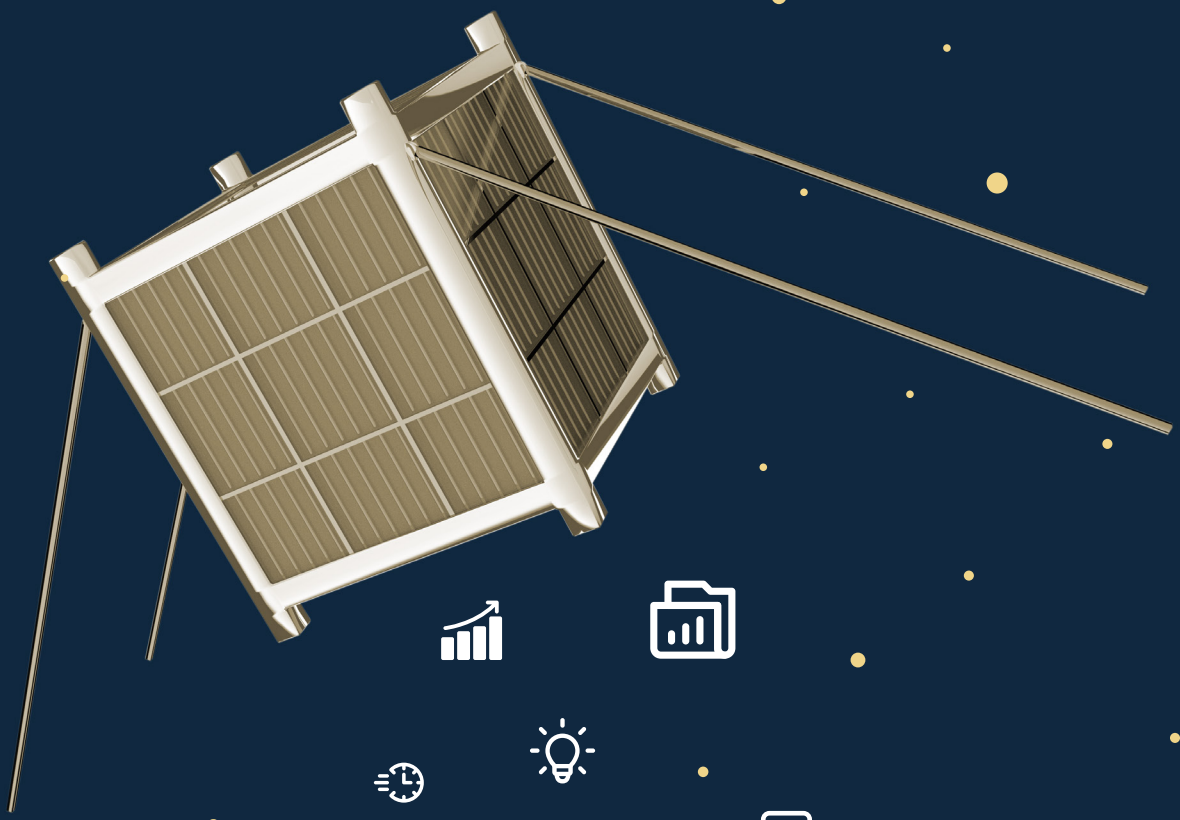
New Space Strategy of Catalonia



Generalitat de Catalunya
Government of Catalonia

Catalonia NewSpace Strategy

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In collaboration with
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Ministry of Territory and Sustainability and Ministry of Business and Knowledge

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1. Introduction

NewSpace represents a new use of space, a new technology, a new set of services and, therefore, a new economy based on democratising space and the aerospace industry. One of the catalysts of this change is the appearance of the nanosatellite CubeSat standard. NewSpace includes technologies that will enable us to manage our territory better and also be better informed about it; to be proactive in the face of climate and meteorological emergencies; to have uniform Internet of Things (IoT) coverage and basic communications, thus supplementing the capabilities and coverage offered by existing service operators. NewSpace will also enable us to obtain new data that will contribute value to the territory, to people and to players in the productive sector.

The NewSpace concept is based on the use of smaller satellites which cost less and require less development time compared to the current ones, that orbit the Earth at low altitude (LEO)[1] and use commercial-off-the-shelf (COTS)[2] technologies. These characteristics represent a paradigm shift in the way we develop space missions and enable many more players to use their services in vertical and/or cross-cutting applications in diverse productive sectors.

NewSpace provides opportunities to use and exploit space platforms for a great variety of applications, including scientific research, space technology development and training, Earth observation (EO) and telecommunications, such as machine to machine (MTM)[3] technology, 5G and IoT[4]. The first revolution has occurred in the field of EO but it is in the latter sphere, telecommunications, where we see the most disruptive change coming and the one with the most potential for establishing a new market. A market capable of meeting the challenge of offering connectivity services on a uniform basis across the globe. The constellations of satellites already offer lower revisiting and latency times, and the integration of these new networks with new standards resulting from 5G technology could lead to a convergence of services linked to IoT and business to business (B2B) connectivity that will help to give us service continuity, regardless of where we are.

One of the users and also major consumers of this technology will be public administrations and their ministries, departments or agencies. The Earth is going through a convulsive time where governments need more services so they can monitor the state of their territory, the impact of different phenomena – atmospheric, meteorological or terrestrial – and predict situations that could have direct consequences for their citizens and their environment. Consequently, the information and data received from EO services, combined with other data from different types of sensors spread around the country, will enable governments to manage their territory now and ensure they have the related analysis and decision-making tools.

Today, some states already have a NewSpace strategy, legislation under which they can structure plans for promoting and encouraging NewSpace-related activity, as well as investment strategies for boosting their capacity and attracting investment from the big companies emerging in the sector. NewSpace is a growth sector expected to mature in the

[1] <https://www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits#LEO>
[2] <https://www.techopedia.com/definition/1444/commercial-off-the-shelf-cots>
[3] <https://www.etsi.org/technologies/internet-of-things>
[4] <https://ietf.org/topics/iot/>

coming years. It has been calculated there will be around 3,500 new CubeSat launches between 2020 and 2025, with 450 of them in 2020. Those figures indicate a growth of over 600% compared to the launches that have taken place in the last four years.

So this is the ideal time for us to make a firm commitment to the NewSpace sector and develop a new market and a new technological network that will have a pull effect and bring together other technologies, such as 3D printing, artificial intelligence (AI), advanced electronics for sensors and computers, secure communication, and new-generation mobile communications (5G and IoT, among others).

Catalonia has the capacities and necessary potential to position itself in this emerging sector. We have the talent, successful experiences and a technological fabric which, duly aligned and with proper support, can make the most of existing synergies in EO, mobile communications and IoT to become a global benchmark. Moreover, Catalonia, regarded by the *Financial Times*[5] as a region with great potential for technological investment, could become a pole of attraction for international investment linked to this NewSpace economy. Finally, it should be pointed out that in Catalonia, and more specifically in the public research and innovation sector, various missions have already been launched with the aim of validating the technology and new applications developed here. For that reason, as well as others outlined in this document, the Government of Catalonia is behind the drafting and launch of the NewSpace Strategy of Catalonia.

In the first sections of the Strategy you will find information on the current NewSpace ecosystem in Europe, Spain and Catalonia, including companies, research and innovation centres, and universities, as well as other players involved. Knowledge of this ecosystem is essential for identifying where we can grow from and where we need to go –obviously without forgetting the space sector's legal framework– spelling out aspects that have to be developed and insisting on the creation of a regulatory framework that can promote NewSpace development in Catalonia.

This Strategy is in line with the Government of Catalonia Digital Agenda, which encourages experimental, open, digital infrastructures that can drive the innovation ecosystem and boost the roll-out of communications services in Catalonia, as well as pushing for the implementation of pilot projects with public authorities that can improve public service delivery through the adoption of advanced digital technologies. At the same time, this document makes clear that developing space missions, in the context of NewSpace, is a multidisciplinary task that combines a great deal of expertise and numerous technologies whose impact will extend to many sectors of society and help to create a competitive business and research environment, with meeting points for technological supply and demand.

The NewSpace Strategy of Catalonia is an initiative coordinated by the Catalan Ministry for Digital Policy and Public Administration, in collaboration with the Ministry of Territory and Sustainability and the Ministry of Business and Knowledge, and also with the participation of other Catalan Government ministries. The Strategy will implement a multisectoral, cross-

[5] <https://barcelonacatalonia.eu/es/archivos/3648>

cutting plan focused on public authority needs and its impact on people and businesses, prioritising action areas such as territorial management, agriculture and livestock farming, hydrography, cartography and public services, among others.

It will be implemented through an action plan based on the following areas:

- **Ecosystem:** promoting a broad-based governance model in various areas that supports the development of a coordinated NewSpace ecosystem which is connected to the world and includes all the players in the value chain.
- **Research and innovation:** fostering research and innovation by applying specific instruments and establishing synergies between different government ministries, universities, and specialised research and innovation centres, organisations making intensive use of the data generated by the satellites, and the private sector.
- **Talent and society:** creating, attracting and retaining specialised talent that drives the development of new services and solutions in NewSpace, and training professionals from other sectors to cope with their impact.
- **Infrastructure and data:** having experimental satellite infrastructures in place that enable new solutions and technologies to be validated, and having new data available to facilitate secure, open and transparent access.
- **Adoption of NewSpace services:** promoting the use of new services and data facilitated by NewSpace as a driver of innovation in the public administration and in various strategic sectors, both traditional and emerging ones.
- **Regulatory framework:** having a structure within the public administration that provides a legal and regulatory framework applicable to NewSpace.

A working group was set up to develop the Strategy which, apart from members of the government, has involved a group of experts in telecommunications and the NewSpace sector, representing various Catalan institutions, who have contributed their view on the current situation and the future development of NewSpace in Catalonia. Those experts are as follows:

- Dr Adriano Camps, Full Professor, Scientific Coordinator of the UPC-CommSensLab Maria de Maetzu Unit and the UPC NanoSat Lab in the Department of Signal Theory and Communications at the Technical University of Catalonia (UPC), researcher at the Institute of Space Studies of Catalonia (IEEC) and researcher in the Space Sciences and Technologies (CTE-UPC) group.
- Joan Adrià Ruiz de Azúa, Joan Francesc Muñoz-Martín, Lara Fernández and Adrián Pérez, pre-doctoral researchers from the departments of Telematics Engineering and Signal Theory and Communications at the Technical University of Catalonia (UPC).
- Dr Ignasi Ribas, Director of the Institute of Space Studies of Catalonia (IEEC) and researcher at the Institute of Space Sciences (ICE-CSIC).
- Dr Josep Colomé, Head of Corporate Development and Projects Manager at the Institute of Space Studies of Catalonia (IEEC) and the Institute of Space Sciences (ICE-CSIC).

- Dr Juan Jose Ramos, university lecturer and researcher at the Institute of Space Studies of Catalonia (IEEC) and in the Space Sciences and Technologies (CTE-UPC) group.
- Dr José María Gómez, university lecturer and researcher at the Institute of Space Studies of Catalonia (IEEC) and the Institute of Cosmos Sciences (ICC-UB).
- Dr Màrius Montón, Head of Space Embedded & HW/SW Development at the Institute of Space Studies of Catalonia (IEEC).
- Lluis Gesa (†), Director of the Engineering Programme at the Institute of Space Studies of Catalonia (IEEC) and at the Institute of Space Sciences (ICE, CSIC).
- Dr Jordi Corbera, Head of the Earth Observation Area at the Cartographic and Geological Institute of Catalonia (ICGC).
- Dr Juan Fernando Marchan, specialist engineer in the Earth Observation Area at the Cartographic and Geological Institute of Catalonia (ICGC).
- Mònica Roca i Aparici, First Deputy Chair of the Barcelona Chamber of Commerce and Chair of the Space and Aeronautics Committee.
- Rafael Harillo, lawyer and aerospace consultant at the Bufet Mas i Calvet.
- Dr Sergi Figuerola, Director of Technology and Innovation at the i2CAT Foundation and 5G Barcelona.
- Dr Daniel Camps, Director of the Mobile Wireless Internet area at the i2CAT Foundation.
- Dr Ana Isabel Pérez-Neira, Full Professor at the Technical University of Catalonia (UPC) and Scientific Coordinator of the Catalonia Telecommunications Technology Centre (CTTC).
- Dr Michele Crosetto, Head of the Geomatics Division at the Catalonia Telecommunications Technology Centre (CTTC).
- Dr Màrius Caus, researcher in the Communication Systems Division at the Catalonia Telecommunications Technology Centre (CTTC).
- Dr Joan Bas. Senior Researcher in the Communication Systems Division at the Catalonia Telecommunications Technology Centre (CTTC).
- Dr Carles Fernández-Prades, Senior Researcher and Head of the Communication Systems Division at the Catalonia Telecommunications Technology Centre (CTTC)

In addition, the Strategy has been externally reviewed by Dr Jordi Puig Suari of the California Polytechnic State University, aerospace technologist and co-inventor of the CubeSat standard, and also by Xavier Lobao, Head of the Future Telecommunication Projects Division at the European Space Agency (ESA).

The agreements and contributions of the working group have provided the basis for drafting the NewSpace Strategy of Catalonia, which envisages everything that Catalonia offers and has at its disposal to become a global success case in rolling out NewSpace services and solutions, as well as policies that the Government of Catalonia will launch to achieve that.

2. NewSpace: a new ecosystem

2.1. What is NewSpace?

The term 'NewSpace' has clearly meant different things since it first started to be used in 2000. Space has always been a source of inspiration for explorers and researchers. And space research has generated revolutionary technologies that have expanded humanity's knowledge. In other words, those technologies have improved everyday life in many ways. Until recently, space use and exploration were synonymous with national public investment and government policy, where the high cost and associated risk implied made it difficult for private entities to access this sector.

Thanks to huge technological development and a big reduction in costs, however, the barriers to entering space have gradually become blurred, generating a global movement inside the so-called 'NewSpace' sector. NewSpace represents a current trend where new private players have emerged seeking new commercial opportunities in space use and exploration. More specifically, space missions are geared towards specific services that could be offered directly from satellites or by means of the data that they collect.

Access to space has been democratised by a reduction in the time and cost of developing satellites, achieved mainly by making much smaller ones. Nanosatellites in particular and specifically CubeSats have become ideal platforms for balancing satellite services and capacities with production, launch and maintenance costs. These satellites are usually launched in low-altitude orbits known as low Earth orbits (LEOs).[6]

Thus space is no longer a place where only national agencies carry out activities. It has finally become a catalyst for new service markets and an area for economic growth.

Definition of NewSpace:[7] *industrial movement that encompasses new investment and a series of technological innovations and services which, at the same time, promotes the development of a new community in the space sector and offers multiple services by using small, low-cost satellite platforms orbiting at low altitude.*

From a business point of view, businesses linked to this new sector are noted for being more agile and independent than traditional ones, with very low risk acceptance and a high degree of reliability, which has a direct impact on production times and costs. NewSpace focuses on lower budgets to achieve new services by means of technological innovation which enables this private sector to expand services on a global scale while profiting from economies of scale. Investment in this sector[8] is growing at a rapid rate, approximately 80% between the periods 2000-2005 and 2006 -2011, and 350% between 2006-2012 and 2012-2017. Access to funding continues to be the bottleneck in Europe. Most investment in the NewSpace sector (approximately two thirds) is in the USA, followed by Japan (19%), the United Kingdom (15%), Israel (15%), Canada (14%), Spain (12%), India (10%) and China (9%).

[6] More information can be found on the different orbits in section 2.2.
[7] Definition based on the document <https://www.eib.org/attachments/thematic/future_of_european_space_sector_en.pdf>
[8] <https://www.eib.org/attachments/thematic/future_of_european_space_sector_en.pdf>

2.2. The origin of NewSpace

The satellites designed at the start of the space era were small. Sputnik 1 was the first artificial satellite to orbit the Earth. It was launched by the Soviet Union on 4 October, 1957, and was active for three weeks until the batteries failed. But it kept going for a further two months. The satellite was a metal sphere 58 cm in diameter and weighed approximately 84 kg, By following and processing the different signals received from it, scientists were able to compile information on the density of the atmosphere's upper layers and the propagation of radio signals via the ionosphere.

A long list of satellites have followed Sputnik 1, growing in size and mass. Due to their enormous variety, they have been classified according to weight. Figure 2.1 shows this classification, where large satellites weighing more than 1,000 kg can be identified , followed by medium-sized satellites of between 500 kg and 1,000 kg. Below that we find small satellites with a mass of between 100 kg and 500 kg, together with microsatellites with a mass of 10 kg to 100 kg. Finally, at the bottom end of the scale come the nanosatellites and picosatellites, with a mass less than 10 kg.

Figure 2.1. Classification of satellites according to their mass.

Satellites are constantly going round the Earth, following a trajectory known as an orbit. This trajectory is determined by a series of orbital parameters. Among those parameters, altitude is normally used to differentiate between the type of orbit. A low-altitude orbit is known as a low Earth orbit (LEO) and refers to all those with an altitude under 2,000 km. If we continue moving away from the Earth, an orbit with an altitude between 2,000 km but below 35,786 km is called a medium Earth orbit (MEO). Satellites that follow orbits with higher altitudes are known as satellites in a high Earth orbit (HEO). Within this group there is a very characteristic kind of orbit which, in contrast to those referred to, enables us to see the satellite from Earth and always in the same position in space. This orbit is known as a geostationary orbit (GEO) and it has an altitude of 35,786 km on the same plane as the Earth's equator. Figure 2.2 shows these orbit regions with a series of satellites orbiting (or with planned launches) in those regions.

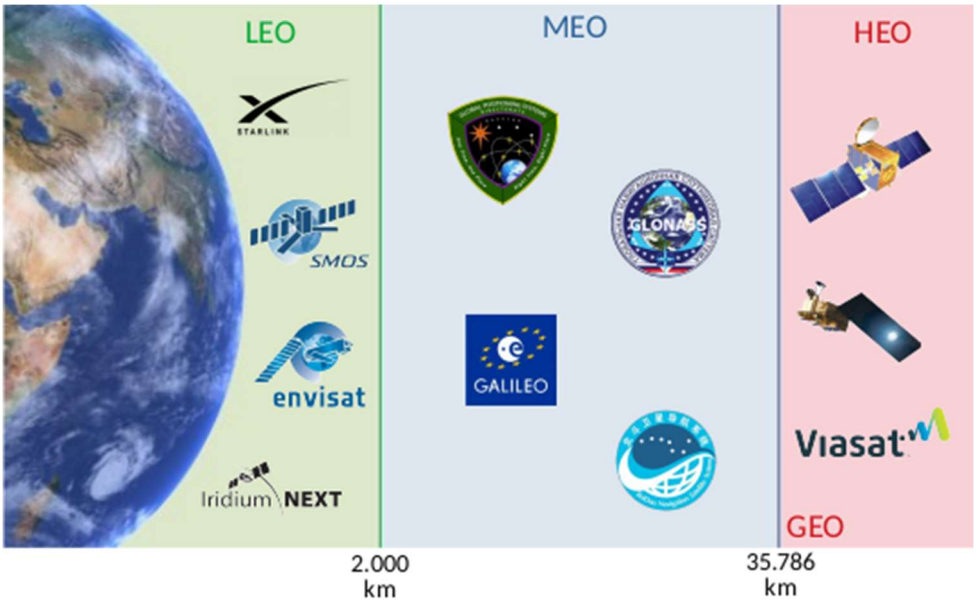

Figure 2.2. Representation of the regions and types of orbits, together with some examples of satellites.

Satellite development, implementation, verification and operation activity is encompassed in the 'mission' concept. Traditional mission development depends on institutional programmes defined according to national needs and administered by space agencies such as NASA or ESA, although there is a lot of activity on a commercial scale, especially in broadcasting and telecommunications satellites. This development has been carried out in various sequential phases that make up the different parts of the mission.

The V development system, as it is known, has a direct impact on the production philosophy, with large cycles and a significant cost to ensure the system's viability and robustness. Consequently, traditional satellites have their own design adapted to each mission. In recent years a new concept has arisen as an alternative to the traditional way of working, one that seeks more flexible models, with reduced commercialisation time, a high repositioning rate and relatively low production costs that were unthinkable a few years ago: NewSpace.

These small satellites, as they are cheap and easy to manufacture and put into orbit, are more accessible for developing countries and players with fewer resources, such as companies or universities and research centres. Apart from the cost of missions, one of the most important characteristics is the capacity to greatly reduce the time window, from taking the decision to carrying out the mission. This makes it possible to use more innovative technologies when the mission is launched, in contrast to the traditional way of launching satellites, where development requires several years.

