veneto, Piemonte, Trento-Alto Adige and Friuli-Venezia Giulia with 3, 8, 5, 6, 2, and 4 incubators, respectively. Although the research was mainly focused on northern Italy, almost all the incubators in all regions were searched beyond their location. The reason lies in some incubators, for instance, located in the south could incubate start-ups in the north and vice versa. There are 47 incubators available in Italy regarding 'Camere Di Commercio D'Italia'. Since the total number of target start-ups was insufficient, the research continued with surfing on the 'registroimprese.it' which completed the list.

All samples are non-space-related start-ups, except Studiomapp, a space-related start-up. They are using the technologies introduced into space ecosystem technology trends as long as adding value to the agriculture value chain. Thus, it could be said that these start-ups are focusing on the agriculture sector, and they are adding value to their products, mainly through the downstream segment of the space ecosystem value chain.

The start-ups' products are vast applications that their end-users can access online through their digital communication equipment such as pc, phones, and tablets.

Also, end-users are significantly farmers. They need applications to help them deploy sustainable agriculture. It could be assumed that the service is B2C, respecting the relationship between start-ups as business providers and farmers as a customer.

Error! Reference source not found. is giving information regarding the start-ups working in precision farming. However, there are other start-ups available in Italy. The data were collected due to their location in Northern Italy. It is essential to mention that considering the concept of the start-ups' definition regarding the date of establishment; all start-ups have an age less than or equal to five. Nevertheless, data related to the star-ups were published in 2020; thus, the start-up established in 2015 was included. However, start-ups established in 2021 are included due to the last update until 2022.

Table 4-1 List of Start-ups and date of establishment

Start-ups	Region	Date of incorporation
In4Agri	Emilia-Romagna	05.2021
La Valle	Emilia-Romagna	04.2020
AgroAdvisor	Emilia-Romagna	12.2019
Fragile	Emilia-Romagna	04.2018
IBF	Emilia-Romagna	06.2017
Studiomapp	Emilia-Romagna	12.2015
Free Green Nature	Veneto	08.2020
Precision Testing	Veneto	01.2019
Finapp	Veneto	12.02018
Ono Exponential Farming	Veneto	10.2018
XFarm	Piemonte	01.2019
Silvergeko	Piemonte	05.2018
XAgriFly	Lombardy	04.2021

4.3 Technology Trends and services

In Table 4-2, regarding the technology trends, the data show the different technologies that start-ups are using to give a variety of services to their end-users. Thus, the prerequisite for the services is the technology trends, of course.

Table 4-2 Technology trends and services

Start-up	Technology Trends	Services
Precision Testing	Agriculture 4.0 machines Test sensors Drones AI IoT: Smart tractors Cloud computing	Environmental monitoring Vegetative monitoring Soil monitoring Field mapping
Finapp	CRNS probes (Cosmic Ray Neutrons Sensing)	Water measurement in: Agriculture SWE (Snow Water Equivalent) Water leaking
IBF	Satellite images UAV/Drones Geoelectric sensors Remote and Proximal sensors VRT technologies DS Systems	Ergonomic Indexes Weather data Land morphology Soil sampling and analysis Farm information Fertilization Sowing Irrigation Crop protection
Studiomapp	Satellite images UAV images AI ICT ML (Deep Learning models) Data fusion Remote Sensing Big Data Object Detection SDG (Sustainable Development Goals)	WebGis Climate solution Environmental solution Security solution

AgroAdvisor	Satellite images Blockchain Cloud computing WebApp DS Systems	PAP management Interoperability API Weather detection Satellite analysis Water evaporation analysis Soil composition analysis Production forecast Environmental impact estimation Crop operation log Fertilizer database PPPs (Plant Protection Products)
In4Agri	ICT Sensors IoT Cloud computing Blockchain WebApp	Field mapping and processing tracking Collection of environmental and atmospheric data Energy control CO2 emissions control Geolocation and data collection of agricultural vehicles Water consumption control Fertilizer control Pesticide Control Transition 4.0
La Valle	Digital cartography Drones WebApp MobileApp Cloud computing	Consultancy, Assistance, and Provision of service in Agriculture and forestry
Fragile	Remote sensors Rapid Areal InSAR Survey (RAINS) Multi-temporal InSAR analysis (MT-SBA) Satellite line-of-sight (LOS)	Ground-based monitoring Customised InSAR data Deformation maps
XFarm	Sensors Satellite images (NDVI- NDRE-SAVI- EVI- LAI- NDWI- CHI-RGB) IoT WebApp	Crops: Manage fields, Map, Activities Logistics: Digital warehouse, Phytosanitary products, Silos management Machinery: Maintenance, Documents, Hours worked Documents: Farm report, Activity log, Documents for PAC Agroweather Alerts