One of the big shifts in thinking that enables this new development is focused on reducing satellite mass and volume, leaving behind the era of big structures. The CubeSat standard has become essential in that regard. This format was conceived in 1999 by Professor Jordi Puig-Suari from the California Polytechnic State University (CalPoly) – a native of Catalonia and one of this Strategy's advisers – and Bob Twiggs from Stanford University. Their objective was to develop a standard that allowed students to design, implement, verify and operate a satellite in orbit in a reasonable and feasible time. Thus, CubeSats are small satellites of multiple units (1U), in the form of a cube 10 cm x 10 cm x 11.35 cm, with a maximum weight

of 1.33 kg. These small satellites have many of the subsystems of the traditional large satellites but, in order to cut production time, those of CubeSats are common components installed on the market,[9] in other words they are readily available and quickly acquired. The original idea, which became standard, only describes the external structure of a 1U CubeSat to simplify its integration into the launcher. The CubeSat design standard[10] is currently defined in terms of 1U, 1,5U, 2U, 3U, 3U+, and 6U, and efforts are being made to standardises 12U and 16U platforms, although some companies have worked with 27U.

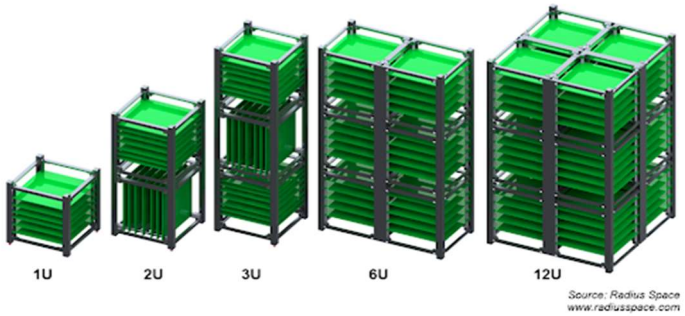

Figure 2.3. Structure of CubeSats from 1U to 12U.

Figure 2.4. Structure of a PocketQube.

The latest trend has been to keep reducing platform dimensions, reaching one eighth of 1U CubeSat standard. This new format is called PocketQube and it enables a considerable reduction (approximately 25%) in launch costs. It is therefore an ideal platform for testing specific technologies for short periods. Alternatively, CubeSat platforms have become sufficiently robust for evaluating technologies over a longer period and eventually offering commercial services, such as Planet Labs[11] or Spire Global.[12]

In the last few years, many organisations have launched CubeSats with different numbers of units. The dominant format since 2013 has been that of 3U CubeSats (Figure 2.5). Statistics confirm that this will continue to be the main format in the coming years, following in the footsteps of 1U and 2U. However, it is expected that the next wave of launches will be based mainly on 6U and 12U platforms, because they offer a better balance between production and launch costs, and the possibility of launching more powerful payloads.

[9] In the space sector they are known as commercial off-the-shelf (COTS).
[10] Known in the space sector as CubeSat Design Specifications.
[11] <https://www.planet.com>
[12] <https://spire.com/>

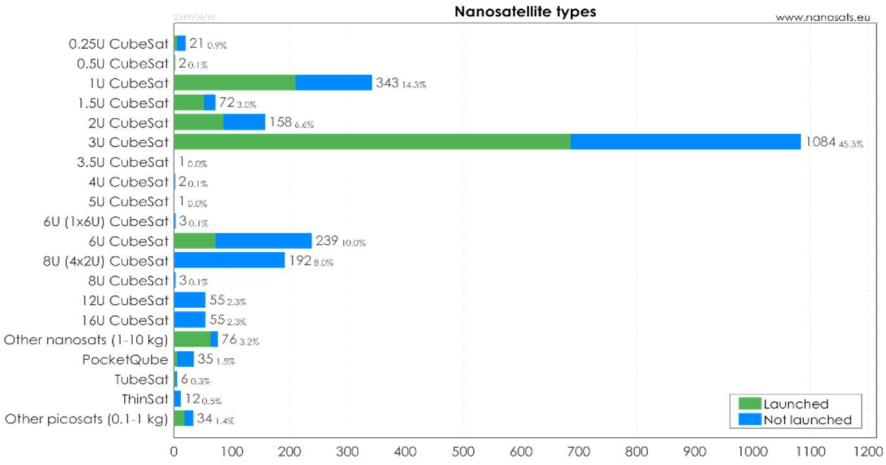

Figure 2.5. Number of CubeSats launches according to the type of platforms.[13]

Figure 2.6 shows the global number of nanosatellite launches in recent years. The first launches (until 2013) involved nanosatellites developed by universities to show the utility of various technologies. Over the years, new players have started to develop their own CubeSats, mainly produced by private companies, institutes, military institutions and space agencies.

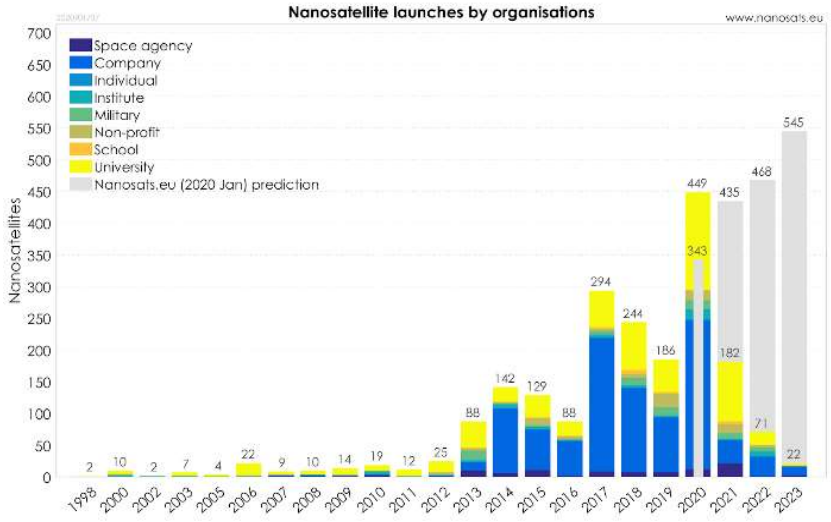

Figure 2.6. Number of CubeSats launches in recent years.

In the course of 2019, a total of 186 nanosatellites were launched, for the most part by universities and private companies. It is forecast that 449 satellites will be launched in 2020, with private companies leading the way. This prediction includes a considerable increase on the part of companies, due to the various business opportunities open to them. The total number of nanosatellite launches planned according to the EU nanosatellite database is 3,000 in six years. Most of these launches have taken place without any problems and ensured the

[13] <https://www.nanosats.eu/>

deployment of the satellites in the corresponding orbits (Figure 2.7). The current launchers offer a high level of reliability and promote ongoing satellite development.

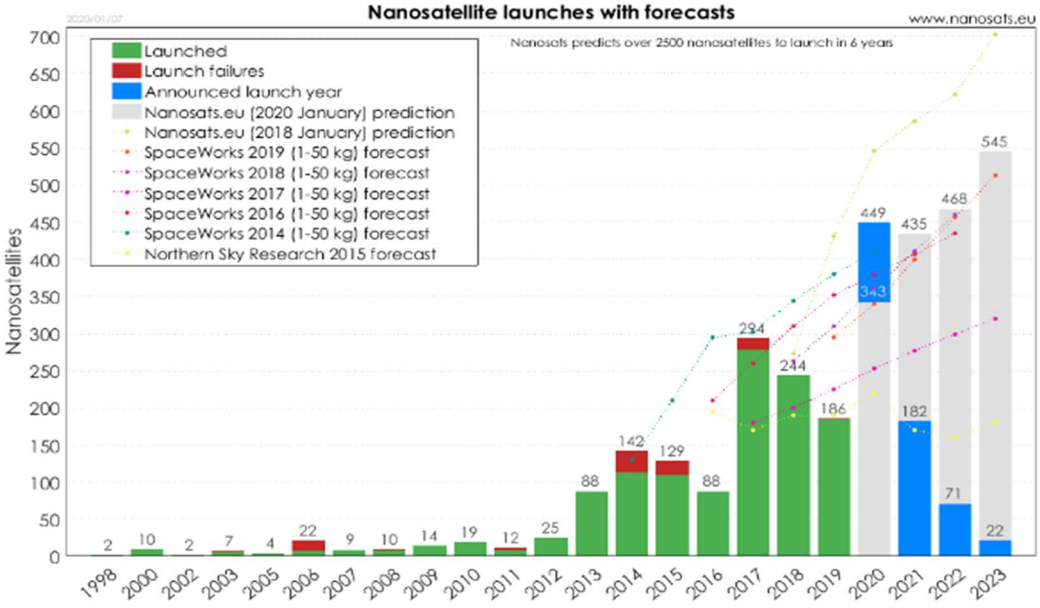

Figure 2.7. Number of launches according to completion status.

Thus, NewSpace means a paradigm shift in the way we develop satellites which has led to the appearance of new entities and encouraged the development of new technologies and applications. In other words, it is a development framework that has given rise to new opportunities, and it is expected it will give rise to more in the coming years.

2.3. NewSpace and internet

Space has always been the last frontier for human kind, while the emergence of the internet has probably been one of the most disruptive developments in recent decades. As the 21st century progresses, space and internet technologies are converging more and more. Global leading technology players who regard the internet's evolution, in terms of adoption, affordability, performance and reach, as fundamental to their continued growth, are investing tens of billions of euros in space technologies.

Disruptions in the fundamentals of internet architecture, design and roll-out do not occur very often. In the last two or three decades innovations have largely been incremental and the big change has been the shift from circuit switching to packet switching. At the same time, various iterations of wireless technologies have been rolled out with a broad ecosystem of infrastructures to support internet evolution (e.g. large-scale data centres and clouds) while 5G mobile networks are in the early stages of deployment.

We could say that recently new technologies have arisen with a capacity to impact on the design and development of internet services and infrastructures, with significant consequences for content delivery models, cloud networks and distributed computing. An area that includes technologies such as blockchain and decentralised internet technologies, 5G, quantum communications, and low Earth orbit (LEO) satellite communication networks.

LEO constellations have been around for some time. One of the best known is the Iridium network. The novelty lies in the fact that recent network launches are focused on enabling global-scale internet connectivity in a new era of space-based internet technologies. Practically all internet and cloud computing providers are working on various aspects of these roll-outs, including Amazon, Google and Facebook, other large-scale technology players such as Virgin, SpaceX and Softbank, existing satellite communication providers already present in GEO and MEO, venture capital-backed start-ups and public consortiums in China, Japan, Korea, and North America.

The new LEO satellite networks currently being designed offer a completely new set of opportunities and services, taking advantage of the low latency (compared to that of GEO and MEO orbits), broad reach and high capacity of such networks. Meanwhile, increased investment in initiatives of this kind, mainly from the private sector, adds a significant advantage to their potential. These LEO networks are being designed with the intention of leveraging mechanisms designed for terrestrial networks such as those of routing, switching, quality of service (QoS), resources management, software defined network control, virtual network functions, service orchestration and cybersecurity, among others Yet a lot of these mechanisms are far from optimal, given the characteristics LEO networks offer in terms of mobility as well as Earth-to-space wireless links management and space-to-space wireless links connectivity. Consequently, in some cases, these mechanisms need to be adapted and in others completely redesigned.

Other initiatives have tried to take internet architecture to space to enable networks to be established with satellites from different entities and private players. The concept of the Internet of Satellites (IoSat) is driving this new interconnection, by following this heterogeneous architecture and developing networks dynamically. With this Strategy, collaboration between different constellations will make it possible to offer services that otherwise would only be possible with extremely large constellations (involving tens of thousands of satellites) and thus avoid the complexity and cost which that would involve.

This is therefore an opportune time for taking advantage of the latest-generation internet designs and ensuring their development enables the deployment of a new generation of space networks.

2.4. Importance of NewSpace

Traditionally space activity has always been associated with space exploration to extract knowledge that will be of use to humanity. This acquired knowledge has then been put to use in society in the form of new technologies that have been changing everyday life. One example of this technology transfer to everyday life are ski glasses, which have filters to protect users from solar reflection that were originally developed for astronauts. Others include air purifiers, also previously developed for international space station activity, and which have reached our homes in the form of a commercial product. There are many more everyday technologies,

besides these two examples, whose origins can be found in research for space activities.[14] The commercial activity of satellite communications has become critical for the connectivity of people and businesses, while GPS and Galileo navigation is essential for guiding and positioning objects. Space activity generates advantages for society in general, although for sure people often need educating to understand these benefits.

In addition, the applications that can be achieved by means of satellites enable a whole series of socially beneficial services to be deployed. The European Union (EU) Copernicus programme[15], managed by the European Space Agency (ESA), is an example of how the data gathered and offered by satellites can take the form of services for studying and protecting the environment. So NewSpace is no exception, and thanks to participation being opened up to new players in space activity, new applications and, consequently, new services, can be developed for society's benefit. The European Commission has commented on the importance that the NewSpace revolution has acquired in recent years, a revolution that had become a key factor in the European space industry's renewal, which will increase the competitiveness and quality of European products in the sector[16],[17]. More specifically, NewSpace offers Europe the necessary flexibility and diversity in the various activities that could be developed. This environment means Europe has at least 200 emerging business linked to the sector, 90% of which were set up between 2013 and 2018. As it happens, these are small companies, with 10 to 20 workers. Another key factor is the rapid transmission of laboratory-developed technologies to the private sector, and the establishment of partnerships to develop new concepts and technologies.

This new activity must be geared towards humanity's benefit. Thanks to the knowledge acquired by satellites it has been established that the Earth has finite resources which must be managed so as not to put future generations at risk. The data and information gathered from space offer the fundamental possibility of monitoring with management metrics and indicators that will tell us about the Earth's economic, social and environmental sustainability. This is the strategy behind the Sustainable Development Goals (SDGs)[18] set by the United Nations.(UN). Those goals are focused on getting rid of poverty and hunger, furthering peace and justice, optimising terrestrial resources, protecting the planet's fauna and flora, fighting against climate change, expanding human knowledge and equitable education.

Figure 2.8 shows some of the impacts NewSpace has on the SDGs included in the Technological Capsule on NewSpace in Catalonia produced by ACCIÓ.[19]

[14] <https://homeandcity.nasa.gov>
[15] <https://www.copernicus.eu/en>
[16] <https://ec.europa.eu/info/files/european-partnership-globally-competitive-space-systems_en>
[17] <https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme/european-partnerships-horizon-europe/candidates-digital-industry-and-space_en>
[18] <https://www.un.org/development/desa/disabilities/envision2030.html>
[19] <http://www.accio.gencat.cat/ca/serveis/banc-coneixement/cercador/BancConeixement/new_space_a_catalunya>

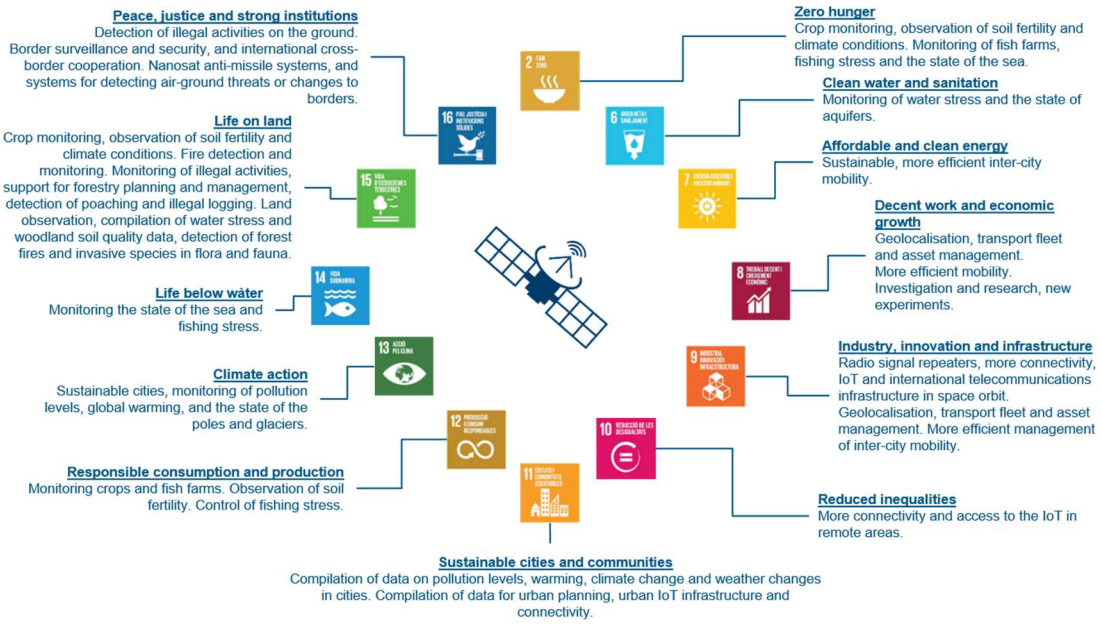

Figure 2.8. NewSpace impact on the Sustainable Development Goals.

It should be noted that the NewSpace concept arose basically as a space industry movement geared towards the appearance of new markets and new technologies. More specifically, it has become a commitment to generate innovation, technology transfer and new products and services, with the capacity to promote the business fabric of a territory according to its characteristics:

Integration of other technologies. Satellite development is a multidisciplinary task where many people and technologies interact. The most important synergies come with technologies such as robotics, artificial intelligence, 3D production, 5G or big data.

Complementarity of Earth services. There are currently many areas of Catalonia which not only lack connectivity but also any possibility of continuity in any of the services offered in areas covered by terrestrial service providers Furthermore, the entry of 5G technology makes service continuity between the different segments even more important, so NewSpace must offer a technological development environment in the field of telecommunications as well.

Innovation and business opportunity. The low cost and accessibility of NewSpace give almost any company, or consortium of companies, access to these new satellites. The economic benefits of using them will be an incentive for setting up new companies linked to this new technology. On a global scale it is estimated that the business generated by the satellite industry in 2040 will be around $1.104 trillion,[20] 37% of which will be accounted for by internet services. In addition, according to the European Association of Remote Sensing Companies,[21] in a technical note issued in October 2019[22], the growth in companies geared towards this sector is over 12%, with more than 500 companies, over 8,400 employees, and profits of more than €1.24 billion in Europe in 2018.

[20] Source: Satellite Industry Association, Morgan Stanley Research, Thomson Routers
[21] European Association of Remote Sensing Companies: <http://earsc.org/>
[22] Called EARSC EO Industry Survey Report: <http://earsc.org/library/>

Low-cost technology. Low nanosatellite production costs and short development times mean this is a technology within reach of practically all countries. That means they can enjoy virtually all the benefits of a conventional satellite for the cost of a nanosatellite, which is between 100 and 1,000 times lower. In that sense, NewSpace represents a certain "democratisation" of space and the aerospace industry.

Facilitating technology. NewSpace technologies will enable the full potential of the Internet of Things, 5G and connectivity to be deployed, while nanosatellite constellations will facilitate data compilation from space.

Platform for scientific applications. Nanosatellites, microsatellites and picosatellites open the door to new possibilities for space observation, environmental studies, system tests in orbit, biomedical research and new materials, thanks to their low cost and the relative ease of putting them into orbit.

Platform for new scientific, technological and pharmaceutical developments. Small satellites will (in fact they already do) enable scientific developments to go ahead that require risky technologies in which developers have no wish to invest large amounts of money, or which require long periods of observation that are not within the scope of big astronomical infrastructures, where the observation time is very limited. Assessing the behaviour of crystals, cells, bacteria or plants in the absence of gravity and/or presence of radiation, however, is supremely important for developing pharmaceutical products.

Smart City / Smart Country platform. Reinforces the government-driven strategies such as AI, 5G, smart or blockchain that it connects with, together with others that could be developed in territorial management, agriculture, the environment, energy and other fields.

Space activity has always been regulated by a number of national and international bodies, such as the United Nations Office for Outer Space Affairs (UNOOSA), to ensure the proper use of space. Furthermore, between 1967 and 1979, five international treaties were drawn up to facilitate regulation of this kind of activity. Satellite system access to the radio spectrum is also regulated by the International Telecommunications Union (ITU).[23] Licences for launching satellites are awarded by states, which are responsible to the UN for their proper use and any damage or harm that may be caused to third parties. The treaties are now out of date and are therefore limited as regards the new activity defined by NewSpace. So it is important to develop new regulations for that. Section 5 goes into more detail on this need.

This revolution entails not only covering state-run public programmes or those sponsored by government agencies and international bodies but also that there is private interest in investing in space. The development we are seeing now and which we will see in the immediate future will depend on the existence of viable pioneering initiatives which cover the development of a space ecosystem that impacts on the sector's economic growth in one or more territories. That is one of the main goals of the NewSpace Strategy of Catalonia, to be achieved by the measures outlined in Chapter 7 for driving the Catalan ecosystem and reinforcing the structures it generates.

[23] https://www.itu.int/

2.5. NewSpace spheres of action

The various initiatives encompassed in NewSpace are geared towards application, so each satellite is optimised to carry out the desired tasks. In contrast to the traditional solutions, in which each platform carried the as many instruments as possible to leverage the costs, today's solutions enable new instruments to be launched when they are needed and are available, thus allowing the application to grow organically. Moreover, the fact that the life cycles are very short provides an opportunity for using the best technologies, especially in electronics (processors and memory).

These satellites enable services to be offered directly, from the satellites themselves or by means of the data generated, to a whole series of communities or economic and social sectors, such as those of Catalonia. An obvious example of that is transport, a sector revolutionised by the appearance of positioning systems. Based on various initiatives, we can identify a number of services that could be offered by satellite infrastructures. Table 2.1 shows a series of sectoral applications that are of particular interest in the Strategy's scope of action.