		PPPs (plant protection products) data Finance Plant Protection Irrigation Asset Manager SaaS management
Ono Exponential Farming	AI Robotics ML Cloud computing Blockchain algorithms IT Biotechnology	‘Seed to Pack’ platform Indoor vertical cultivation Exponential farming
Silvergeco	Cybersecurity Cloud system IoT Automation systems Monitoring systems Sensors Weather stations WebApp	Providing forecast models in weather, and agriculture
XAgriFly	Drones Robot	Hardware
Free Green Nature	Robot	Wind speed Temperature Humidity Dew point Rain sensor

Source: Created by the Autor

The general overview shows that most start-ups apply the same technology trends when displaying all the main features for the end-users. However, it could be possible to limit their technology due to their specific services. Mobile applications or web applications are how start-ups release information to their customers. Having registered to the applications, end-users access the information with their Pc, tablets, or phone via an internet connection.

Registration is based on the different business plans. Noteworthy, the business plan of the samples was not mentioned on their websites except just for one of the samples. The reason could be that these start-ups are in the early stage of their life cycles, and they still need to find paying customers. However, due to the lack of access to the information, their business plan was omitted from the research.

All these services provide essential information to the end-users helping them with their decisions. However, the start-ups also assist them with direct consultancy over their production plan and take the ultimate attitude of regional, national, and international regulations like ‘Horizon 2020’ or ‘Horizon Europe’. Hence, to name a few:

- Optimize the use of primary resources (e.g., Water, fertilizer)
- improve the quality of the product and the soil (e.g., control irrigation, fertilization, soil moisture)
- reduces costs of the production
- increase productivity
- improve operator safety
- promote the traceability of individual activities

Also, the technology trends implemented by the start-ups are:

- IoT (Internet of Things)
- Sensors
- Satellite and drone imaging
- Cloud computing
- Blockchain
- AI (Artificial Intelligence)
- ML (Machine Learning)
- ICT (Information and Communication Technology)
- Big Data
- Cyber security

4.4 Methodology

Before introducing the methodology to measure the growth of the start-ups, it is essential to summarize the method.

Evaluating the start-up's growth has several conditions and parameters. It should be said that considering just one year to examine the growth of the start-ups is insufficient, and it is crucial to study the data in both the early stages and their growth. Hence, two of the samples were excluded from these measurements due to the date of establishment. In others in which the date of establishment is 2020, the overall view of the growth was examined. Moreover, to examine the start-ups' growth, observation of the internal and external conditions allows to find the better expectation of the start-ups in the market (Jeong et al., 2020).

Hence, the internal parameters are those related to:

- The number of the employees and its changes from the year of the establishment
- Revenues from sales and service during the years of working
- Changes in total asset rates with respect to the first year
- Founder's prior experience in both the start-ups regarding the academic background and industry regarding the previous jobs
- Connections with research centers, universities, and technology parks

The number of the employees has a direct connection with the aggregate conditions at the time of the start-up's entry (Sedláček & Sterk, 2017). Conditions like economic recession are affecting the numbers of start-ups entering the market, which impacts the number of employees. However, the number of employees is a parameter to examine the growth because of the significant role of the start-ups in creating new jobs. Also, venture capital investment in the start-ups positively affects the number of credentialed employees hired by them. The hiring procedure of the employees follows the different cycles of the venture capital investment at the early stage or in the growth stage. It is said that start-ups can hire more employees mainly after they receive new funds (Davila et al., 2003). The concept of headcounts is an approach to measuring the growth of start-ups. For instance, it is assumed that the start-ups with venture capital investment backed have a more remarkable growth in their headcount respecting the non-venture capital back ones (Davila et al., 2003).

Revenues from sales and service during the years of working show the relative income of the start-ups, and it is not directly related to the growth. Nevertheless, to indicate how much income they earned due to the technology-software nature of their business, the income was shown. Also, the latest data shows that during the covid-19 pandemic, businesses that provided software services had higher incomes than the others. Due to the nature of the sample of the technology-oriented start-ups, total asset rates are another benchmark to measure growth. It could be said that the rise in total assets during the early stage and growth respect the first year shows a significant commitment to product development and improvement, which will support future sales. As a result, venture capital investors take a high interest in them.