Table 2.1 List of sectors and services obtained by means of satellite infrastructures

Fields	Applications or services
Geographic and meteorological analysis	• Mapping of the territory, changes and effects. • Detecting oil and gas fields. • Monitoring movements in the coast lines, technical images for insurers, accreditations, compensation for environmental changes, and weather forecasting.
Monitoring	• Detecting illegal activities on the ground. • Detecting and assessing accidents.
Agriculture and aquaculture	• Monitoring and evaluating the state and health of agricultural areas or forests and climate conditions. • Monitoring fish farms, automation of agricultural production or fishing, the state of the sea and fishing stress.
Safety, security and emergencies	• Detecting and monitoring fires, trying to improve the response, measures, effects and recovery. • Support for rescue and communication tasks in disaster areas and more precise forecasting for hurricanes, tornadoes, floods, etc.
Telecommunications and audiovisual	• Radio signal repeaters, more connectivity and IoT, even in remote areas, acting as a genuine international telecommunications infrastructure in space orbit. • Precision, infra-red images, 3D mapping, detecting anomalies in the universe, aerial photography and international programmes.
Transport and logistics	• Geolocalisation and transport fleet management, GPS signalling, managing more efficient and more sustainable inter-city mobility thanks to nanosatellites. • Monitoring and managing public service assets (vehicles, planes, vessels, etc.) immediately and with an overall vision.

Fields	Applications or services
Research	• System trials in orbit, biomedical research in space, innovation and new experiments thanks to the nanosatellite infrastructure. • Space exploration, interplanetary missions, development of NewSpace programmes and international cooperation in space research.
Environment, energy and water	• Follow-up and monitoring of the state of water reserves and water basins. • Monitoring biophysical variables associated with water stress, capacity index, pollution level analysis and nanosatellites with lower energy consumption.
Livestock farming and agriculture	• Surveillance and security of animal movements in areas with no coverage, and control and management of protected species. Support in processing SIGPAC subsidy applications, which will make it possible to identify the type and size of farms and estimate harvest dates, as well as detect changes that could mean vulnerabilities for the area, due to various natural or artificial factors.
Forests	• Monitoring forestry operations, support for forestry planning and management, as well as detecting poaching and illegal hunting. • Land observation, compilation of data on water stress and soil quality in the wood, detecting fires and invasive plant and wildlife species.
Smart cities	• Data compilation in combination with instrumental networks and satellite data, from which information can be derived on city pollution and warming levels, as well as environmental and meteorological changes. • Data compilation for urban planning, IoT urban infrastructure and connectivity thanks to the network of nanosatellites, microsatellites and picosatellites.

Of all the services we have highlighted as important for Catalonia, there are two of more interest, where Catalonia can and must be very competitive:

1. **Providing coverage for the Internet of Things (IoT):** at present, Catalonia has no standard or licensed technologies for integrating IoT and 5G solutions. The technological challenge lies in developing a payload for a CubeSat and having coverage for the whole territory to extend terrestrial coverage. Besides developing this coverage it is also important to equip satellites with links between them so they reduce the latency or time it takes to reach the ground station. That way IoT technologies can improve coverage in remote areas and also help to establish smart cities, by compiling data on pollution, warming and climate change, as well as smart management of urban areas and transport routes.

2. **Monitoring and displaying the state of the territory:** gathering territorial information on different levels enables administrations to manage the territory better and deal with the changes and effects on natural and urban ecosystems in the short and medium terms. This enables the socio-economic impacts associated with climate change to be measured, as well as natural resource-exploiting activities. To achieve that we need more effective tools for identifying and monitoring, on a repetitive and stable basis, the state, vulnerability and

changes in our territory, in order to feed the tools for taking decisions on the resources or services to be used at any given moment. Thus we have identified the need to design, develop, control and exploit a territorial monitoring and observation system based on constellations of small satellites that add value to the products already available through the EU Copernicus programme.

As pointed out above, developing NewSpace would generate added value in different sectors of society through service roll-outs. There follows a non-exhaustive list of some of those fields which are directly linked with many government ministries and departments and also the competencies assigned to them:

Connectivity. A territory can improve the connectivity of its population by deploying a satellite infrastructure. Because using satellites makes it possible to offer a communications network that complements the one on Earth, as well as offer more communication capacity and infrastructure redundancy in the event of a disaster. Furthermore, satellites are able to connect isolated rural areas that terrestrial infrastructure cannot connect as well as offer IOT services in addition to those that the infrastructure of traditional telecommunications operators can. Finally this increased connectivity offers the possibility of having a rapid communication and reaction system in the event of an emergency, as well as the possibility of repopulating rural areas abandoned because of the lack of telecommunications infrastructure.

Training and access to knowledge. As indicated above, satellites provide communication back-up when Earth-based solutions are limited. That way, remote areas can have internet access and the knowledge on it. Thus, the imbalances caused by this limitation in communication infrastructure can be reduced and training, on the different levels, can be facilitated in remote parts of the country.

Emergency systems. Lots of sectors can benefit from the growth in connectivity. More specifically, satellites can offer signalling and communication systems for emergencies that might happen in isolated parts of the country (in mountains and forests, for example). It also enables the state of forests and soil moisture to be studied. Water masses can be analysed from space too, providing indicators of their state. Finally, the combination of satellites and IoT technology means storm and meteorological event monitoring systems can be offered that enable a rapid reaction.

Transport and mobility. The movement of people and goods can also be observed from space. The different sea, air and land transport flows can be optimised by means of satellite resources, so optimum control of transport fleets can be achieved by monitoring the traffic data of different areas. Connectivity of goods and passenger transport vehicles therefore enables direct fleet management, operations management, passenger and luggage communications and increased safety.

Urbanisation. Satellites enable us to have an overall view of a whole territory. This feature means we can observe rural and urbanised areas. And thanks to these observations we can analyse the activity and growth of different towns and cities. Moreover, by means of these satellites it is possible to obtain information on pollution in those areas. It would therefore be possible to plan the structure of these urban developments better to the benefit of people's health.

Observation of population growth. Satellites also provide information on population growth, which would facilitate administrative tasks in this area. An example of this would be land registries.

Production of natural resources. Observing the state of fields (moisture, water stress, plagues, etc.) makes it possible to define more efficient crop strategies and change the traditional way of planning them. That ensures better food quality and security, as well as protecting the environment. Other productive sectors, such as mining or gas and oil drilling, can also benefit from satellites, Fishing could be regulated and optimised by having more control over the state of sea banks.

Environment. Climate change is an obvious and proven fact these days. Satellites are becoming key elements in combating this change as they provide different measures for monitoring and studying a territory. For example, the air quality and polluting gases in a city or oil slicks floating on a sea can be observed from space and, therefore, monitored. Satellites also enable coastal monitoring, which means changes in the state of the sea can be anticipated. Likewise, they enable the state of forests to be observed in order to anticipate deforestation and fires. Other applications might be controlling the state of reservoirs, observing river basins, adopting precision agriculture, controlling landslides, etc.

Apart from the benefits a NewSpace mission might bring all those sectors, it also requires the interaction of many people and organisations. The following figure shows the NewSpace value chain based on the level of maturity of the various players and spheres of action, clearly detailing all the elements that need to be borne in mind from the design and provision of technology stage to the provision of constellation services. As noted in Chapter 3, Catalonia has capacities and capabilities in each of the players in the chain. Moreover, it can rely on international players with enormous potential for developing the sector.

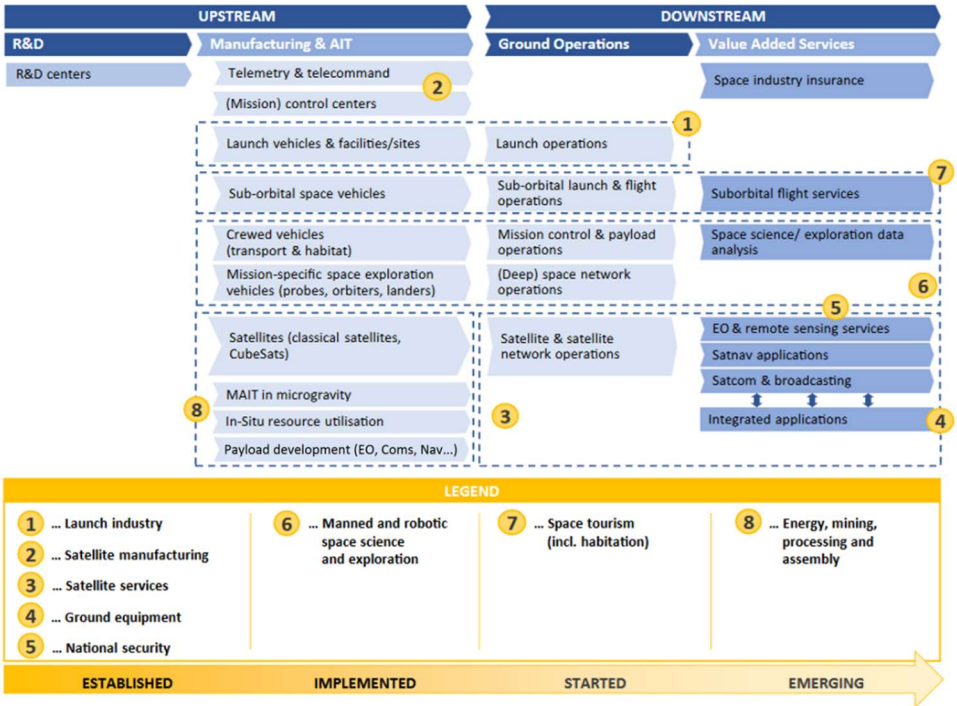

Figure 2.9. NewSpace value chain.

Below we outline the main players in the NewSpace value chain and the role they play in fully developing a mission:

Research centres. The development of new technologies and concepts is fostered by the research carried out in research and development centres, together with universities.

Satellite platform manufacturers Obviously, satellite manufacturers and integrators are vital players in NewSpace. These manufacturers provide low-cost access to space by means of a platform with certain features.

Payload manufacturers. Payloads are the part of a satellite responsible for carrying out the main objectives of the mission. For example, if the satellite is for 5G coverage, the payload will be a 5G communications system. So the manufacturers of these payloads are, along with satellite platform manufacturers, the ones who define the end satellite.

Ground station operators. These stations are used to control the satellite and retrieve the data it generates- Without these stations, many services could not be provided.

Satellite operators. These are responsible for remotely operating the satellite by means of ground control stations. They are an important player in a mission and must therefore be leveraged to ensure the development of future missions.

Data processing entities. Once the satellite-generated data are retrieved, they can be processed so they can be interpreted correctly. Very often, the large volume and complexity of these data make it necessary for independent entities to carry out the corresponding processing.

Service provider companies. Once the data have been processed, the resulting information can be offered as a separate service. Other types of service are those where satellites serve the end user directly, such as satellite communications.

End users. Finally, every service is destined for some end users who can range from public and private entities to individuals.

2.6. Future challenges for research and innovation in NewSpace

Despite the considerable technological development carried out in the NewSpace sector, there are still technological challenges that must be resolved so the new paradigms and applications can be rolled out, and we can have a fully operational and competitive sector. This section therefore outlines a number of those challenges which, bearing in mind the research and technological environment we have in the territory of Catalonia (see Chapter 3), are regarded as being feasible in the near future.

Table 2.2 Future challenges for NewSpace research and innovation

Technology	Level achieved	Future challenges
On-board subsystems		
On-board computer	• Use of on-board OEM modules	• To develop open-equipment RISC platforms with radiation-resistant technologies.

Technology	Level achieved	Future challenges
Operating system	• Installation of Linux operating systems with real-time features	• To develop virtualisation in on-board computers, with partitions for running payload software. • To standardise a system for changing equipment in flight. • To develop an operating system geared to satellites that encompasses the features of the new communication systems (e.g. 5G. IoT, IoSat).
Propulsion	• Micro-thruster and ionic propulsion	• To deploy constellations, formation flying and carry out evasive manoeuvres to avoid collisions.
Satellite-Earth communications	• Use of SDR • Transmitters in X and Ka bands	• To transmit in Ku band and optical communications to increase the downlink and avoid problems in assigning frequencies. • To develop deployable antennas.
Reliability	• Moderate reliability	• To increase reliability by carrying out more tests, more process systematisation, and the use of some system-scale redundancy (e.g. constellation scale instead of component, equipment or satellite level).
5G and IoT in satellites		
Network architecture	• Initial discussions on architectures and applications, and deploying constellations with standards and proprietaries.	• To develop a system that covers these applications. • To deploy a network of satellites that act as a bridge between sensors/users and the terrestrial core network. • To develop a 5G hub in space. • To develop a 5G NB-IoT hub in space that integrates LEO services.
IoT and 5G communication devices	• Initial checks on the use of IoT devices in CubeSats and PocketQubes.	• To apply technologies implemented on Earth in space, such as NB-IoT devices, for example. • To mitigate the conditions of the “sensor/user-satellite” radio channel, which are very different to the conditions of the terrestrial radio channel, which are the ones that were considered in the design of NB-IoT and 5G technology. • To develop devices that can cope with long distances (~1.000 km). • To develop devices that can cope with high communication speeds (~100 Mbps). • To develop antennas for connecting a large number of sensors (e.g. multi-direction antennas) • To develop communication systems for connecting a large number of users and avoiding interference (e.g. massive MIMO).
Communication protocol stack	• Establishing communications standards (e.g. 3GPP)	• To develop a large (massive) number of users for one satellite. • To develop protocols that make it possible to cope with the temporary nature of the satellite-sensor connection. • To apply cybersecurity protocols in satellite IoT

Technology	Level achieved	Future challenges
		communications paradigms. • To develop an operating system that integrates all the features in a simple and flexible way. In other words, to develop a Linux distribution for space in the future.
Communication between satellites		
ISL devices	• First prototypes tested • Low speeds • Low communication distances • Very direct emissions	• To install a commercial product. • To increase transmission speeds (~ 100 Mbps). • To increase communication distances (~4.500 km). • To increase connectivity by combining multiple ISL devices in a single platform. • To develop new technologies that mitigate the satellite channel effects (e.g. Doppler, ionosphere). • To develop communication interference mitigation techniques (e.g. MIMO).
Communication protocol stack	• Closed and well-defined architectures • Planning new more flexible routing systems • Techniques for coping with network fragmentation (e.g. DTN) • Use of mathematical models to predict network fragmentation	• To develop flexible routing systems that would enable interaction between different satellites. • To develop hybrid routing systems that would enable interaction between satellites and Earth stations. • To use artificial intelligence in detecting satellite network fragmentation. • To develop an operating system that integrates all these features in a simple and flexible way. In other words, to develop a Linux distribution for the future IoSat.
Earth Observation		
Pointing control	• Pointing control with a precision of less than 1 arcsec	• To implement missions to acquire high-resolution images (submetric).
Orbit control	• First attempts made	• To carry out orbit rendezvous and coupling operations for constructing large structures in space. • To carry out formation flying by interferometry and creating synthetic openings.
Payloads	• In recent years most payloads have been miniaturised (see Figure 14)	• To develop sensors in the X-ray, UV and SWIR bands, as well as synthetic aperture radars, altimeter radars and < 100 Ghz microwave radiometers. • To make more intensive and extensive use of SDR • To improve sensor thermal stability, calibrating precision and repeatability. • To develop large, rotating, reflecting (parabolic) antennas and mirrors. • To create distributed and fractionated systems. • To make coordinated acquisitions between payloads on different platforms (requires on-board intelligence, attitude and orbit control and communications). • To make acquisitions on request: low power sensors

Technology	Level achieved	Future challenges
		ask the satellite for the acquisition from Earth (requires wide-area , low-consumption communication e.g. NB-IoT or LoRa).
On-board computer	• First attempt to apply artificial intelligence in space (PhiSat-1 experiment on board the FSSCat mission).	• To apply AI techniques to optimise: o the acquisition o the processing o The compression of images on board
Earth segment and launchers		
Multi-node communication	• Simultaneous TM/TC with different satellites	• To implement multi-satellite connectivity services simultaneously.
Interconnected TM/TC stations	• Smart networks of interconnected stations	• To roll out services integrated into distributed networks with one or more marketing companies (Amazon Web Services/AWS business model). • To increase global coverage using fewer on-board resources.
Launchers for small satellites	• Prototypes for sustainable and reusable launchers	• To facilitate access to space in orbit and time negotiable with the client.

3. Available capacities in Catalonia

We need to analyse the differentiating factors to ensure the success of initiatives to promote NewSpace, taking the places where the most notable progress has been made as an example and taking note of those factors. Catalonia has a number of capacities that make it ideal for developing a NewSpace ecosystem. In particular, Catalonia has a firmly rooted business, technical. scientific and entrepreneurial culture where private initiative can see this new trend is an opportunity and not an eccentricity. We can therefore say that, as an emerging research and development (R&D) ecosystem, Catalonia is a region which, with more support, could be one of the potential global players in the NewSpace revolution. It is predicted that the current window of opportunity will last about three years, after which the sector will reach maturity.

Catalan presence in NewSpace currently manifests itself in R&D&I and a set of start-ups that are making headway in the space market. In the past, certain initiatives in the Old Space sector failed to come off. At the time it was a market that required a great deal of investment and strategic support to be competitive on a global scale. Now, with the arrival of NewSpace and very different economies of scale, is the time when the public administration can play an important role and become a reference player that has a pull effect on the system with the focus on mission-driven strategies that have an impact on the private sector (dual use) and encourage the appearance of new corporate-driven opportunities.

In this section we present all the Catalan entities that are developing technology linked to the NewSpace sector, which shows how much potential Catalonia has in this sector. Apart from the companies, working groups and research groups that have worked and continue to work in what we could call Old Space, today the NewSpace knowledge and R&D ecosystem is based on the following main players: the Technical University of Catalonia (UPC) and the UPC NanoSat Lab in particular; Institute of Space Studies of Catalonia (IEEC) and, more recently, the contribution of the i2CAT Foundation, Internet and -Digital Innovation in Catalonia (i2CAT), and the Catalonia Telecommunications Technology Centre (CTTC), which are contributing experience of how the new 5G services can impact on this emerging sector. That does not exclude the possibility of other players applying their expertise to the NewSpace sector.

3.1. CubeSat-based missions developed in Catalonia

The UPC NanoSat Lab,[24] part of the Specific Research Centre CommSensLab-UPC, has led the way in this field in Catalonia and, until now, has been the only body to have carried out missions based on CubeSats. It has two objectives: 1) training, from bachelor's degree to doctoral students, and 2) carrying out research projects based on doctoral theses. The NanoSat Lab's activities, led by Professor Adriano Camps, began in 2007, a time when the first projects in this field were started and which gave way to what are called the ³Cat (read as "cube-cat", paraphrasing "cube-sat"). This CubeSat family (Figure 3.1) comprises the following missions:

- **³Cat-1** (read as "cube-cat-one") is the first satellite developed in Catalonia, aimed at exploring the capacity of the CubeSat standard and integrating up to seven different payloads in 1U. The mission had three objectives: education, technology demonstrations and small scientific experiments. After three frustrated launch attempts, ³Cat-1 was finally launched with an Indian PLSV on 28 November 2018. The launch was funded by the IEEC and construction of the satellite by internal UPC funds.
- **³Cat-2** (read as "cube-cat-two") is the second (6U) satellite developed in Catalonia, and its main payload was a new GNSS (GNSS-R) signal reflectometer designed and manufactured at the UPC remote sensing laboratory. It also integrated a pointing sensor and the magnetometer designed and made at the IEEC for ESA's future LISA mission. ³Cat-2 was launched with a Chinese LMD-2 on 15 August 2016. The launch and payload were funded by the European FP7 E-GEM project (https://www.e-gem.eu/, subsidy agreement 607126), construction of the satellite by the UPC and a doctoral thesis on this by the IEEC.
- **³Cat-3** (read as "cube-cat-three") was a study carried out by the Cartographic and Geological Institute of Catalonia (ICGC) to analyse the feasibility of a mission using a small satellite (6U) with a GNSS-R reflectometer and a multispectral camera. The ICGC Strategic Plan provided for its development but that proved impossible for budgetary reasons.
- **³Cat-4** (read as "cube-cat-four") is designed to show the capabilities of nanosatellites, in particular those based on the 1U CubeSat standard for Earth observation (EO) by means

[24] <https://nanosatlab.upc.edu/en>

of GNSS reflectometry and L-band microwave radiometry, and also for Automatic Identification Services (AIS) for shipping. It was selected by the ESA Academy programme "Fly Your Satellite" and will be launched in the first quarter of 2021. The launch will be funded by ESA, while construction of the satellite has been funded by the UPC.