Founder experience also is a feature affecting the start-ups growth. Not only in term of the knowledge they are able to assist their start-ups, also in terms of experience they are able to become the main source of the growth. Adding to this, it seems that the former experience of the founder is playing the key role on venture capital investment absorption. Moreover, the prior experience is significant when it combines with the high-technology start-up. The founder prior experience could measure in two sided. One it comes from the coherence between the founder’s experience on the same firm and another could interpret as the prior experience on the same industry (Hashai & Zahra, 2022). Thus, four combinations of the founder are existed. The founder prior experience in the same firm-same industry; the prior experience in the same firm but other industry experience; same industry but other firm experience and finally other firm and other industry experience. It assumes that founders’ prior experience on the same firm same industry, would lead to the higher growth at the early stages of the start-ups life cycle, however, founder same firm, but other industry experience achieved better result on the start-ups growth over time (Hashai & Zahra, 2022). Besides, the prior experience of the founder could follow with the higher rate of sales overtime. On founder experience’ table, the data were collected due to the background study of the founder and the number of the years with experience in the market, weather ICT or Agriculture. Finally, founder experience is significant feature when it comes to the VC investment. Regarding the econometric parameters of the annual report of legislation in support of innovative startups and SMEs to the Italian Parliament, VC investors has a particular attention to the managerial experience and the strong correlation has been seen between VC and founder prior experience (Calenda, n.d.).

4.5 Region Dispersion

Table 4-3 Region Dispersion

Region	Year					
	2021	2020	2019	2018	2017	2016
Emilia-Romagna	In4Agri	La Valle	AgroAdvisor	Fragile	IBF	Studiomapp
Veneto	-	Free Green Nature	Precision Testing	Finapp	Ono Exponential Farming	-
Piemonte	-	-	XFarm	Silvergeko	-	-
Lombardy	XAgriFly	-	-	-	-	-

4.6 Number of Employees

Table 4-4 Number of Employees

Start-ups	Date of incorporation	Year				
		2020	2019	2018	2017	2016
In4Agri	05.2021	-	-	-	-	-
XAgriFly	04.2021	-	-	-	-	-
Free Green Nature	08.2020	3	-	-	-	-
La Valle	04.2020	0	-	-	-	-
AgroAdvisor	12.02019	0	-	-	-	-
XFarm	01.2019	8	3	-	-	-
Precision Testing	01.2019	1	0	-	-	-
Finapp	12.2018	0	0	-	-	-
Ono Exponential Farming	10.2018	1	1	0	-	-
Silvergeko	05.2018	n.a.	n.a.	n.a.	-	-
Fragile	04.2018	0	0	0	-	-
IBF	06.2017	19	16	7	5	-
Studiomapp	12.2015	1	1	0	1	0

Source: (*Aida - Home*, n.d.)

4.7 Revenue from Sales and Service

Table 4-5 Revenue from Sales and Services

Start-ups	Date of incorporation	Year 2020 €	2019 €	2018 €	2017 €	2016 €
Free Green Nature	08.2020	0	-	-	-	-
La Valle	04.2020	0	-	-	-	-
AgroAdvisor	12.02019	0	-	-	-	-
XFarm	01.2019	773,857	2,970	-	-	-
Precision Testing	01.2019	389,12	268,38	-	-	-
Finapp	12.2018	75,610	0	-	-	-
Ono Exponential Farming	10.2018	0	0	0	-	-
Silvergeko	05.2018	26,175	17,557	14,720	-	-
Fragile	04.2018	72,608	126,890	11,050	-	-
IBF	06.2017	3,848,786	1,763,105	817,820	115,941	-
Studiomapp	12.2015	73,531	122,689	18,680	14,866	3,200

Source: (*Aida - Home*, n.d.)