- **³Cat-5/A and /B** constitute the FSSCAT mission, winner of the 2017 ESA Small Satellite Challenge S^3 and Global Winner of the Copernicus Masters Competition. FSSCAT is an innovative concept consisting of two federated 6U CubeSats in support of the Copernicus Land and Marine Environment services. They carry a dual-use microwave payload and a hyperspectral optical payload, enhanced with ϕ-Sat-1, an AI model promoted by the ESA Phi-Lab. It also includes a technological demonstrator of an optical inter-satellite link (OISL) and a federated satellite system (FSS) proof of concept. ESA's FSSCat mission has a planned launch in June 2020. Both the launch and the payload have largely been funded by ESA, with UPC and IEEC participation in a grant for carrying out a doctoral thesis on the federated satellites proof of concept.

The future lab missions (³Cat-6 and ³Cat-7) have a payload that includes:

1. **³Cat-6**, in a 3U CubeSat for Earth observation, a hyperspectral camera, an L-band microwave radiometer and an experimental LoRa module based on SDR. The launch will take place on an opportunity flight in 2022.
2. **³Cat-7**, in a 6U CubeSat, a dual payload based on SDR for L5/E5-band GNSS-R reflectometry and for monitoring ionospheric glows. The launch will take place on an opportunity flight in 2021. The payload is funded by a RETOS project.

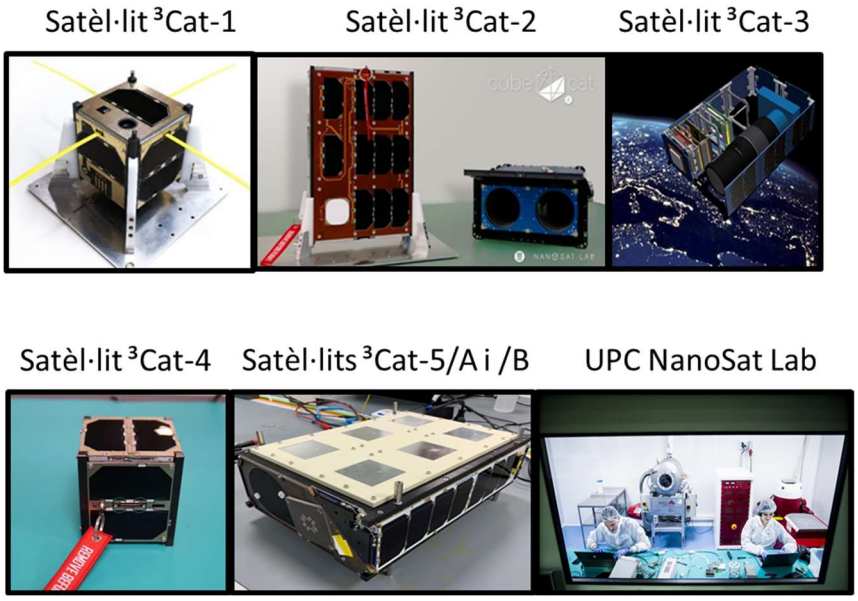

Figure 3.1. CubeSat missions developed by the NanoSat Lab.

In collaboration with the IEEC, the UPC NanoSat-Lab has developed a ground station for monitoring and controlling satellites at the IEEC' Montsec Astronomic Observatory (OAdM). This station has the necessary equipment for establishing two-way communication in the VHF

and UHF[25] bands used for the ³Cat-1 i ³Cat-2 missions. For the present, it will be used for downloading data from the FSSCat mission ³Cat-5/A satellite in the S-band frequency.

Figure 3.2. Ground station for monitoring CubeSat operations, located at the OAdM.

Besides the activity at the NanoSat Lab, other CubeSat missions have been carried out by private entities. In particular, the Barcelona-based company Aistech has launched two CubeSats: AistechSat-1 (December 2018) and AistechSat-2 (April 2019). Aistech is currently involved in the operational phase of the two satellites.

Finally, the IEEC has developed an exploitation strategy and also increased the technological maturity level of an SDR system and a high-performance on-board computer under the Government of Catalonia Knowledge Industry programme's product module. It has also been awarded the ESA-Open Cosmos Call to Orbit prize, to develop the 4DCube mission with the objective of carrying out a proof of concept on an instrument for studying space debris, with a launch planned for 2021.

3.2. Research and innovation centres

There are various research and innovation centres in Catalonia related to space in one way or another (see Table 3.1).

Table 3.1 Research centres and institutes in Catalonia with activity in the space sector applicable to NewSpace

Name	Area/Comments	Category/ Type	Website
UPC NanoSat Lab	• Measuring and testing facilities • Satellite monitoring station • Payload development • Small satellite development and operations	Space sector Earth sector	https://nanosatlab.upc.edu/en

[25]Very-high frequency and ultra-high frequency.

Name	Area/Comments	Category/ Type	Website
UPC / CommSens-Lab / Remote Sensing Lab	• Satellite data processing • Measuring and testing facilities • Payload development	Space sector Earth sector Applications	https://ars.upc.edu/ https://prs.upc.edu/ https://ors.upc.edu/
UB / ICCUB / EEB / FQA	• Payload development • Measuring and testing facilities • Satellite data processing	Space sector Earth sector Applications	http://icc.ub.edu/ https://www.ub.edu/portal/web/dp-electronica https://www.ub.edu/portal/web/dp-fquanticaastrofisica
IEEC	• Satellite monitoring station • Satellite data processing (Earth observation, astrophysics, etc.) • Payload development	Space sector Earth sector Applications	http://www.ieec.cat
I2CAT	• Development of 5G/IoT in small satellites	Applications	https://www.i2cat.net
ICGC	• Satellite image processing (optical and SAR)	Applications	https://www.icgc.cat/
CTTC	• Research on communication systems with satellites	Space sector Applications	http://www.cttc.es/
ESA BIC Barcelona	• Multidisciplinary	Cross-cutting Economic and admin support	http://www.esa.int/Space_in_Member_States/Spain/ESA_BIC_Barcelona
CREAF	• Earth Observation • Biodiversity	Applications	http://www.creaf.cat/es
SMOSBEC	• Satellite image processing (radar altimeter, SAR, optics, SMOS) • Generation of SMOS products	Applications	http://bec.icm.csic.es/data/browse-maps/
ICE/CSIC	• Satellite image processing (radar altimeter, SAR, optics, SMOS) • Remote sensing	Space sector Applications	http://www.ice.csic.es/es/inicio
UAB/CVC	• Earth Observation • Computer vision	Cross-cutting	http://www.cvc.uab.es/
IFAE	• New technologies for space missions • Multidisciplinary	Cross-cutting	http://www.ifae.es/eng/s
EURECAT	• Satellite data processing	Applications	https://eurecat.org/

Name	Area/Comments	Category/ Type	Website
	• Satellite materials research		

3.3. Technology companies ecosystem

Catalonia's aerospace industry is in a period of incipient growth, with local companies being set up and international companies moving in, to a large extent attracted by the pull of the ICT and mobile communications sector, Most of these businesses are SMEs with a limited number of workers, dedicated to data use and data processing (downstream applications). Others are the Catalan subsidiary of big companies in the Old Space sector, both Spanish and international.

Another group come from the electronic technologies sector (communications, Earth observation and navigation sensors) and they supply small systems and payloads. A recent addition is the subsidiary of a UK company set up by former UPC students to make small satellites and carry out missions. Finally, there are some companies that are trying to develop systems for putting small satellites into orbit more efficiently, which underlines the importance of assessing the possibility of using Lleida-Alguaire Airport for such activities.

At present, this incipient network of companies based in Catalonia do not form any kind of cluster, nor do they share any kind of common infrastructure, and their work is very much unconnected.

In order to analyse the sector and its companies, we have segmentalised them on the basis of their main area of work, although some supply all the sectors.

- Space segment: everything to do with developing satellites or on-board systems, as well as developing payloads or integrating satellite platforms and putting them into operation.
- Earth segment: the key element here is the development of monitoring stations (teleports) for satellite control and reception, as well as their software. For big missions, there are already companies solely dedicated to those tasks (e.g. KSAT,[26] SSC[27]), but for small satellite constellations other companies have their own ground stations (e.g. Aistech), make use of university ground stations (e.g. the IEEC-UPC station at Montsec) or hire the services of third parties (e.g. Spire which uses Amazon Web Services AWS).[28]
- Launcher segment: companies in the launch field have added value in increasing the flexibility and reducing the launch costs of small satellites by means of innovative techniques which make the most of this new smaller and lighter satellite model. In this context, the European Commission's H2020 programme has promoted innovative concepts for low-cost launch services for mini-, micro- and nanosatellites, and advanced concepts for building launch systems and infrastructures.

[26] <https://www.ksat.no/>
[27] <https://www.sscspace.com/ssc-worldwide/ground-station-network/>
[28] <https://aws.amazon.com/es/ground-station/>

There follows a list of the main companies based in Catalonia with their areas of interest.

Table 3.2 Space segment companies (in alphabetic order)

Company name	Area/Comments	Category/Type	Website
ADTelecom	• RF and microwaves, digital electronics, photonics, DSP, SDR	Space segment Design of RF circuits for payloads	http://www.adtelecom.es/
AisTech Space	• AIS, IoT/M2M, imaging • Proprietor, integrator and operator of GomSpace ADS-B and IoT satellites • GomSpace ADS-B and IoT satellite operators, with own ground station	Space segment Applications	https://aistechspace.com/
AsgardSpace	• Satellite monitoring and data positioning	Earth segment Applications	http://asgard-space.com/
Balam Ingeniería de Sistemas	• RF and microwaves • Radiometers, GNSS-R and radar • Applications: ground, rover, airborne and spaceborne	Space segment Design of RF circuits for payloads	https://www.balamis.com/
Celestia Aerospace	• CubeSat launches from adapted MIG 29	Launcher segment	https://celestiaaerospace.com/
DAPCOM Data Services	• On-board data compression • Earth data processing	Space segment Earth segment	https://www.dapcom.es
Dares	• Data processing • Applications	Earth segment Applications	http://dares.tech/
Everis	• Communications and intelligence • IoT (tests with PocketQubes)	Applications	https://www.everis.com/global/en/industries/aerospace-defense
GMV	• Software engineering, communications, control and navigation	Earth segment Old Space	https://www.gmv.com/en/
GTD	• Software engineering, communications and control	Space segment Earth segment Old Space	https://www.gtd.es/es

Company name	Area/Comments	Category/Type	Website
INDRA	• Communications, space monitoring and surveillance	Earth segment Old Space	https://www.indracompany.com/es/space
isardSAT	• Development of data processing algorithms for on-board and Earth-based microwave sensors • Applications	Earth segment Applications Space segment (SW)	https://www.isardSAT.cat/
MITIC Solutions	• Interference cancellation systems for navigation systems	Earth segment Applications	https://miticsolutions.com
Open Cosmos	• Integrated CubeSat platforms and turnkey missions	Space segment	https://open-cosmos.com/
Pangea	• Reusable rockets for small satellites	Launcher segment	https://pangeaaerospace.com/
ROKUBUN	• Navigation	Earth segment Applications	https://www.rokubun.cat/
Sateliot	• Proprietor and operator of Open Cosmos IoT satellites	Operator Earth segment Applications	https://sateliot.space/
Satellogic	• Operates satellites with hyperspectral satellites	Space segment Operator Applications	https://satellogic.com/contact/
SpaceSur	• Data processing • Applications	Earth segment Applications	https://www.spacesur.com/
Starlab	• Data processing • Applications	Earth segment Applications	https://www.starlab.es/
Tryo Aerospace / SENER	• RF and microwave subsystems	Space segment Earth segment Old Space	https://www.tryo.es/
VerasatGlobal	• Communications via satellite • Applications	Earth segment Applications	https://www.verasatglobal.com
Zero2Infinity	• Small satellite launches from stratospheric balloons	Launcher segment	http://www.zero2infinity.space/bloostar/
Pildo	• Satellite data processing	Applications	https://pildo.com/
Lobelia	• Satellite data processing	Applications	https://www.lobelia.earth/es

Company name	Area/Comments	Category/Type	Website
Nearspacelabs	• Satellite data processing • Stratospheric balloon launches	Applications	https://www.nearspacelabs.com/
Airbus DS Geo SGSA	• Satellite data processing	Applications	https://www.intelligence-airbusds.com/

3.4. Companies with potential synergies with the space sector

Various Catalan companies are carrying out tasks that are essential for the development of NewSpace but not focused on satellite development. The following table presents this set of companies which show synergies with the space sector, based on available data.

Table 3.3 Companies with products and services of interest to the space sector (in alphabetic order)

Company name	Area/Comments	Potential synergy	Website
2CISA	• Make printed circuit boards (PCBs) • Urgent PCBs with short delivery times	PCBs for satellite payloads or subsystems	https://www.2cisa.com 2cisa.com
CIM-UPC	• Verification of machined parts with MMC • Product approval • Production of mechanical parts • Generation of CAD files from a physical model • Digitalisation of parts and comparison with a 3D model • Rugosity measurement in 2D and 3D	Structures for satellites	https://www.fundaciocim.org/es
Broncesval	• Precision aluminium	Structures for satellites	https://www.broncesval.com/ broncesval.com
ELHCO	• Chemical treatment of aluminium	Structures for satellites	https://elhco.com/ elhco.com
Gutmar	• Precision mechanics	Structures for satellites	http://www.gutmar.com/ gutmar.com
Lab Circuits	• Make printed circuit boards (PCBs)	PCBs for satellite payloads or subsystems	https://www.lab-circuits.com/ lab-circuits.com

Company name	Area/Comments	Potential synergy	Website
Rierge	• CNC machined aluminium	Structures for satellites	http://rierge.com/ rierge.com

3.5. Scientific and technological facilities

Catalonia has most of the infrastructures that enable the trials required for space equipment testing and qualification to be carried out, although they are dispersed and not always easily accessible. Moreover there are centres with the equipment for producing and integrating nanosatellite components. Finally, it is also possible to find other equipment in the Catalan centres that is geared towards monitoring and controlling satellites once they are in orbit. Table 3.4, below, provides information on these centres and their facilities.

Table 3.4 Facilities relevant to NewSpace in the Catalonia's various centres

Centre name	Facilities	Website
UPC Nano Sat Lab	• Clean room ISO 7 • Thermal vacuum chamber (TVAC) for 6U CubeSats • Equipment for verifying the pointing control system • Equipment that emulates the solar beam • Vibration table to emulate launches • Ground station for monitoring and controlling satellites by different frequency bands	https://nanosatlab.upc.edu/en/facilities-folder
UPC	• Anechoic chamber for measuring and characterising antennas • Faraday chamber for testing radiated emissions from equipment • Vibration table • RF diagnosis chamber (electromagnetic fields) • Satellite monitoring station (Terrassa School of Aeronautical Engineering) • Source of radioactive cobalt for testing radiation • 5G and IoT laboratories for carrying out proofs of content • Design and construction of mechanical prototypes • Design, production and assembly of electronic prototypes	https://www.upc.edu/ca
UB	• Surface analysis equipment • Design and construction of mechanical prototypes • Design and construction of vacuum chambers • Design, production and assembly of electronic prototypes • Clean room ISO 7	https://www.ub.edu

Centre name	Facilities	Website
UAB	• Biological samples irradiation service • X-ray diffraction service (single-crystal and powder) • Microscopy service for various fields of research	https://www.uab.cat
CSIC: CNM / ICM / ICE	• Radiation laboratory for characterising sensors and electronic devices • Two clean rooms (ISO 7 and ISO 8) with an ISO 5 booth and environmental control systems	https://www.csic.es/
IEEC	• Support to the NanoSat Lab at the UPC, the IEEC-UPC clean room, the IEEC-CSIC labs and ICC labs at the UB, as well as the CERES labs at the UAB campus • Montsec Astronomic Observatory (OAdM) operations management • Development of the technology required for detecting space debris	http://www.ieec.cat
UPC - IEEC	• Ground station for monitoring and controlling satellites by different frequency bands at the OAdM	https://nanosatlab.upc.edu/en/facilities-folder/ground-segment
ICGC	• Three of its own planes at Barcelona Airport • Photogrammetric and hyperspectral airborne sensors • Sensor calibration laboratory • Network of over 15 positioning stations • Own calculation centres using dedicated servers	https://www.icgc.cat/
LGAI center	• Manufacturers of space industry components • Mechanical testing facilities • Materials testing facilities • Structural testing facilities	https://www.appluslaboratories.com/global/en/

4. NewSpace sector in Spain and Europe

The European space industry is one of the most competitive in the world. Directly or indirectly it gives work to 231,000 people, accounts for 6% to 9% of the EU economy and generates added value estimated at between €53 billion and €62 billion.[29] All that in an international context which according to the Euroconsult report "Prospects for Space Research"[30] means that in the 2020s global government investment in space will be $260 billion. A third of all satellites are made in Europe. Thus, the activity in this sector has been led by various European countries. As will be seen in this document, some of these countries stand out for developing NewSpace in their structures and are becoming important players in the sector.

As far as Spain is concerned, the governments of various autonomous communities, such as Galicia, the Canary Islands, Andalusia and Valencia, are already clearly committed to this sector. The Community of Madrid should be considered a case apart, as it can rely on the implicit support of other central government bodies and the head offices of large companies in their region.

This chapter offers an overall view of the state of NewSpace in various European countries and the Spanish State, excluding Catalonia, which has been outlined above in Chapter 3.

4.1. Universities

Picosatellite and nanosatellite projects are currently in vogue in universities, since they offer students a rapid learning curve, as well as training them in critical engineering systems, and this learning can later be applied to any area (telecommunications, structures, electronics, and so on). The reduced cost of commercial systems, even if they are not prepared for space, mean many universities can implement preliminary systems based on products regularly used by the sensor or telephony industry.

4.1.1. Universities in the Spanish State

There are a set of universities in Spain that are working in the space field in general and which have developed missions linked to satellites.

Table 4.1 Spanish universities with activity in the NewSpace sector

University	Area of knowledge/Comments	Autonomous community	Website
University of Granada	GranaSat. Educational project	Andalusia	https://granasat.ugr.es/

[29] Euronews report https://actualidadaeroespacial.com/la-industria-espacial-de-la-ue-se-estima-en-hasta-62-000-millones-de-euros/
[30] < https://gisuser.com/2020/04/prospects-for-space-exploration-2020-edition/>

University	Area of knowledge/Comments	Autonomous community	Website
University of Cádiz	UCanFly. Nanosatellite, participant in the "Fly Your Satellite!" programme (third edition)	Andalusia	https://ucanfly.uca.es/
University of Vigo.	XatCobeo, HumSat-D Both satellites launched successfully	Galicia	https://www.uvigo.gal/es
Polytechnic University of Madrid.*	QBito – Launched successfully UPMSat-1 and UPMSat-2	Madrid	http://www.upm.es

(*Universities that have carried out CubeSat launches)

4.1.2. Universities in Europe

From a European point of view, and with the aim of having list of leading universities as regards developing nanosatellite missions, we have only included those that have had some relation with ESA's Fly Your Satellite! Programme in the table. This programme is part of the Agency's academic programme and is based on support from various universities in the form of free consulting and project monitoring. Universities that can complete the programme get a completely free nanosatellite launch. ESA has so far held three editions of Fly Your Satellite(FYS): FYS I, in 2013-2016, FYS II, from 2017 to 2020/2021, and FYS III, just starting in 2020.

Table 4.2 European universities with known activity in the NewSpace sector

University	Area of knowledge/Comments	Country	Website
Surrey Space Centre, University of Surrey	• One of the "veteran" universities in the world of small satellites in Europe (from 1979) • SSTL: company derived from the University of Surrey. • ~40 satellites launched	United Kingdom	https://www.surrey.ac.uk/surrey-space-centre/about
University of Stuttgart	• Finalists in the FYS III programme	Germany	https://www.uni-stuttgart.de/en/
University of Warwick	• Finalists in the FYS III programme	United Kingdom	https://warwick.ac.uk
University of Southampton	• Participants in the FYS II programme	United Kingdom	https://www.southampton.ac.uk/

University	Area of knowledge/Comments	Country	Website
University College Dublin	• Ireland's first satellite, part of the FYS II programme	Ireland	https://www.ucd.ie/
TU Berlin*	• One of the oldest universities in the world of small satellites in Europe • Satellite families TUBSat and BEESat.	Germany	https://www.raumfahrttechnik.tu-berlin.de/menue/research/tubsat_missions/parameter/en/
University of Montpelier	• Participants in the FYS II programme	France	https://www.umontpellier.fr
ISAE-SUPAERO	• Finalists in the FYS II programme	France	https://www.isae-supaero.fr
KTH Royal Institute of Technology	• Finalists in the FYS III programme	Sweden	https://www.kth.se/en
	• Participants in the FYS III programme	Finland	https://www.aalto.fi/en
Aalborg University*	• Participants in FYS I who went on to set up GomSpace	Denmark	https://www.en.aau.dk
University of Liege	• Finalists in the FYS II programme	Belgium	https://www.uliege.be
Delft University of Technology*	• ISISpace: company derived from the university	Netherlands	https://www.tudelft.nl/
University of Applied Sciences Wiener Neustadt	• Finalists in the FYS III programme	Austria	https://www.fhwn.ac.at
La Sapienza Università di Roma*	• Participants in the FYS II programme	Italy	https://www.uniroma1.it/it/pagina-strutturale/home
Politecnico di Torino*	• Participants in FYS I, now part of Tyvak Int. in Turin	Italy	https://www.polito.it/
Instituto Superior Técnico Lisboa	• Portugal s first nanosatellite, part of the FYS II programme	Portugal	https://tecnico.ulisboa.pt
Aristotle University of Thessaloniki	• Participants in the FYS III programme	Greece	https://www.auth.gr/en

(*Universities that have carried out CubeSat launches)

The following map shows the location of the various universities presented above in Europe and Spain.

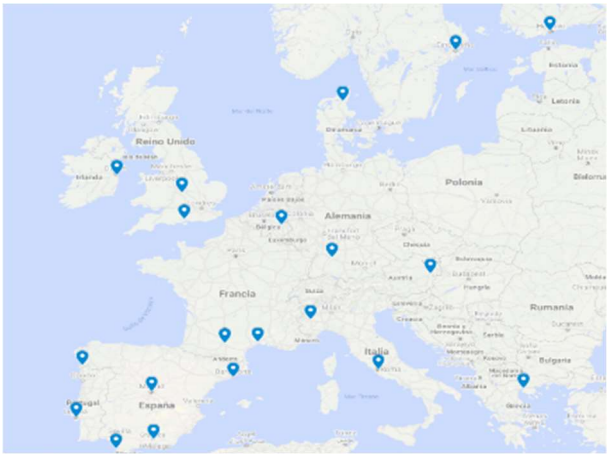

Figure 4.1. Location in Europe and Spain of the various universities with branches of activity in the NewSpace area and/or direct participation in the European programmes linked to NewSpace

4.2. Research and innovation centres

4.2.1. Research and innovation centres in the Spanish State

The research and innovation centres in the Spanish State include both research institutes, directly dependent on public institutions, and technological development centres, private or dependent on other European institutions. One centre that stands out is the National Institute of Aerospace Technology (INTA), which is linked to the University of Vigo for the conception, creation and start-up of the Xatcobeo programme, driven by the Autonomous Community of Galicia as the Spanish benchmark in nanosatellite development.

Table 4.3Research and innovation centres devoted to NewSpace in the Spanish State

Centre name	Area/Comments	Category/ Type	Autonomous community	Website
National Institute of Aerospace Technology	• Development of defence satellite missions • Instruments for interplanetary missions (Mars)	Space segment	Madrid/ State	http://www.inta.es
Higher Scientific Research Council	• Support for scientific and technological development • Nanomaterials and nanotechnology • Funding, projects	Cross-cutting Economic and admin support	Madrid/ State	http://www.csic.es
Aerospace Innovation and Engineering Centre	• Business incubator • Support for developing aerospace technology	Cross-cutting Economic and admin support	Andalusia	http://aeropolis.es/centro-de-ingenieria-e-innovacion-aeroespacial_ii1.html

Centre name	Area/Comments	Category/ Type	Autonomous community	Website
Centre for Advanced Aerospace Technologies (CATEC)	• Project funding • Automation and robotics • Test bench • UAV platforms • GNSS simulation • Industrial IoT	Space segment Applications	Madrid	http://www.catec.aero/es
ESA BIC Madrid	• Business incubator	Cross-cutting Economic and admin support	Madrid	http://www.esa.int/Space_in_Member_States/Spain/ESA_BIC_Comunidad_de_Madrid
Centre for the Development of Industrial Technology (CDTI)	• Project funding	Cross-cutting Economic and admin support	Madrid/ State	https://www.cdti.es

4.2.2. Research and innovation centres in Europe

There is an important ecosystem of research centres that allocate a large amount of resources to nurturing important Earth exploration and space research missions of the world's main space research agencies.

These centres receive public funding from their national governments and also project funding from the agencies mentioned above. The following table includes some of those institutions which are currently working in the NewSpace field, both funding projects and developing modules or missions.

Table 4.4. Research and innovation centres devoted to NewSpace in Europe

Organisation name	Area/Comments	Category/ Type	Country	Website
Centre National d'Études Spatiales	• French government body in charge of national space development • Support for launchers • Support for the Earth sector with monitoring stations	Space segment Earth segment Launcher segment	France	https://cnes.fr
Institut National des Sciences	• Earth observation missions and multi-constellation communications with	Space segment	France	http://www.insa-toulouse.fr/

Organisation name	Area/Comments	Category/ Type	Country	Website
Appliquées Toulouse	nanosatellites			
Luxembourg Space Resources Research Centre	• Communications, IoT and nanosatellite synchronisation missions	Space segment Applications	Luxembourg	https://space-agency.public.lu/en.html
Group of Astrodynamics for the Use of Space Systems	• Development of equipment for low-cost nanosatellites • Mission design services	Space segment	Italy	https://www.gaussteam.com
Space Research Centre - University of Leicester	• Development of instruments, critical systems and payloads for ESA and NASA missions (BepiColombo, JWST)	Space segment	Leicester	https://le.ac.uk/physic
Space Research Centre of Polish Academy of Sciences	• Space research in general, the solar system and the Earth • Design of observation instruments for various ESA and NASA missions	Space segment	Poland	https://www.cbk.waw.pl/en/
Institute for Systems and Computer Engineering, Technology and Science - Portugal	• Business incubator • A consortium of businesses and universities committed to nanosatellites	Cross-cutting	Portugal	https://www.inesctec.pt/en
Satellite Applications Catapult	• Researching new technologies • Exploring new applications	Applications	United Kingdom	https://sa.catapult.org.uk/

4.3. Companies and clusters

This section looks at the situation of the industrial ecosystem with a map of the main companies carrying out a task that is directly related to the space sector and developing hardware or software for platforms, payloads, launch platforms or satellite control and operational units for agencies as well as other companies in the sector.

4.3.1. Companies in the Spanish State

Private companies are one of the fundamental pillars of the space sector. The Spanish Association of Defence, Aeronautics and Space Technology companies (TEDAE) includes

Spanish technology companies with a presence in those three areas of activity. This non-profit association was set up to promote and safeguard the general interests of its members, supporting them in the commercial and industrial aspects of their activity, facilitating their relations with national and supranational public administration bodies and contributing towards their development. This promotion has resulted in increased activity in the space sector. The figures available for the financial year 2018 show a business fabric in Spain with a turnover of €11.838 billion that exports 66% of its products and services and contribute 1% to GDP. Furthermore, the Association allocates 9% of its turnover to R&D&I, a much higher percentage than that of other sectors.

Traditionally, the companies in this sector in the Spanish State have been grouped in geographic clusters. The most important of these are in Madrid, the Basque Country and Seville. Years ago, Catalonia had its own aerospace cluster based in Barcelona but various factors led to its break-up and the loss of what should have been an important coordination centre for activities in this sector. However, for some years now, emphasis has been put on the existence and importance of NewSpace, resulting in various conferences and initiatives, such as the one on the NewSpace Economy, organised by the Barcelona Chamber of Commerce in February 2020.

As can be seen in Table 4.5, there are nearly a dozen companies in the Spanish State that are related to this new sector in some way. For the most part, these are companies that want to offer end users a service based on a nanosatellite constellation. Generically speaking, all of them design or are planning to design part of the satellite hardware and software. Only those companies coming from the Old Space concept, and currently undergoing change, do not have a general vision.

Table 4.5 Companies with NewSpace sections or which are solely dedicated to NewSpace in Spain

Company name	**Area/Comments**	**Category/Type**	**Autonomous community**	**Website**
Deimos	• Microsatellite platforms • Data processing platforms	Space segment Earth segment Applications	Madrid	https://elecnor-deimos.com/es/
GTD	• Software engineering, communications and control	Space segment Earth segment Old Space	Madrid, Andalusia and Catalonia	https://www.gtd.es/es
Everis	• Communications and intelligence • IoT (tests with PocketQubes)	Applications	Centres all over Spain	https://www.everis.com/global/en/industries/aerospace-defense
Fossa Systems	• Picosatellites platform	Space segment	Madrid	https://fossa.systems/es/home-spanish/

Company name	Area/Comments	Category/Type	Autonomous community	Website
AMSAT-EA	• Radio enthusiast satellites	Space segment	Madrid	https://www.amsat-ea.org/
Karten Space	• Earth observation through nanosatellite constellations	Space segment Applications	Basque Country	https://kartenspace.com/
Alen Space	• Development of communications systems for nanosatellites	Space segment	Galicia	https://alen.space/es/inicio/
Solar Mems	• Nanosatellite determination sensors	Space segment	Andalusia	http://www.solar-mems.com/
PLD-Space	• Low-cost satellite launcher	Space segment	Autonomous Community of Valencia	https://pldspace.com/es/

As a final point, the following map shows the location of various companies currently carrying out activities directly related to NewSpace in Europe. As you can see on the map, Catalonia and Barcelona in particular, currently has very important group of companies that are wholly or partially connected with NewSpace. In Section 3.3 you can find more information on the NewSpace companies in Catalonia.

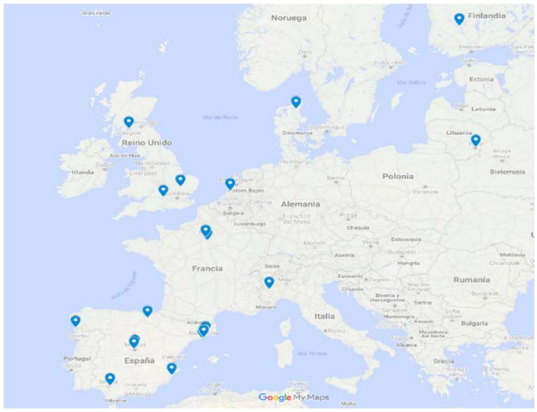

Figure 4.2 Location of the various companies in Spain and Europe activity branches in NewSpace.

4.3.2. Companies in Europe

Like the Spanish State, Europe has a network of Old Space companies, a very big one largely dependent on contracts with ESA for Earth or solar system observation projects or services and on private satellite communications companies. This web of companies is immense and present in almost all European companies.

As regards NewSpace in Europe, there are now more companies offering platforms and payload integration services. This is a very important difference compared to Spain as these players, listed in the following table, provide services that enable the end user to concentrate on data processing or the application they want to offer. This ecosystem has helped the appearance of companies devoted to creating sensors or module with specific goals. And Europe's non-generalist ecosystem has encouraged the appearance of a competent NewSpace ecosystem. However, there is a clear lack of companies that can support the concept of missions in general or that of constellation-based missions. Not only from the point of view of mission design but also in putting the constellation itself into operation. The following table includes some of the more important companies in Europe's NewSpace sector.

Table 4.6 Leading companies in the European Union linked to the space sector

Company name	Area/Comments	Category/Type	Country	Website
Tyvak International	• Nanosatellite platform designer • Operator • Launch integrator	Space segment Launch sector	Italy	https://www.tyvak.eu/
ISISpace	• Nanosatellite platform designer • Operator • Launch integrator	Space segment Launch sector	Netherlands	https://www.isispace.nl/
GomSpace	• Nanosatellite platform designer • Operator • Launch integrator	Space segment Launch sector	Denmark	https://gomspace.com/
NanoAvionics	• Nanosatellite platform designer	Space segment	Lithuania	https://nanoavionics.com/
ClydeSpace	• Nanosatellite platform designer • Operator	Space segment	United Kingdom	https://www.aac-clyde.space/
Lacuna Space	• IoT sensor developer for communications with space	Applications	United Kingdom	https://lacuna.space/
Dassault Systems	• 3D design	Space segment	France	https://www.3ds.com/es/
Airbus	• Payloads • Communications • Platforms • Satellite navigation systems • Systems integrators	Space segment Earth segment	France (multiple headquarters in Europe)	https://www.airbus.com/space.html

Company name	Area/Comments	Category/Type	Country	Website
Thales	• Payloads • Communications • Platforms • Satellite navigation systems • Systems integrators	Space segment Earth segment	France (multiple headquarters in Europe)	https://www.thalesgroup.com/en/global/activities/space
OHB	• Earth Observation payloads • Communications • Platforms • Satellite navigation systems • Systems integrators • Flight systems • Crewed flight	Space segment Earth segment	Germany	https://www.ohb-system.de/program.html
ArianeSpace	• Leading EU launcher • Large payloads • Module designer for launching small satellites (SSMS)	Launcher segment	France	https://www.arianespace.com/
IceEye	• SAR developer for microsatellites	Space segment Applications	Finland	https://www.iceye.com/
Eutelsat	• IoT sensor developer for communications with space	Applications	France	https://www.eutelsat.com
Hiber	• IoT sensor developer for communications with space	Applications	Netherlands	https://hiber.global/
Kineis	• IoT sensor developer for communications with space	Applications	France	https://www.kineis.com/

4.4. Public administrations

The public sector has been a key player in leveraging the development of the space sector, especially in the Old Space sphere led by institutional missions promoted by national states or international bodies. Likewise, there is a very well established market for satellite communications and broadcasting system, which also sustains the productive sector. This section outlines the public sector structures that support the development of space sector programmes and projects in Spain and Europe.

4.4.1. Public administrations in the European sphere

On European level there are two key large structures in the public sector sphere that provide support for developing space programmes and projects:

I) European Space Agency (ESA)

ESA was set up to coordinate the efforts in space-related matters of those European countries with space capabilities and to orchestrate a system of investment in the sector that would yield a return for the companies in each country and benefits for citizens as a whole. Currently it comprises 22 members, for the most part from the European Union, and has collaboration agreements with nine other states. Likewise, it works extremely closely with other international agencies, including NASA, Roscosmos and Jaxa. ESA develops a wide range of launchers, satellites and scientific missions, besides participating in crewed flights and Earth segment activities, with the Kourou spaceport in French Guyana.

ESA's main mission is draw up and carry out Europe's space programme. In fact there are two types of programmes: the mandatory ones, which include those linked to science and technological developments, and the optional ones, in which states decide their participation. A key element in deciding the participation of member states is GeoReturn. This is the mechanism by which the companies of a member country receive a certain workload proportional to that country's contribution to ESA.

ESA employs approximately 2,200 people. Its head office is in Paris and it has representative and coordination offices in the United States, Russia and Belgium. It also has series of centres spread around Europe's geographical area:

- EAC: European Astronauts Centre, in Cologne (Germany).
- ESAC: European Space Astronomy Centre, in Villanueva de la Cañada, Madrid.
- ESOC: European Space Operations Centre, in Darmstadt (Germany).
- ESRIN: European Space Research Institute. ESA Centre for Earth Observation, in Frascati, near Rome, (Italy).
- ESTEC: European Space Research and Technology Centre, in Noordwijk (Holland)
- ECSAT: European Centre for Space Applications and Telecommunications, in Oxfordshire (United Kingdom).
- ESA Centre in Redu, Belgium.

One of the key aspects for ESA is being able to have a solvent budget that allows it to carry out its activities. A record budget of €14.4 billion is planned for the period 2020 to 2026. Spain will contribute €1.543 billion in that period, representing an increase of €586.7 million on the previous period. It is worth remembering this upward trend means considerable support for Spanish companies and ESA's activity. And it makes Spain the Agency's fifth largest contributor. It should also be borne in mind that besides ESA's own resources, the annual budgets are increased by contributions from third parties, with the European Union being one of the main contributors.

ESA's governing body is the Council, which provides the basic political directives that the Agency bases itself on. Each of the member states is represented on the Council by one vote, regardless of its size or financial contribution. The Agency is headed by a Director General who is chosen by the Council every four years. Each research section is independent of the Agency Management ,which is responsible to the Director General.

II) European Commission

Apart from the ESA's activities, the European Union (EU) itself, aware of space's importance to the continent, joined in the initiatives in this field and currently has a programme with initiatives such as the well-known Galileu, EGNOS and Copernicus programmes. The European Commission. (EC) is in charge of managing this programme, in close collaboration with ESA. We need to keep in mind that ESA is an intergovernmental organisation, while the EC is a supranational body. They are two different organisations which collaborate in achieving common objectives. In effect, both institutions have different levels of competences, different member states and are governed by different rules and procedures.

Thanks to the application of flagship programmes and the support offered by EU research and innovation programmes, in particular the multi-year Framework Programme, around 20% of the funds managed by ESA come from the EU budget. The legal basis for the cooperation between the EC and ESA is a framework agreement which came into force in May 2004. In recent years, the two institutions have made an effort to strengthen their cooperation in light of global developments that affect the European space sector.

The overall goals of the European Commission's Space Strategy for Europe are to:

1. Maximise the benefits of space for society and the EU economy by promoting the use of European services and improving access to space data for start-ups. This is a sphere in which there is ample room for developing the NewSpace economy.
2. Ensure a globally competitive and innovative European space sector, by making it easier for companies to access space data by means of specialised platforms. Promote more private investment for start-ups, in particular in the context of the Investment Plan for Europe and the Pan-European for Venture Capital Fund.
3. Reinforce Europe's autonomy for accessing space in a safe and secure environment, by supporting the development of cost-effective, reliable and competitive European launchers.
4. Strengthen Europe's role as a global player and promote international cooperation.

4.4.2. Public administrations in the Spanish sphere

Having looked at the two main structures in the space sphere in Europe, it is important to move onto the Spanish State to see which are the main entities linked to the space sphere here. It should be borne in mind that Spain is part of the EU and ESA, so everything said about them is directly applicable. In the administrative sphere, the structure of the Spanish State geared towards space activity is centralised in four centres/institutions.

I) Centre for the Development of Industrial Technology (CDTI)

The CDTI is a public business organisation attached to the Ministry of Science and Innovation, which promotes innovation and technological development in Spanish companies. It channels the applications of Spanish centres and companies for grants and support for their R&D&I projects in the Spanish and international spheres. It also manages and offers support in securing industrial contracts with a high technological content generated by various national and European organisations, such as ESA or the European Organisation for Nuclear Research (CERN), among others. Historically, it has been playing the role of Spain's representative in ESA.

II) National Institute of Aerospace Technology (INTA)

INTA is the public research body responsible to the Ministry of Defence. In addition to carrying out scientific research and systems and prototypes development activities in its sphere of knowledge, it provides technological services to businesses, universities and institutions. The Institute specialises in technological research in aeronautics, space, hydrodynamics, security and defence. Its organisational structure includes the General Subdirectorate of Space Systems. Traditionally it has been the body that has maintained relations with NASA and managed the Madrid Deep Space Communications Complex (MDSCC) in Robledo de Chavela. It has also taken part in space mission such as the NASA Apollo missions.

INTA's main functions include:

- Carrying out various kinds of tests to check and certify materials, components, equipment, systems and subsystems.
- Providing technical advice and services to official bodies and entities, as well as industrial or technological companies.
- Acting as the Ministry of Defence technology centre.

III) Interministerial Committee for Industrial and Technological Space Policy

As is well-known, Spain does not have a unified body that could act as a "space agency". Consequently an inter-ministerial cooperation body was set up to fill this gap. That is the task of the Interministerial Committee for Space Industrial and Technological Policy. It is attached to the Ministry of Industry, Energy and Tourism and is composed of representatives of the different bodies with powers or interests in space activity. It's first agreement was to design a national strategy for the space sector up to 2020.

IV) National Aerospace Security Council

Recently (in March 2020) the Spanish Government set up the National Aerospace Security Council in order to link state security to the various space activities carried out on the ground. This shows the importance attached to this sector and which it has from a strategic point of view.

The National Aerospace Security Strategy is an important document for the space sector as it provides for a series of elements that can all be extrapolated to the NewSpace Strategy, with the due adaptations and corresponding competence nuances:

1) It regards space as a single sphere in terms of aerospace security as there are no physical limits between aerospace and outer space.

2) Aerospace is governed by the concept of national sovereignty and outer space is regarded as the common heritage of all humanity.

3) NewSpace players are looking for new business models beyond Earth and in some cases challenge state capacity to legislate over outer space.

4) The aerospace sphere is growing rapidly and continuously and is based on infrastructures regarded as critical, given the high dependence of modern-day societies on them.

5) It establishes that Spanish administration management of space policy and coordination and collaboration between ministerial departments will be regulated by the following coordination committees:

a. The Interministerial Committee for Global Navigation Satellite Systems
b. The Steering Committee of the National Earth Observation Programme
c. The Interministerial Committee for Industrial and Technological Space Policy
d. The Interministerial Monitoring Committee for Surveillance Systems and Space Tracking

6) Space is profitable for the State, society as a whole and industry.

7) The space sector is weakly regulated, except for telecommunications. One of the challenges, therefore, is to equip it with a regulatory framework accepted and ratified by all states, taking into account that the major international treaties date from the Cold War era and, in any event, preceded the sudden appearance of new players under the NewSpace concept.

8) When Spain ratifies international treaties on space matters, the State has subsidiary responsibility for any activities that may be carried out by its nationals (natural or legal persons and public bodies, which is why it is necessary to regulate space activities that may be carried out by non-state operators).

All the points mentioned above are important but it should be borne in mind that they merely describe how the system of powers work and the role of international legislation regulating space matters. The subject of international treaties is the State as such, not private companies carrying out a space activity or a specific administration within the State. Given it is the subject, it is responsible to third parties (other states) for national activities that could imply damage or injury. Consequently, this architecture has to be provided for and be as effective as possible in reducing the possibilities of risks, as that would ensure having the necessary authorisation to carry out space activities, especially those linked to launch, re-entry (if applicable) and use of the radioelectric spectrum.