4.8 Total Asset Growth

Table 4-6 Total Asset Growth

Start-ups	Year 2020 €	2019 €	2018 €	2017 €	2016 €	Total Asset Growth
Free Green Nature	2,281,190	-	-	-	-	-
La Valle	6,306	-	-	-	-	-
AgroAdvisor	1,388,432	-	-	-	-	-
XFarm	1,276,500	114,785	-	-	-	+ 10.12
Precision Testing	513,031	505,70	-	-	-	+0.014
Finapp	252,095	12,376	-	-	-	+19.36
Ono Exponential Farming	1,244,018	-	12,621	-	-	+97.57
Silvergeko	17,196	-	4,425	-	-	+2.89
Fragile	76,586	-	17,281	-	-	+3.43
IBF	9,182,542	-	5,414,307	-	-	+0.70
Studiomapp	94,683	-	-	-	21,428	+3.42

Source: (*Aida - Home*, n.d.)

4.9 Founder Prior Experience

Table 4-7 Founder Prior Experience

Start-ups	Date of incorporation	Academic background	Firm experience (yr/mos)	Industry Experience (year/s)
In4Agri	05.2021	n.a.	1 yr 2 mos	38 yr
Free Green Nature	08.2020	Bachelor's degree Electrical Eng.	1 yr 8 mos	30 yr
AgroAdvisor	12.2019	Bachelor's degree electrical Eng.	2 yr 2 mos	28 yr
XFarm	01.2019	Mater of Technology and Economics/ Agriculture Science and Technology	1 yr 1 mos	21 yr
Precision Testing	01.2019	Ph.D. in Environmental Agronomy	3 yr 4 mos	15 yr
Finapp	12.2018	Ph.D. Nuclear Physics	3 yr 6 mos	-
Ono Exponential Farming	10.2018	Mater of Business administration	3 yr 8 mos	47 yr
Fragile	04.2018	Post-doctoral research	4 yr 1 mos	-
IBF	06.2017	Bachelor's degree- Agriculture Science	4 yr 11 mos	30 yr
Studiomapp	12.2015	Bachelor's degree- Computer science	6 yr 5 mos	19 yr

4.10 Scientific Partners

Table 4-8 Scientific Partners

Start-ups	Scientific Partners
IBF	*IREA **ISMEA University of TUSCIA University of Padova Michigan State University University of Teramo Bonifiche Ferraresi
Finapp	University of Padova MITO TECHNOLOGY EIT food MASSCHALLENGE Cadi Ayyad University
Fragile	University of Bologna via AlmaCube srl
Ono Exponential Farming	CUOA Business School

* Istituto per il rilevamento elettromagnetico dell'ambiente
** Istituto di Servizi per il Mercato Agricolo Alimentare

4.11 Data Interpret

Data related to the location dispersion (Table 4-3) shows no start-ups available in some regions, such as Trento-Alto Adige and Friuli-Venezia Giulia. The author could not directly confirm that it is true, yet due to the research and the criteria of looking just for start-ups in northern Italy, the result showed no start-ups in these regions. Also, Emilia-Romagna introduces a start-up for each year from 2016 until 2021. Moreover, the Veneto region has the second number of start-ups introduced in precision farming. Finally, Piemonte, with two start-ups, and Lombardy, with just one start-up established in 2021, stand for third and fourth among regions. Table 4-4 shows the changes of the number of employees from the date of establishment. The source shows the number of employees who are officially registered. Some unofficial data could be available, yet these data are trustable for being released from the official source. In4Agri and XagriFly had no data due to the incorporation date of 2021. IBF had significant growth in the total number of employees. Also, XFarm shows the same trend as IBF. Free Green Nature respect for the other start-ups shows an impressive start.

Table 4-5 indicates the changes in the revenue from sales and services. Excluding two newly established start-ups, IBF and XFarm are showing more significant income compared to the others. Next is Precision Testing, and it follows with Studiomapp, Finapp, Fragile, and Silvergeko. Also, revenue in Fragile and Studiomapp decreased in 2020 compared to their income in 2019. Before, from the date of establishment, they had an income growth. However, revenue from sales and services does not necessarily show the growth of the business.

Table 4-6 gives the information related to the growth of the business, and it is a good benchmark to see whether they have had growth. Regarding the numbers, Ono Exponential Farming, Finapp, and XFarm have significant growth in their business. Fragile and Studiomapp have the same level of growth. Also, even if IBF has less growth in total assets, the total asset value is the biggest compared to other start-ups. Interestingly, Free Green Nature has had the second-biggest total asset in the first year of its establishment. AgroAdvisor also follows the same trend. XFarm and Ono Exponential Farming are the next on the asset rankings.