However, the competence sphere for promoting scientific, business and technological activity is basically limitless for any other administration as it will coordinate the aforementioned activities with the competent authority.

4.5. European NewSpace support programmes

It is possible to find a variety of programmes in the European sphere that are devoted to promoting nanosatellite development and the corresponding missions. On that point, the two main generators of European R&D&I projects are ESA and the EC (described in Section

4.4.1). This section offers information on the different programmes offered by these two organisations.

4.5.1. ESA programmes

ESA has started to use CubeSat platforms as essential tools for demonstrating new miniaturised technologies in orbit, carrying out specific, limited-action missions and for training (carried out by ESA Education). Its interest in small satellites stems from the fact that these satellites have already demonstrated their value for such missions and offer the possibility of rolling out various promising applications. For ESA, therefore, these platforms are key to their space programme for the following reasons:

- They are a driver for system miniaturisation and a totally new approach to assembling and integrating these systems.
- They are an affordable means of testing new technologies and new techniques such as formation flying.
- They are an opportunity to carry out multiple Earth measuring operations simultaneously in various points in space.
- They are a means of deploying small payloads such as very compact radio receivers or optical cameras in lots of satellites.
- They are a means of stepping up exploration of the solar system.

Since 2013, ESA has initiated various CubeSat missions funded under the technological demonstration framework of the General Technological Support Programme. The projects funded are as follows:

- GOMX-3: a 3U CubeSat mission to test the reception of plane signals and measure the quality of the signal emitted by GEO telecommunications satellites. It was launched from the International Space Station on 5 October 2015 and re-entered the Earth's atmosphere after a year of successful operations.
- GOMX-4: a mission involving 2 6U CubeSats to test inter-satellite links (ISLs) and propulsion technologies for formation flights. The mission carried additional payloads for Earth Observation (EO) It is still operational, compiling data on its long-term performance and carrying out additional experiments

The following missions are currently being prepared in this funding programme:

- QARMAN: a 3U CubeSat mission to demonstrate the usability of a CubeSat platform as an atmospheric entry vehicle.
- SIMBA: a 3U CubeSat mission to measure the climate variables linked to solar irradiance and the balance of radiation to the Earth.
- PICASSO: a 3U CubeSat mission to measure the distribution of stratospheric ozone, the mesospheric temperature profile and electron density in the ionosphere.
- RADCUBE: a 3U CubeSat mission to test miniaturised instrument technologies for measuring space radiation and the magnetic field in LEO orbit.
- PRETTY: a 3U CubeSat mission to test new techniques for detecting sea ice.

- GOMX-5: will implement technologies related to future generations of constellations with 12U CubeSats, which include electronic propulsion, communication between high-speed satellites, a new high-speed transmitter and a high-pressure positioning receiver.
- M-ARGO: an autonomous 12U CubeSat capable of meeting objects close to Earth (asteroids).

It is important to stress that the countries that have led these ESA programmes are basically Denmark and Belgium, although there are other important players such as the United Kingdom, Germany, France, Italy, Luxembourg and Lithuania. In the Earth Observation Programme, the first and only mission approved so far is FSSCat, proposed by the UPC, which received the ESA Sentinel Small Satellite (S^3) Challenge award and the top prize in the Copernicus Masters Competition in 2017. FSSCat consists of two small 6U satellites that provide data on ice extent, ice thickness and soil moisture. The satellites will compile data to supplement the European Copernicus system and, in particular, to support the land and marine environment services. FSSCat also includes a link between radio and optical satellites to test some of the techniques and technologies of future satellite constellations It could be the precursor of a constellation of small Earth Observation satellites, achieving a high temporal resolution and a moderate spacial resolution in a cost-effective manner. The FSSCat CubeSats will be put into orbit with a Vega launcher and the launch is planned for the end of June 2020.

In addition to the above, ESA also manages two other programmes. One is the Φ-lab, which is part of ESA's Earth Observation Programme's Φ-department developing future EO systems. The aim is to accelerate EO in the future by means of new disruptive methods. They are currently working with Artificial Intelligence (AI) on Copernicus programme data, the Earth Explorer missions and CubeSats, as well as drone and hyperspectral payload data and virtual reality. The lab also hosts ESA's Incubed programme, providing rapid funding for innovative public-private partnerships to explore new markets It is worth pointing out that following the Φ-sat-1 experiment on board FSSCat, at the end of 2019, ESA issued a call for ideas for the Φ-sat-2 mission. This mission will be used to demonstrate AI's capacity for enabling new, useful and innovative EO techniques of relevance to EO communities. The other programme worthy of note is the Telecommunications Programme, which supports the sector's competitiveness in the global market. In the NewSpace sphere it is driving the development of technological telecommunications solutions f(payloads, antennas, user terminals, etc.) and added value applications using space data. It also supports the development of constellations, e.g. OneWeb, as well as the presence of NewSpace service providers to facilitate the access of new business ideas and new standards (e.g. 5G) to space.

4.5.2. European Commission programmes

In recent years, most EC programmes have been linked to the framework programme Horizon 2020 (H2020). This funding programme, soon to end, includes lots of examples of projects linked to nanosatellites that help us to study the evolution of this ecosystem and the research fronts related to NewSpace. More specifically, the following projects have been developed within this framework:

ONION project. Formed by a consortium of businesses and universities, one of which was the UPC, to develop an orbital simulator with the aim of fully covering EO capacities. The objective was to use a satellite network based on microsatellites, minisatellites and nanosatellites with inter-satellite communication to free up ground download stations[31].

HERMES-SP project. Mission based on federated nanosatellites with the objective of localising Gamma-ray bursts from low orbits.

Recovery and Return to Base project. Led by the Barcelona-based company Pangea, this project will recover and return to base the first stage of the launch vehicle. The recovery and re-entry are divided into two parts: re.-entry into the atmosphere and a horizontal landing using a system of helices.

Once the Horizon 2020 programme is finished, it will be followed by the next EC framework programme, Horizon Europe,[32] from 2021 to 2027. In contrast to the former, the latter will not include a specific budget allocation for space programmes. Space activity is, however, included in a common section.[33] Although this might be seen as a loss of influence on the part of space programmes, it can also be interpreted as an opportunity for integrating this sector in industry and its vertical sectors.

[31] <https://www.youtube.com/watch?v=LF7alaLTSyc>
[32] <https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme_en>
[33] Horizon Europe: Global Challenges and Industrial Competitiveness.

5. Competence and regulatory framework applicable to the space sector

The competence framework is an important aspect when it comes to developing NewSpace in Catalonia, as it determines the capacity that the Catalan authorities have for taking action. A key factor in that framework which has to be developed in the right way is that many of the capacities traditionally linked with space activity correspond directly to states. Despite that, there are many activities, also linked directly to the space world and specifically NewSpace, which could be carried out with the competences Catalonia has. So it is crucial that we identify them and, based on those competences, see which capacities can be worked on to achieve the desired goal.

This chapter presents the legislation and regulations that regulate space activity in different spheres, to enable us to offer an overall view of the sector. One of those spheres is the international one, which determines the subject of rights and duties is always the State. These international regulations are reflected in the framework of international public law, and the various international treaties, which identify all the obligations imposed on the Sate and, therefore, all their national players involved in space activity. As explained below, these “space laws” were drawn up at the start of space activity and are not adapted to the needs of NewSpace. This Strategy therefore emphasises the need for real regulatory progress in this sector to introduce NewSpace in Catalonia.

5.1. Current competence framework in the sector

To be able to understand the capacity for action that Catalonia enjoys, it is important to note the legislation that governs it. So in this section we will review the legislation and regulations of the European Union and Spain and what is applicable to Catalonia.

5.1.1. European legislation and regulations

First, it needs to be borne in mind that, in space matters, we move in two areas of action in Europe: on the one hand, ESA, which is governed by its own regulations established by different members (states) in line with the 1975 Convention, and, on the other hand, the European Union, governed by the Treaty of Lisbon which, in Article 172 bis, establishes the following:

1. To promote scientific and technical progress, industrial competitiveness and the implementation of its policies, the Union shall draw up a European space policy. To this end, it may promote joint initiatives, give support to research and technological development and coordinate the efforts needed for the exploration and exploitation of space.

2. To contribute to attaining the objectives referred to in paragraph 1, the European Parliament and the Council, acting in accordance with ordinary legislative procedure, shall establish the necessary measures, which may take the form of a European space programme, excluding any harmonisation of the legislations and regulations of the Member States.

3. The Union shall establish the appropriate relations with the European Space Agency.”

We can conclude from Article 172 bis that there is no standard space legislation for the whole of Europe but common projects and programmes can be drawn up by the appropriate institutions, Consequently, and given that at present there is no European harmonisation as regards legislation that regulates space access or activities, various states have developed their own space legislation. This legislation has regulated aspects such as access to space, the authorisation system, promotion of space activities, the requirements for promoting and carrying out operations, both technical and financial, and aspects related to registering space objects, monitoring them and responsibility to third parties, among other things.

The countries that have developed space law most include Austria, Belgium, France, Holland Germany, Ireland, Italy, Norway Portugal, Russia, Sweden, Ukraine and the United Kingdom. Apart from this regulation, there are all the rules and regulations that promote and regularise business activity, financial agreements, company-university agreements, and so on.

5.1.2. State legislation and regulations

Thus, having seen that each state develops its own regulations for space activity, it is important to understand the situation in the Spanish State, where two complimentary approaches can be identified in the body of legislation and regulations.

Firstly, we have those that refer to international treaties, covered in Articles 93 to 96 of Chapter 3 of the 1978 Spanish Constitution, which establish the formalisation mechanism and stipulates they shall form part of the internal legal order. That is fundamental as far as the four international treaties relating to space activity are concerned and which Spain is an integral part of. The content and rights and duties implied are described in the following four points:

1. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, signed on 27 January 1967.
2. Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, signed on 22 April 1968.
3. Convention on International Liability for Damage Caused by Space Objects, signed on 29 March 1972.
4. Convention on the Registration of Objects Launched into Outer Space, signed on 14 January 1975

It should be pointed out that Spain, like many other countries with space capabilities, has not ratified a fifth convention, the Agreement governing the Activities of States on the Moon and Other Celestial Bodies, signed on 18 December 1979.

Secondly, we have the Spanish State's own powers, among which we can highlight specific legislation relating to space, apart from the laws regulating telecommunications:

1. Royal Decree 278/1995, of 24 February, establishing in Spain the Registry provided for in the Convention adopted by the United Nations General Assembly on 12 November 1974 on registering objects launched into outer space.

2. The Order, of 4 May 1968, regulating the launch of space artefacts of a private nature of any kind in Spanish territory, promoted by the Air Ministry of the time, and still in force today.

It is also necessary to stress the powers that the Constitution grants the State which have been transferred to the different autonomous communities, depending on the provisions of their statutes of autonomy. Article 2 is applicable in that regard because it recognises the right to autonomy, whereas Article 149 establishes the exclusive competences of the State. For the purposes of what interests us here, it is worth highlighting that international relations are the responsibility of the State, thus covering it in signing international treaties and, consequently, laws that regulate international obligations in the space sphere. Furthermore, belonging to multinational institutions and managing general-interest airports, as well as the control of air space, traffic and air transport (including the launch of space objects) also fall within the State's powers.

5.1.3. Existing legislation and regulations in Catalonia

With regard to Catalonia, we can differentiate between the State's powers that are applied to the various autonomous communities and the communities own competences. To identify the State's powers applied to Catalonia, it is necessary to check which competences it may assume on the basis of Article 148 of the Constitution and by virtue of Article 149.3.*a*). On that basis, the basic law of Catalonia is that included in Act 6/2006, of 19 July, on the reform of the Statute of Autonomy of Catalonia (SAC).

From the point of view of the Statute, the provisions that confer competence relating to space activity are those referred to below. It should be noted that the development of NewSpace and the economy linked to it in particular, implies a broad context that will require its own regulations (as argued further on in this document). In any event, the current competences highlighted below can serve to develop the desired legislation.

Article 44 of the SAC - Education, research and culture: the promotion of science and technology, basic in space activities, must be central in promoting NewSpace activities.

Article 53 of the SAC - Access to information and communication technologies: the promotion and development of space capabilities will give full coverage to access to audiovisual services, especially in areas of Catalonia where access to information and communications are more difficult due to the terrain and/or lack of terrestrial infrastructure.

Article 84 of the SAC - Local powers: it will be very important to coordinate the capacities of Catalan local authorities and the Catalan Government for promoting, encouraging and offering financial help to NewSpace companies that establish themselves in a specific municipality.

Article 114 of the SAC - Promotional activity: this provision is particularly relevant as it contains the legal basis for carrying out two of the most important actions for developing NewSpace in Catalonia. Those are:

1. Promoting activity: means unlimited power and capacity to develop that activity without any legal impediments.
2. Regulating eligible objectives, i.e. creating laws that protect the promotional activities, their objectives and the requirements for being able to access funding, which is vital in many of the projects that this economy requires.

Article 115 of the SAC - Territorial scope and effects of powers: the various competences of the Government of Catalonia that require the concurrence of technologies, applications and capacities that can be provided by NewSpace is what makes sense of the fact that the Government administration wants to equip itself with the basic tools that it needs to comply with this article.

Article 139 of the SAC - Industry, craftsmanship, meteorological control and evaluation of metals: competence over industrial activity is basic for developing NewSpace regulations.

Article 140 of the SAC - Transport and communications infrastructure: three aspects that flow from this competence need to be highlighted:

1. The existence of Airports of Catalonia, the body which manages Lleida-Alguaire Airport. This facility could be essential in developing space activity because from the outset the airport plans were geared towards suborbital flight activities for a potential spaceport that foreign companies could exploit. Currently it operates as an industrial airport with a lot of activity related to the aerospace industry. The availability of industrial land is another asset to keep very much in mind.
2. Management of the road network: real-time satellite traffic control, with diverse applications interacting to supplement the positioning networks, represents a very significant pole of development.
3. The space field's importance to electronic communications is widely known and boosting its capabilities and development in Catalonia is a clear objective.

Article 152 of the SAC - Planning, organisation and promotion of economic activity: this article has to underlie the justification of any regulatory development linked to space activities in Catalonia.

Article 158 of the SAC - Research, development and technological innovation: finally, the list includes a series of instrumental articles that enable various actions to be carried out in relation to space development policies.

In addition, on the legal basis of the **Eleventh Additional Provision of the SAC - Regulatory capacity,** it is possible to ensure the Government of Catalonia has the opportune powers for developing and promoting NewSpace in Catalonia. These competences have a cross-cutting effect on fostering industrial, business and research activity, with an impact on many of people's everyday activities. Many public administration activities too, both autonomic (regional) and local.

It needs to be stressed that not only does this mean promoting and fostering various types of activity by third parties but also the fact of having our own space capacities, adapted to Catalan reality, is a vital tool for complying with the obligations that the legal order imposes on

authorities, basically, as regards delivering a series of services that increasingly depend on those technologies and which have to reach every single citizen, without exception. It is vital that we have full powers in communications, control, verification and support matters without any real-time limitations and with the highest possible level of coordination between all the intervening administrations. The key to the Strategy for developing NewSpace in Catalonia is using each and every one of the powers that the administrations involved have available to them, which are many and varied, in order to form a solid business fabric in the flight and applications segments.

Indeed, the competences that could remain outside the scope of the Catalan strategy are those that have to do with the regulation, authorisation and control of the launch and flight of space equipment. Apart from those cases that involve "horizontal" launches and landing, most, if not all launch activities take place in other latitudes for technical reasons, which should not pose any problem in carrying them out. Likewise, the fact of taking into account that in a very significant part of the activity associated with NewSpace there is no need for direct contact with space equipment, since it is more likely to involve applications and data management, gives us ample capacities in the sector without any limitations on their development, which must clearly be in line with other government-driven strategies linked to advanced digital technologies with the goal of turning Catalonia into the most important digital pole of attraction in southern Europe.

5.2. Need to establish some support regulations in Catalonia

In the competence framework, we have seen and outlined the capacities and the room for manoeuvre that the Government of Catalonia has for developing regulations. In this case, given we are talking about a very specific activity and there are other cases where legislation has helped to promote NewSpace in a territory, we believe good legislation is a basic starting point.

Developing legislative support aimed at promoting the economy and industry linked to NewSpace will create a favourable and competitive ecosystem, show institutional support and offer the legal security that is essential for the sector's growth. Consequently, it is important to have a clear vision of what this legislation should entail, its bases, objectives and raison d'être. Intelligent legislation promotes, encourages and develops an activity at the same time that it provides the ecosystem with the necessary legal security. Thus, this legislation will help to attract investment and also create business initiatives which, from the outset, will be clear about the rules of the game and the foreseeable options.

One of the most significant examples is that of Luxembourg,[34] which has created a legal framework and low taxation system that enables it to attract businesses from all over the world to exploit space resources by taking advantage of the barriers and loopholes in the legislation of the major space powers such as the USA. It is worth pointing out that Luxembourg's NewSpace legislation has even been recognises as an example of best practice by UNOOSA, the United Nations Office for Outer Space Affairs.[35] Another example in the European sphere

[34] https://space-agency.public.lu/en.html
[35] https://www.tradeandinvest.lu/news/luxembourg-and-un-launch-space-law-for-new-space-actors-project/

is Germany, which is studying creating a legal basis of its own to encourage companies linked to the space business to move there, with a view to attracting part of the enormous investment anticipated in the coming decades. This new legislation would, among other aspects, seek to limit legal and financial responsibilities in the event of accidents in orbit, establish standards for space operations and offer incentives for new projects. By June 2018, the German Confederation of Industry[36] had already made it clear the country lacked a body of national legislation regulating those matters and that, in their opinion, it put them at a competitive disadvantage as regards the future of the sector, citing precisely the US and Luxembourg examples.

The benefits of developing legislation to promote NewSpace have been seen in other countries or territories such as the United States, Luxembourg or the United Arab Emirates, and that is an important reason for doing so.

The current competences of the Government of Catalonia provide for ample legislative development directly related to the space sector, basically because it has all the powers over essential aspects of NewSpace: telecommunications, research and technological innovation, business and economic activities, the media, access to ICTs, traffic, emergencies and civil protection, energy, the environment, meteorology and many other things.

Accordingly, within the NewSpace Strategy of Catalonia framework, the Government will promote a legal framework that will be developed on the basis of two main tools, which it needs to ensure the measures put forward in the Strategy are effective: regulatory legislation and a government body to manage its application.

5.3. Ways to develop competences

Implementing the regulatory and legal framework outlined in Section 7.2.6.1. will involve a draft bill with the force of Law being passed by the Catalan Parliament at the behest of the Catalan Government. Developing this regulatory legislation will constitute a unified, simple and effective body of legislation which will promote these activities based on the following parameters:

a) Regulations focused on the business world and directly related research.

b) Regulations that promote the business creation related to NewSpace and offer advantages as regards:

- Taxation and a proper assessment of the time required for businesses to make a profit on their investment.
- Promoting and creating benefits for collaboration between companies, universities and technology centres.
- Promoting joint ventures between businesses and the public administration to develop space activities.

[36] https://english.bdi.eu/

- Studying, if applicable, setting up a specialised investment fund with public and private sector involvement, for example, through the Catalan Finance Institute (ICF in Catalan).

It needs to be borne in mind that, along with direct economic measures, what the NewSpace Strategy and the legislation it advocates offer is institutional support, the creation of a suitable ecosystem and attracting the talent which that implies. However, creating the body that will have to centralise and drive this sector is one of the main reasons for creating the law. This institutional support does not only take the form of a mere declaration of intent but also a commitment to work closely with companies in the sector, either through a public-private partnership (PPP), a holding or as a customer of the products and services.

There are three examples that can serve as a guide, albeit by taking different ideas from each one.

- **The United States** promoted the development of NewSpace by means of Federal Aviation Administration (FAA) legislation and, specifically, through the Commercial Space Office, which promoted commercial access to space and facilitated private activity in the sector, which was traditionally geared to the national agency.

  This office has a current budget of $25.5 million for operations, almost 19 million of which go on staff salaries and 6.4 million to the cost of various programmes, such as the Commercial Space Regulatory Reform. (By way of comparison, NASA is working with $22.6 billion this year.) Part of its income comes from licences, permits, safety inspections, technical analyses and developing legislation. Obviously we are talking about the USA, so it would be necessary to resize the budget.

  These funds go towards promoting and organising the office's activities but they also participate directly in private operations. The FFA has so far authorised over 370 launches and re-entries.

  Although its specific powers and capabilities cannot be compared to those of Catalonia, this example shows how action by the public administration promotes the space field by means of specific legislation.

- **Luxembourg** is perhaps the closest example to what we want to do in Catalonia, as well as an example of how supporting legislation and a specialised body can promote NewSpace activity in Europe. The Luxembourg Space Agency (LSA) is geared towards business development. It does not carry out space exploration nor does it develop its own programmes but it does work on developing businesses, and creating jobs and added value.

  The LSA's partners include a number of bodies and other entities that provide institutional and financial support: the Luxembourg Chamber of Commerce; the public employment agency (ADEM); the national cluster of the aerospace sector (GLAE); the intellectual property institute (IPIL); the Luxembourg Science Centre (LSC), a private non-profit for developing science; the Luxembourg Space Tech Angels (LSTA), a network of private investors; Luxinnovation, the national body that works with innovation activities in Luxembourg; the National Research Fund (FNR in French), the main national funding provider; SES, the global leader in marketing satellites, set up as a PPP in 1985; the Societé Nationale de Crédit et d'Investissements (SNCI), a public company that

specialises in project funding; Technoport, a technological projects incubator, and, finally, Luxembourg's public university.

However, the law and the Agency are not enough for achieving the goals, because economic and financial support is key. Accordingly, the authorities have developed a series of tools:

- Orbital Ventures: a PPP fund involving the government, banks and investors that invest in space technology and start-ups that have already raised the €70 million available for projects. (Bear in mind that Luxembourg's contribution to ESA is €30 million a year, which shows the involvement in the development project in this project.)
- Direct link with the European Investment Bank.
- Link with Luximpulse, the national programme of state aid for innovation and development.
- Managing access to acceleration programmes, with the Ministry of Economy.
- Participants in ESA programmes.

They also have good digital infrastructures, a capacity for attracting talent, high labour productivity, an inclusive economy, innovative funding with funds specially devoted to the space sector, and the presence of the main world banks plus Private Equity International.

With this idea, the Luxembourg Government has made a commitment to attract companies so they establish branches in their territory, with an active tax incentive campaign that offers benefits, deductions and advantages to workers and skilled employees, and good loan conditions, thus providing innovative financial solutions.

- **The United Arab Emirates** (UAE) also developed a law to regulate the space sector. This law is part of the strategy presented in the National Space Strategy Document, with the aim of formulating a strong, sustainable space sector that contributes to the UAE economy's growth and diversification. That document established the future goals of space activity and how to achieve them. In that regard, the NewSpace Strategy of Catalonia follows the same line and motivation of the Emirates' strategy. Many of the actions they have undertaken can easily be extrapolated to developing legislation in Catalonia, just taking into account the competence aspects for it to be effective.
  In contrast to Catalonia, the Arab Emirates Space Agency enjoys strong financial backing from the State, with a budget of over $5 billion, although it needs to be borne in mind that apart from developing satellites, its goals include a crewed space flight to send astronauts to the International Space Station (ISS), interplanetary missions to Mars, collaboration with Virgin Galactic for suborbital activities, and so on. In other words, the Emirates serve as an example for the organisation and ideas in general but there are aspects of their goals and the scale that are beyond the scope of Catalonia's plans. However, we should hold on to the idea that they want to be the benchmark space technology centre of their region. One of the relevant parts of their space policy are the so-called "key enablers":

  i. Continuous awareness of the importance of space and its activities.
  ii. Training skilled professionals.
  iii. Developing an effective and attractive ecosystem:
      a. Increasing transparency, effectiveness and resilience.

b. Providing appropriate protection for intellectual property rights.
c. Providing suitable insurance policies and sustainable facilities.
d. Facilitating information and data sharing to give companies appropriate support.
e. Providing suitable incentives.
f. Minimising the regulatory burden on commercial space activities.
g. Balancing the regulations governing commercial activities with security requirements.

In other words, there is a direct reference to the need for a favourable ecosystem where incentives for commercial activity and the removal of administrative barriers is essential. The existence of regulations to provide legal security should not be confused with the fact that they can end up being so complex that they become a problem and not a solution.

Besides the three examples outlined as a driver for developing space activity, we need to mention other aspects that could help us to size up the task before us. It needs to be borne in mind that the model proposed is defined as an instrument to promote, regulate and encourage space activity, geared towards economic development, business creation and adding social value, not to exploring the solar system or managing crewed space missions. For the most part, therefore, financial resources have to go in that direction, as we have seen in the case of Luxembourg.

In the context of Europe, the UK Space Agency, with a budget of £360 million, allocates £3.8 million to its structure and the rest to projects and programmes carried out in the sector. In Australia, the agency structure costs approximately A$6 million a year and , in the case of New Zealand, NZ$3.5 million.

The associated budget is a factor to be kept in mind in establishing the size of the structure that Catalonia wishes to create where, apart from expenditure on the support structure, most of the investment has to go, for example, towards a PPP-type fund to support initiatives in the sector and also towards getting the financial sector to channel productive aid in the form of advantageous loans, besides all the stimulus activities we have already talked about.

In the last decade, and with more urgency in recent years, 13 countries have created organisations to steer their NewSpace strategy and boost the economic and social activity around it. The main motivation is economic, to contribute value to society and equip their companies with the necessary competitive edge. We have mentioned three pertinent examples and referred to the United Kingdom but other countries have joined this race such as Bolivia, Mexico, South Africa, Turkmenistan, Paraguay, Kenya, Australia, Turkey, Portugal and the Philippines. For the most part these countries are drawing up their own laws for attracting companies and investment. Catalonia will have to follow this path if it wants to compete and be an important pole of attraction in this race to the NewSpace economy, a driver of technological innovation and a window of opportunity for developing innovative services that impact favourably on the whole of society.

6. Strategic analysis of NewSpace in Catalonia

Having reached this point, and to understand the overall situation of the NewSpace sector better, the following pages offer a SWOT (strengths, weaknesses, opportunities, and threats) analysis, which gives us a summary picture of the current situation and enables us to weigh up the possible actions to be taken.

Table 61 SWOT analysis of the NewSpace sector in Catalonia

	Considerations regarding beneficial aspects	**Considerations regarding counter-productive aspects**
Internal	Strengths • Presence in an industry growing with start-ups from the NewSpace sector around universities and research centres. • Possibility of growth and retaining talent, which it will be possible to absorb so it will not have to go abroad. • Experience in small scientific missions (GNSS-R, microwave radiometry and hyperspectral family ^{3}Cat), medium-sized missions (SMOS, PAZ) and large ones (GAIA, LISA Pathfinder, CHEOPS, SolO), plus other studies in phase A (PARIS IoD, GEROS-ISS, G-TERN EE9, HydroTerra EE9). • Experience in transforming satellite data (navigation, Earth Observation) into products and services (diverse companies and institutions, ICGC, SMOS BEC ICM/UPC). • Basic infrastructure for doing tests and receiving satellite data from companies that make small payloads, and the subsidiaries of medium-sized companies that make complete small satellites. • Ample experience in the two big NewSpace sectors: Earth Observation and broadband communications (5G, IoT). • In 2018 and 2019 Catalonia was regarded as the best region in southern Europe for investment by the *Financial Times*. Moreover, Barcelona is the 4th most innovative city in Europe and the 21st in the world. • Options open for developing legislation within the broad competences Catalonia has. • Ad hoc legislative capacity for the sector that would make it easier to attract companies. • Powerful ICT ecosystem. • Good ecosystem of investors in the ICT sphere.	Weaknesses • Lack of access to patents or registered trade marks due to lack of product-oriented research. • Low number of trial and integration facilities (come from other spheres). • Geographical position too close to very experienced satellite clusters (Toulouse, DLR, etc.) to be able to contribute differential added value in a federated approach. • Public investment very limited or non-existent. Projects carried out on the basis of competitive European or ESA funds managed by the CDTI and the voluntarism of the professionals. • Private capital with short-term vision, with no specialised risk capital in the sector. • Lack of public awareness of all the advantages that the space sector brings society. • Non-existence of a regulatory framework that would provide a stable, attractive environment. • Lack of dialogue on an international scale.

	Considerations regarding beneficial aspects	Considerations regarding counter-productive aspects
External	Opportunities • High demand for products and services, with a low supply of government-sponsored businesses. • Job and business creation: great opportunity for investment with risk capital, public and private, to develop new services. • Need for basal public funding to maintain the system. Big ripple effect on many sectors. • Large number of technologies and services for sectors that could benefit from the use of space: precision farming, woodland control, monitoring coastal erosion and crude-oil spillage in the sea, satellite communication, IoT and 5G communications in rural areas, remote medicine, remote education, and so on. • Lots of political and social interest in tackling the UN's Sustainable Development Goals with uniform, impartial, global space data, as well as the Catalan Government's Agenda 2030 SDGs. • Impact on the education system with education and training on Earth Observation applications from primary school (e.g. the Argentinian 2MP model, unique in the world). • Possibility of seeking agreements with other states or states with "flags of convenience" to process use of the radioelectric spectrum. • Catalonia will have a strategy and an associated strategic plan that will enable us to overtake other countries. • It already has big scientific and technological facilities (BSC and ICFO) that can supplement NewSpace with computing power and quantum space communications.	Threats • A lack of institutional support (basal maintenance infrastructures) would lead to the disappearance of the incipient sector. • The window of opportunity will remain open for another three years. Catalonia lags somewhat behind other parts of the Spanish State (e.g. Galicia) and Europe, despite being strong in IoT/5G and Earth Observation (e.g. Sat5G projects, Copernicus Masters Competition). • Difficulties in sharing resources and knowledge and in competing with some companies in the Old Space industry. The space sector is very strong as regards the lobbies that can block or slow down the entry of new players and markets. • The interested parties/points of contact/people responsible for strategic decisions on space infrastructures are State or international and not regional. Catalonia has no voice. • Double-use technologies can cause reticence in the "centres of power". • Difficulty in achieving spectral results (e.g. use of frequency bands), The central digital administration does not operate efficiently. Official business must cease to be done in person at established power centres. • We need to educate and involve potential new end users (companies) in satellite-based technologies. • Possible recentralisation of the BICs (if it is only based on the public sector, the private sector needs to be involved). • The lack of legislative/regulatory support with incentives and the shortcomings in legal security which that implies could keep investors away. • Not having positive cooperation with the institutions of the Spanish State on shared competences and those that require authorisations, licences, etc.

7. The NewSpace Strategy of Catalonia

Giving an impulse to NewSpace is a priority for the Government, which wants to support the roll-out of this new economy in order to make Catalonia a pole of innovation, entrepreneurship and leadership, and for attracting talent and companies to this sector, while at the same time encouraging its expansion and use by the various industrial sectors that make up our social and productive fabric.

With this general goal in mind, the Government wants to drive the NewSpace Strategy of Catalonia which will roll out a programme of specific actions to strengthen the Catalan NewSpace ecosystem and lead the generation of knowledge, its social and business application, and the creation of new solutions based on data provided by the use of new technologies, in order to stimulate economic growth and improve people's lives.

The NewSpace Strategy of Catalonia is coordinated by the Catalan Ministry for Digital Policy and Public Administration, in collaboration with the Ministry of Territory and Sustainability and the Ministry of Business and Knowledge, and also with participation from the other ministries.

7.1. Goals

The NewSpace Strategy of Catalonia is fully in line with the global trend towards emerging sectors such as NewSpace and will boost all the related capacities of the Catalan ecosystem, both public and private, as well as cooperation, innovation and internationalisation, so Catalonia can become a benchmark in southern Europe and a top-rank player in the global environment.

NewSpace is an emerging sector in the technological sphere that will give the Government and other Catalan administrations more advanced knowledge than other territories and an innovative telecommunications infrastructure, based on low-orbit satellites, through which it will be possible to validate and develop new services and applications with a country vision. This context poses the challenge of giving a decisive boost to the sector linked to the NewSpace economy as a whole, at a key time for its technological development and the search for new solutions as a competitive factor in most industrial sectors.

Thus, the Government is responsible for driving the NewSpace Strategy, which will roll out an action programme to regroup, consolidate and relaunch the NewSpace ecosystem in Catalonia as it establishes itself as one of the main drivers of knowledge generation and the application of advanced solutions and technologies in the sector, all of which will be geared towards fostering economic growth, improving management of the territory and improving people's lives.

The goals pursued by this Strategy will enable initiatives to be developed that contribute to driving and coordinating the various research and innovation players in the NewSpace sector, as well as aligning knowledge and technology generation with social and productive sector needs and those of the various public administrations. Concurrently, action will also be taken to increase our capacity for attracting and retaining innovative and entrepreneurial talent,

establishing new investment, generating new business premises and incorporating benchmark international companies into Catalonia's NewSpace ecosystem. At the same time, activities will be promoted that foster collaboration, knowledge transfer and joint projects between knowledge generating entities, the public administration, businesses and users, all of whom are calling for innovative solutions that require coverage and vision throughout Catalonia. Thus, in an ongoing manner, the data generated by satellites will become a valuable asset of the administration, both in terms of the observations carried out and the fact of having access to an experimental infrastructure of satellites in a low-orbit constellation, where it will be possible to roll out and validate first-rate, innovative Earth observation and connectivity services and applications.

Alongside that, Catalonia will have its own legislative and regulatory framework for managing both the infrastructure and the data generated.

The goals associated with rolling out this Strategy are to:

- Stimulate research, innovation and convergence with ICTs in relation to NewSpace.
- Drive and generate a competitive ecosystem in the Catalan sphere.
- Increase the availability of new services and new technologies and the generation of new added value.
- Have data generated by an infrastructure in the NewSpace sphere in Catalonia.
- Promote the sustainable and economic development of the NewSpace sector in Catalonia.
- Develop new business models in the NewSpace sector,
- Position Catalonia as one of the driving forces of NewSpace and its associated technologies in Europa.
- Create, retain and attract talent specialising in New-Space-associated technologies to Catalonia
- Step up the training of professionals in technologies related with NewSpace.
- Create, maintain and govern an open repository of satellite data and facilitate access to it.
- Encourage use of the data generated by companies and institutions.
- Foster the convergent use of 5G, AI and blockchain technologies in the NewSpace environment.
- Create working, innovation and co-creation spaces on the impact of NewSpace and its services.
- Implement actions to assess the various players and the various initiatives being carried out in Catalonia and internationally.
- Provide the Catalan administration with new services and applications so it can manage the territory better.
- Ensure Catalonia becomes a benchmark for generating and transferring value and knowledge from NewSpace to the various productive sectors of Catalonia's economy and Catalan society.
- Explain to the general public the positive impact of using data generated by NewSpace.

- Establish points of collaboration with other regions and benchmark space management entities.

7.2. Strategic action areas

The NewSpace Strategy of Catalonia will involve rolling out a multisectoral and cross-cutting plan focused on public administration needs and the impact on the country's citizens and businesses, which will prioritise territorial management, agriculture and livestock farming, hydrography, cartography, public services and other spheres. This Strategy will be implemented through an action plan based on the following strategic areas:

- **Ecosystem:** promoting a broad-based governance model in various spheres which supports the development of a coordinated NewSpace ecosystem, connected to the world, that includes all the players in the value chain.
- **Research and innovation:** fostering research and innovation by applying specific instruments and establishing synergies between different government ministries, universities, specialised research and innovation centres, organisations making intensive use of the data generated by satellites and the private sector.
- **Talent and society:** creating, attracting and retaining specialised talent that drives the development of new services and solutions in the NewSpace sector, and training professionals from other sectors to cope with their impact.
- **Infrastructure and data:** having experimental satellite infrastructures in place that enable new solutions and technologies to be validated, and having new data available to facilitate secure, open and transparent access.
- **Adoption of NewSpace services:** promoting the use of new services and data facilitated by NewSpace to drive innovation in the public administration in strategic sectors that are key for the country's future development, both traditional and emerging ones.
- **Regulatory framework:** having a structure in place in the public administration that provides a legal and regulatory framework applicable to NewSpace.

The lines of action and initiatives associated with each of these six areas are outlined below.

7.2.1. Ecosystem

Optimal development of the NewSpace sector requires having a strong, coordinated and favourable ecosystem in place comprising a set of independent and strategic entities that share the environment where they live and develop. Use of the adjective 'favourable' means it has to be an ecosystem that favours the development of the activities which the individuals making up the ecosystem carry out. This ecosystem will make it easier for all the players to be interconnected, thus favouring the generation of complementary synergies to boost existing capacities and initiatives, create new ones and enable more ambitious challenges to be tackled.

The entities that are part of the ecosystem must have a governance structure plus a relationship and collaboration model to make Catalonia an international pole of reference in

the NewSpace sector. At the same time it will have to establish collaborative links with other structures and organisations on a local and international scale to maximise its impact.

7.2.1.1. Create an open, cross-cutting governance structure

The Catalan strategy prioritises creating an operational organisation that plays a leadership role in driving the Catalan NewSpace ecosystem. This structure must be in charge of running the Catalan strategy and, among other matters, that involves managing the resources, infrastructures, talent, opportunities and alliances, and ensuring equitable and transparent use of the data obtained from a NewSpace infrastructure.

For this the **Catalonia NewSpace Alliance** will be created, i.e. an open, plural, transparent, multidisciplinary community for sharing knowledge, generating and attracting ideas and challenges, research and exchanging experiences, participatory and coordinated with the other communities linked to advanced digital technologies, with the capacity to opt for funding at all levels – Catalan, Spanish State and international – and for generating collaboration and knowledge transfer projects, with aim that it could become the basis for taking part in the future definition of a digital innovation centre for Catalonia, following the European Commission Digital Innovation Hub (DIH)[37] model.

This governance structure has to encourage collaboration between the different players for developing ambitious projects by means of public-private partnerships, which give an impetus to long-term collaboration as well as the generation of innovative public services and new technology that can be transferred to the market.

The alliance will offer the possibility of sharing common spaces, physical and/or virtual, for co-creation, innovation and business, as well as infrastructures and laboratories to raise the international profile of the local ecosystem. It will promote the creation, acceleration and incubation of global start-ups with an operational base in Catalonia, focused on NewSpace sector solutions at a critical moment in the growth and roll-out of related technologies.

The structure of Catalan NewSpace ecosystem will be based on three main spheres: the one associated with knowledge generation and the pursuit of excellence; the one related with technology transfer and impact generation, and finally, the one linked to the ecosystem supporting the generation and growth of start-ups and new solutions.

7.2.1.2. Collaboration with other structures and local organisations

It is vitally important that the **Catalonia NewSpace Alliance** is part of the structures that are also strategic for the sector's development. Key in that will be developing a very close relationship with the ESA BICs (Business Incubation Centres) spread around various countries across Europe. These centres were launched by the ESA Technology Transfer Programme Office for entrepreneurs and innovators, Their main requirement is that all start-ups taking part

[37] <https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs>

use space technologies and/or information to create products and/or services, and in this way develop their own business projects. Currently the two most important ESA centres are the ones in Madrid and Barcelona. ESA BIC Barcelona opened in 2014. It is located in the Mediterranean Technology Park in Castelldefels and receives support from various public administrations and institutions.

When the NewSpace Strategy is launched, the Government of Catalonia will step up its participation and support for ESA BIC Barcelona to connect this incubator to the Catalan NewSpace ecosystem so, jointly, they can accelerate the growth of start-ups looking to scale up their development towards marketable products, in many cases by means of the link with the Government's needs or those of the big companies in our ecosystem that act as a magnet. In that regard Catalonia has an advantage because it can rely on a solid industrial fabric in various business sectors that could benefit from space technologies (cars, transport and logistics, power generation and distribution, etc.) and a culture based on open innovation and corporate entrepreneurship that has gradually take route in the country in recent years.

Alongside this, relations will have to be established and collaborative bridges built with the ecosystems promoted under the framework of government strategies linked to advanced digital technologies, for example, those linked to 5G, AI and blockchain. All those communities can complement technologies and services necessary for developing new, innovative solutions for telecommunications and data processing in the NewSpace sector.

The sector's business associations and specialised clusters, which accommodate new and traditional companies, make this a significant network. By combining forces they have a strong, organised voice to address the public administrations. Establishing business clusters with the advantages of access to a physical space, to tools and satellite systems and to support systems is a big incentive for establishing NewSpace companies. Among other organisations, the chambers of commerce must play an important role as business associations par excellence. A relationship with Catalonia's chambers of commerce, especially the Barcelona Chamber of Commerce, whose strategic plan includes promoting this sector, will help to publicise the various activities carried out within the NewSpace Strategy framework through the business fabric and encourage the creation of new, technology-based companies in the sector. At the same time, this relationship will enable the chambers to support various administrations and the space world in defining expansion plans, in interactions with the **Catalonia NewSpace Alliance** and in linking up with other chambers around the world.

7.2.1.3. International projection of the Catalan pole in NewSpace

One of the goals of any strategy is its internationalisation, even more so today when we are immersed in a global digital market. So international cooperation will be enhanced by collaboration agreements with other ecosystems and international associations of excellence that will enable the generation and development of projects, and the creation of joint

programmes, as well as leveraging international programmes such as Horizon Europe,[38] and Digital Europe,[39], of those of the ESA, driven by the European Commission.at a time when developing new digital technologies is a key issue for each of the member states.