Table 4-7 indicates the founder's prior experience in which the founder of Ono Exponential Farming has the most excellent experience in the industry. Comparing the high total asset growth for this start-up shows that this start-up is on the right path. Excluding the In4Agri due to the lack of available data, Free Green Nature and IBF are also following the same route regarding their founder’s prior experience and asset growth. AgroAdvisor, XFarm, and Studiomapp are the same as the previous group in the lower position. Nevertheless, they still support the high prior experience of the founder plus high asset growth. Even if Precision Testing, Finapp, and Fragile have founders with lower industry experience, their academic background fulfills their growth expectations. For instance, Finapp and Fragile have strong scientific partners shown in Table 4-8. IBF and Ono Exponential Farming are also supported by several R&D centers that create more growth opportunities.

5 CHAPTER FIVE

5.1 Introduction

This chapter dedicated to emphasizing main characteristics and summarizing the final results of this study.

5.2 Conclusion

The new space economy is an ecosystem well-fitted into the Circular Economy to transfer the traditional space economy to the new space economy by applying breakthrough innovation and introducing new opportunities for prominent and entrepreneurial actors. Thanks to the innovative technologies used by the public and private actors, the new space economy has improved in readiness and intensity factors. It is a time to benefit from the factor of impact globally and in the EU. During the last years, the overall investment in the space economy has boomed, and the forecasts show that it will become a one trillion-dollar industry by 2040. Commercial revenues, employment, productivity, social welfare, and macroeconomic benefits are positive effects derived from space investment. Commercialization absorbs a high investment rate, and Venture Capital investors have been the main in this sector globally and in Europe for several years. Socio-economic effects derived from the space investments selected different sectors such as environmental management, R&D and science, climate monitoring and meteorology, energy, agriculture, and high-tech industries, which lead to sustainability for people, food, and the environment.

The space economy value chain comprises 22 market domains grouped into eight market segments. The space economy value chain indicates two main essential features to address start-ups working on precision farming. Firstly, the downstream segment of the space value chain is directly feeding the start-ups working on precision farming. It mainly includes satellite services and ground equipment. Novel services provided by satellites let new players come to the scene with limited competition. Earth observation, remote sensing, and navigation are the primary services. On the other hand, ground equipment has a highly competitive landscape, and the entry costs are significantly low. Moreover, Machine learning, IoT, Cloud computing, and Blockchains are the technology trends applied in space economy and precision farming.

They were searching on the start-ups working on precision farming, leading to see how they had had growth from the date of their establishment and how the policy and policymakers can facilitate the growth of the start-ups. Hence, the focus was mainly on the regions located in northern Italy.

The results show that at least one start-up in Emilia-Romagna was established in precision farming from 2016 until 2021 every year. In the same period, Veneto introduced four new start-ups, and in Piemonte and Lombardy, two and one start-ups were established, respectively. Other criteria to evaluate start-up growth were the number of employees, revenues from sales and services, total asset growth, founder's prior experience, and scientific partners. The result regarding the sample indicates that in Lombardy, at least three of the samples have the opportunity to grow further. For instance, IBF is already working in more than one hundred countries. This situation in Veneto is also intense, showing that three out of four have an excellent opportunity for growth. Two start-ups have seen significant growth mainly due to their founder's prior experience. In Veneto, Finapp is already spread its business in other countries such as Vietnam, Chile, and Marrakesh. Piemonte has one outstanding start-up. University of Padova and Bologna are solid scientific partners of the sample start-ups.

Industrial policies and geographical distribution have a significant effect on the clearance for the future attitudes on enabling space applications on the earth, leading to sustainability. European Commission, European Space Agency, and Italian Space Agency play a pivotal role in paving the way for enabling future ambitions. The latest strategic vision document for 2016-2025 is a space policy guideline in Italy. This strategic macro-objective is to build a system able to collaborate and compete in space globalization. Moreover, 'Industry 4.0' and 'ISMEA' are among the national ambitions to facilitate the digital transformation of high technology innovations. Increasing the competitiveness of European industry on the international market need to meet the requirements of the European space program and national programs, encouraging the rationalization and development of an industrial structure appropriate to market requirements, participate equitably and exploit the advantages of the free competitive bidding. Moreover, 'Industry 4.0' and 'ISMEA' are among the national ambitions to facilitate the digital transformation of high technology innovations. 'Horizon Europe' is a strategic orientation investing in research and innovation. Finally, to benefit from the significant opportunities in the global space economy, governments should monitor space activities along the value chains of their national economies.

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