The NewSpace sector's potential market is international but it is difficult to find a region that brings together the whole value chain. So that will require international positioning to know and be known by other players. In that regard, the current position of Barcelona and Catalonia as a global benchmark in digital technologies, especially as Mobile World Capital[40] and the venue for top-level international congresses such as the Mobile World Congress (MWC Barcelona),[41] the Smart City Expo World Congress[42] or the IoT Solutions World Congress,[43] together with the presence of first-class NewSpace research and innovation centres and laboratories with a fibre-optic connection to a Catalan Earth Observation station,[44] offer maximum visibility for attracting cutting-edge companies and research and innovation activities with global leadership in the NewSpace sector, which has a magnet effect on companies interested in setting up their operational centres in Catalonia and/or generating joint programmes, with a significant increase in the quality of the projects generated by the ecosystem as a whole and of the collaboration with the innovative, entrepreneurial and research fabric.

As with the other top-level events related to advanced digital technologies held in Barcelona every year, it will be necessary to explore the option of generating or bringing to Catalonia an international event specialising in NewSpace. In addition, we will have to promote specialised fringe events and acts at the international digital technology fairs and congresses held in Barcelona each year.

In that context we will have to generate a positioning and brand image by creating a catalogue of services, technologies, infrastructures, capacities and companies in our ecosystem that will enable us to promote Catalonia's presence in various international forums. The Catalan NewSpace technological offering, which we will call **Catalonia NewSpace Technology**, will present in a clear and structured way the existing attractive potential to internationally renowned investors and business decision-makers, highlighting the value this technology can contribute to developing today's society.

Monitoring satellites for data reception has similar characteristics, so in some cases it may be necessary to establish agreements with companies or countries that have ground base stations to federate with them for receiving data when it is not possible to receive all the data from our territory. That will involve a strategic rethink of the Montsec ground base station. The fact that communications satellites have to be governed by Union of International Telecommunications (UIT) standards and that there is a Space Objects Register dependent

[38] <https://ec.europa.eu/info/designing-next-research-and-innovation-framework-programme/what-shapes-next-framework-programme_en>
[39] <https://ec.europa.eu/digital-single-market/en/news/commission-welcomes-agreement-digital-europe-programme-2021-2027>
[40] <https://mobileworldcapital.com/es/>
[41] <https://www.mwcbarcelona.com/>
[42] <http://www.smartcityexpo.com/>
[43] <https://www.iotsworldcongress.com/>
[44] <http://www.ieec.cat/en/content/145/oadm-montsec-observatory>

on the UN Secretary-General's Office, as well as Spain's register, are two more examples of how this activity requires an international vision.

With regard to the NewSpace Strategy of Catalonia and the international component linked to it, a network of ambassadors will be created to act as project recruiters in the international NewSpace environment and the creation of an advisory council will be promoted comprising leading international figures in the NewSpace world (e.g. Jordi Puig-Suari,[45] inventor of the CubeSat standard), researchers, administrators and business executives with proven experience in international projects and markets from Catalan communities abroad: or those organisations, companies or institutions they now work with or that could be of interest to the country.

Likewise, as part of the internationalisation strategy and in addition to the presence at international events with the **NewSpace Catalonia** brand, we will rely on the direct collaboration of the Government delegations abroad and the International Network of Trade and Investment Offices to ensure contact with people and organisations at the highest level and promote the generation of opportunities and projects for Catalan entities and companies in this sphere.

7.2.1.4. An attractive country for national and international investment in the NewSpace sector

The presence of international companies and investors linked to advanced digital technologies in our country has increased exponentially in recent years and many of those technologies complement NewSpace (e.g. mobile technologies, AI and 3D printing). In that sense, both the **Catalonia NewSpace Technology**, put forward above, and cooperation with the Agency for Business Competitiveness (Acció in Catalan), as the Government structure responsible for boosting industrial and business competitiveness in the spheres of innovation, internationalisation, business dimension and attracting foreign investment to Catalonia, by means of the "Invest in Catalonia"[46] programme, and the Secretariat for Digital Policy, as the Government structure responsible for fostering growth in the economic fabric and the digital technology sector, as well as for promoting innovation and digital transformation policies, have to enable the improvement of knowledge transfer processes and strengthening of the connection between technology generated in Catalonia and the economic, social and business sectors, both domestic and international, capable of providing funding for individual or cooperative projects linked to NewSpace.

In the context of the NewSpace Strategy of Catalonia, we will promote various actions favoured by corporate or financial investment, especially in technology-based companies and in research and innovation groups or centres, establishing tax incentives or loans with favourable conditions, for example, those linked to programmes connected with the European Investment Bank and the Investment Plan for Europe. Likewise, following on from other experiences here, the Strategy will promote the holding of investment forums or The

[45] <https://es.wikipedia.org/wiki/Jordi_Puig-Suari>
[46] http://catalonia.com/invest-in-catalonia/

Investment Readiness Series within the framework of the Barcelona & Catalonia Startup Hub and the aforementioned congresses or others linked to NewSpace sector applications, such as the NSE Expoforum[47] or the Global Space Congress.[48] We will also promote the incorporation of new investors in the system, by means of specific actions to attract them, as well as training initiatives geared towards building a network of national and international investors interested in knowledge generated in Catalonia in the NewSpace environment

7.2.2. Research and innovation

A key factor in becoming a country that can be competitive on an international scale is having excellent basic knowledge and capacity for technological development in NewSpace technologies. Therefore we need to coordinate and give an impulse to the various research and innovation players working round the NewSpace sector and in the disciplines associated with processing received satellite data, to ensure Catalonia becomes a pole of reference in the generation and transfer of knowledge to the different productive sectors.

The Catalan NewSpace research and innovation system comprises a set of institutes, R&D&I centres and universities which specialise in activities that have a direct impact on NewSpace and which together are dedicated to knowledge generation and transfer. That said, better coordination and collaboration mechanisms need to be established to create critical mass and align this knowledge generation so it can have a global impact on a higher international level.

On the other hand, various open innovation models and agile work methods are being consolidated in the business field with a view to improving competitiveness in the digital world. Society finds itself in a period where the constant evolution of digital new technologies leads to ongoing change in private sector product development and strategies. In the case of NewSpace, those are two of the basic principles of its existence. In contrast to so-called Old Space, where development time lasts years, in NewSpace it lasts months, which enables different technologies to be validated in the same satellite constellation, obviously at a lower cost. The fact that NewSpace allows a certain democratisation of access to space makes open innovation and collaboration between agents and start-ups extremely important.

In this context, it is vital we strengthen the mutual commitment between companies and public research and innovation entities in NewSpace by creating networks, institutes and public-private partnerships that enable the formation of strategic alliances, the establishment of innovative joint projects, not just services, the pull effect of large companies and the rational use of resources, infrastructures and existing technological platforms.

7.2.2.1. Advanced NewSpace research and innovation programme

In order to support research groups, institutes, and research and innovation centres carrying out projects in the Catalan NewSpace sector, as well as foster collaboration between them and with the private sector, an advanced research and innovation programme will be launched

[47] https://www.nseexpoforum.com/
[48] https://www.globalspacecongress.com/

in the NewSpace field linked to the Advanced Digital Technology Research and Innovation Programme. This programme is clearly committed to developing innovative solutions in response to the real needs and challenges facing the Government, which can then be transferred to industry so they can become commercial services.

The projects, of a collaborative nature, will target the participation of research and innovation centres, as well as technology-based companies, which are in process of developing new services, products or technology in general. One of the programme's priorities will be the convergence of different advanced technologies, for example, AI, IoT or blockchain, as well as exploring distributed intelligence (DI) and the future 5G networks. Research and innovation activities will also be carried out in the Earth Observation (EO) field, where the objective is to achieve greater control over the instruments and services these types of constellations can offer. At present, the high costs of licences for software (when required), primary data capture and/or image purchases, as well as user licences, pose a big initial barrier. The Copernicus[49] programme helps a lot but its global scope will not always fit in with the local or national needs of the end user.

Moreover, the synergy between the IoT and EO will also be strengthened. The sensorisation capacity of biophysical, meteorological and other parameters at ground level is a real support for the validation (and even calibration of EO information, if applicable) of derived products based on images, as is the possibility of using models or simulations, of great interest as decision support tools in the short and medium terms.

The EO market continues to be dominated by technology companies (supply sector) rather than by the demand sector. In economics, mature markets are those where end users (collectively or individually) contribute to funding and therefore exercise a certain influence. In the case of civil Earth Observation, this has not happened. A final point on this market is that most applications or uses require the integration of observational and non-observational data to be of use to users and clients. Format harmonisation, compatibility between the two big types of data and common data policies have a long way to go but are essential for achieving maturity.

A very important issue which we need to increasingly take into account are the measures to adapt to or mitigate the effects of climate change on the country, in particular the social and economic consequences they entail and which require multidisciplinary metrics or indicators that enable them to be monitored, measured and comprehensively evaluated. Therefore, the advanced NewSpace research and innovation programme, together with its activities, will have to take the existing measures, expand them and/or improve them with more effective and complementary tools in the identification and repetitive, stable and integral monitoring of the affects on the ground as a decision support tool.

There will also be substantial support for business R&D&I in NewSpace, especially for companies with their own innovation centres or plans to install one in Catalonia in the near

[49] <https://www.copernicus.eu/es>

future. This means support for actions linked to setting up industrial pilot projects, experimental payload launches, the validation of new CubeSats, prototypes or proofs of concept, in real environments, in advanced technologies, and new funding for innovations linked to business growth. Businesses will also be encouraged to take part in international projects and take advantage of tax incentives. In short, a twin task of promoting and financing business initiatives that have made a firm commitment to creating jobs and wealth in the country,

7.2.2.4. Research and innovation activities in the NewSpace value chain

Based on the value chain identified in Section 2.4, a programme will be defined which, over time, will impact on different spheres of action in the chain, where Catalonia can become a vital, leading player. This programme will directly affect the members of the Catalonia NewSpace Alliance and, therefore, add value to manufacturers and operators, to the design of control, management and communications systems, technological improvements at the Montsec ground stations, payload designs, and the application of AI to received information. In short, the big challenge is being able to obtain new information, that is, new data which , once they have been processed and cross-checked, can have a cross-cutting impact on many sectors, both in the public administration and the productive sector. These data will come from different types of sensors, distributed in specific parts of the territory, and information from different instruments (payloads) dedicated to Earth Observation.

One of the goals pursued by the NewSpace Strategy of Catalonia is to acquire the knowledge which will position the country as one of the poles of value generation in the international NewSpace sector with special emphasis on integrating Earth-space-Earth telecommunications for services such as the IoT and broadband in remote areas in the future 5G Standard defined by the 3GPP.[50] For that reason we need to emphasise knowledge and collaboration between research and innovation players and companies that develop tech solutions and applications, as well as with infrastructure operators and service providers, while prioritising convergence with other digital technologies.

The Strategy will rely on various research and innovation activities in the cutting-edge knowledge areas of the Catalan ecosystem. These knowledge areas refer to the technological challenges of NewSpace where the public research and innovation centres, universities and members of the **Catalonia NewSpace Alliance** will carry out R&D projects geared towards satisfying the technological needs identified by the sector, with the objective of developing the technology, platforms and services that can be put at the disposal of the public administration and various companies in the sector. In a complex, constantly and rapidly changing world, it is becoming increasingly obvious that we need to be able to take decisions on the basis of accurate information and constantly monitoring the work done in areas of great strategic importance in the sector. Below we outline the technological research and innovation activities regarded as priorities in the coming years.

[50] <https://www.3gpp.org/>

a. Technologies for integrating IoT-based solutions into NewSpace

The long-term goal is to have solutions that will enable licensed-band Earth-space-Earth IoT/5G telecommunications to be profitably integrated into NewSpace. Although it is expected that this standard will not see the light of day until 2022, it is important we start working on prototypes that can be aligned with the current development of the standard so we can have cutting-edge technologies one the final specifications are available. Projects to develop a core network for a narrow-band Internet of Things (NB-IoT) can be based on Version 13 specifications, so a satellite operator can offer transport services for IoT device signals that work with mobile operator SIMs. Research will therefore have to be done on redesigning NB-IoT architecture to enable base stations to be launched in LEO satellites with intermittent signals with the Earth segment. Likewise, it will be necessary to identify the scientific, technical and economic feasibility of developing an NB-IoT waveform and stack protocol that will improve the features of the solutions currently on the market. That will also require having a test bench representing a hybrid Earth-satellite network, with real base-station and satellite connections, in order to validate the applications and reduce the barriers for entrepreneurs with innovative ideas and show end users and/or entities how it works.

b. Technologies for integrating internet-based solutions in NewSpace

We currently have the opportunity to take advantage of the latest-generation internet architecture designs to ensure they develop in a way that will enable the deployment of this new generation of space networks, which will also have to be fully integrated with ground services and networks. A number of key aspects need to be addressed here in terms of service supply and technological development for rolling out future LEO services that can interact with MEO or GEO systems at the same time. Projects will therefore have to be designed which, while taking advantage of existing mechanisms and internet standards, can be adapted to LEO environments with the objective of cutting latencies and maximising communication capacities that will enable new internet services to be rolled out and validated with latency requirements of the order of 30-80 milliseconds. These services include remote computer connections, VPN connections, encrypted FTP transfers and continuous streaming with no downtime.

The areas of knowledge that will require more research to adapt them to LEO environments are those which will have a direct impact on internet services and customer application, the evolution in technological standards and current regulations for LEO environments, and, above all, the development of service quality and data traffic management mechanisms which, in the 5G sphere, will enable the current routing and signalling protocols to be improved, as well as the systems for balancing loads by means of different space segments. This will have an impact on control and data plans. In fact ,all this knowledge will help to create new opportunities for global mobile virtual network operators.

This research will have to focus mainly on leveraging the network function virtualisation (NFV) systems, software defined networks (SDNs) and orchestrators deployed globally. The LEO space networks are global, so we have to bear in mind how to deploy SDN solution and centralised/distributed network controller and orchestrators so they meet global security and service quality requirements while optimising deployment and operational costs.

Another challenge that will have a big impact on handover mobility, i.e. the transfer of a service from a terrestrial network to a space network, and how its continuity enables uninterrupted service on the understanding, obviously, that this continuity is between terrestrial and satellite mobile services. Communication discontinuity not only affects communication between satellites and stations or users on Earth, it also impacts on communication between satellites themselves. Research therefore has to be geared towards mitigating or living with the effects that degrade the services that can be offered,

In fact, there is also an opportunity for leveraging new distribution models, including those of quantum key distribution (OKD) from space satellites to improve point-to-point encrypting for all sorts of applications, an area of research in the medium and long terms.

c. Technologies geared towards solving the challenges associated with inter-satellite link (ISL)[51] and network function visualisation (NFV)[52] communications, and station-Earth extensions

Given the future needs for inter-satellite communications and offering global IoT solutions, a system will have to be designed, developed, controlled and exploited for managing telecommunication services in small satellite constellations. For that a set of tools will have to be implemented for the identification and repetitive, stable and integral monitoring of the status and evolution of satellite services (e.g. IoT messages) and for optimising the allocation of resources. This is a time of change in the telecommunications sector, where software is becoming more important and there is a growing trend towards using generic hardware. It will therefore be important to work on virtualisation at all levels, from the Earth segment to the space segment, on the use of low-cost hardware, and to study the impact and feasibility of implementing NFV solutions in low computational capacity scenarios, so it will be possible to have integral Earth-LEO systems.

All the results obtained will have to be validated in the satellite environment and at the Montsec ground station, prior to the various trial and simulation stages, to avoid malfunctioning in orbit. Another research activity to bear in mind has to do with developing solutions and new ISL communication protocols on a satellite scale, for LEO or even LEO_GEO orbits, which could be integrated into future communications between nanosats and CubeSats.

Inter-satellite links (ISLs) offer long-distance communications, excellent connectivity and high transmission speeds. The development of ISL systems capable of imposing themselves on the satellite environment (e.g. the Doppler effect) is essential for their future use. In addition, miniaturising these systems and their antennas is fundamental for integrating them into CubeSats, which are still not installed on conventional platforms. The application of SDR[53] technologies also has to be encouraged to provide flexibility and address the possible variety of systems currently found in space.

[51] <http://www.esa.int/ESA_Multimedia/Images/2016/02/Inter-satellite_laser_links>
[52] <https://www.3gpp.org/technologies/keywords-acronyms/1584-nfv>
[53] <https://es.wikipedia.org/wiki/Radio_definida_por_software>

d. Technologies geared towards finding solutions for autonomous satellite networks

The study of satellite networks is still in its early days, so it is a good time to consolidate it. So far, the most advanced research in this field has focused on a conception of this type of network that is based on satellite constellation architecture but proposals have been put forward for huge constellations (comprising thousands of satellites, for example), making their development a real challenge. Research has begun to turn towards making these networks more adaptive and appropriate, and to try to create them on the basis of hybrid constellations without a previously defined architecture. This model is known as the Internet of Satellites (IoT) and offers the possibility that new entities with minimal resources can establish and be part of a network infrastructure made by satellites. Thus, this paradigm presents lots of technological challenges and for research too. These still have to be overcome but, once they have been, they could open up this concept to new applications. Those challenges can be classified on different levels, depending on which part of communication they address:

- **Managing multiple satellites:** the satellite network is characterised by having variable node densities. Device management protocols are currently designed for a certain common number of applications deployed on Earth. However, the number of devices can increase considerably in space. We therefore have to rethink those protocols so they can coexist in the satellite networks environment.
- **The communication protocols for defining the network:** a satellite network that does not know its structure poses a big challenge for defining the links and communication routes that is still to be resolved. Moreover, those networks still have to combat existing network fragmentation caused by satellite movements, which means communication is not always feasible. We therefore have to encourage the development of these types of adaptive protocols and ensure they can mitigate or coexist with that fragmentation.
- **Predicting fragmentation of the network:** as explained above, these networks suffer from fragmentation or disruption, which means inter-satellite communication is not always feasible. It is therefore necessary to develop a set of technologies that can foresee that fragmentation and anticipate its impact. Using technologies from different fields, AI or mathematical models, for example.
- **The decision-making autonomy of the satellites:** in the kind of networks proposed by the IoSat paradigm, satellites become agents that take decisions depending on the surrounding scenario. Satellites are currently controlled from operations centres, so they have limited autonomy. So, developing technologies that offer a certain level of perception and intelligence indecision-making is essential for implementing this paradigm.

In a complex world that is constantly and rapidly changing, the need to be able to make decisions on the basis of accurate information is becoming increasingly obvious.

e. Technologies geared towards improving NewSpace-related infrastructure

Another important area of research is the development of technology, processes and facilities for improving the performance and reducing the cost of deploying and maintaining satellites in LEOs. That means developing the technology of subsystems to increase the performance of satellite platforms and pioneering data generation instruments.

One of the opportunities offered by NewSpace is the possibility of working with industrial electronics. That will require identifying the technological features of other cutting-edge sectors such as mobile telephony, automobiles and/or drones that could be integrated in NewSpace, as well as other tools and interfaces that facilitate the qualification of technologies for space. Catalonia's industrial fabric is currently immersed in a process of transformation which means adopting to industry 4.0[54] solutions. So this is a very important time for identifying how industry 4.0 can be integrated into satellite production for NewSpace. That will require research and innovation activities that develop new processes and facilities, as well as systems for automating trials, the incorporation of massive data and automatic learning for continuous improvement in satellite production and orbital management.

f. Technologies geared towards improving data management

Data are one of the most important assets that NewSpace technology will bring us. That means accessing new data that originates from new services that are rolled out in orbit. Consequently, special emphasis will have to be put on developing technology associated with new processes and algorithms for storing and transforming data into useful information for the end users, and improving optimal use of the download channels from where aggregated data from satellites is obtained. This will involve close collaboration between research and innovation centres, universities and companies with knowledge of data processing, massive data and automatic or deep learning. As mentioned above, collaboration with the new Centre of Innovation in Data Tech and Artificial Intelligence (CIDAI) will be of vital importance.[55]

In this sphere of action we cannot forget the necessary interactions with the data end users. They will be ones best able to express their needs and the challenges they face, which will be turned into requirements in the design of NewSpace data management systems.

g. High-performance on-board computers and SDR for small satellites

Miniaturisation of electronic components and the reduction in their power consumption have enabled high-performance devices to be integrated in much less volume. Thus, the reconfigurable system on chip (SOC)[56] offers the capacity for adapting the hardware to different application needs merely be changing the associated firmware. Both the software and the hardware for all these subsystems is critical. For that reason, a system has to be established that ensures their quality is adapted the ESA requirements for their use and application, for example, functional redundancy on a constellation instead of an individual satellite scale. The use of SDR in the current communication systems has become key, as it enables flexibility and the adaptation of the physical and logical layer of various current and future communication protocols for exchanging TM/TC information with Earth, GNSS receivers or EO applications, among others.
The future communication applications loaded on small satellites envisaged in this Strategy, such as 5G or IoT, will require a large number of channels that operate simultaneously in

[54] <https://www.accio.gencat.cat/ca/sectors/industria-40/>
[55] <https://cidai.eu/>
[56]<https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Microelectronics/System-On-Chip_SOC_Development>

different frequencies and wavebands to cover different geographical areas or users. Moreover, the design of nanosatellite constellations will require an inter-satellite communication network so they can maintain continuous coverage over the territory and add more communication capacity. For all those reasons it will be necessary to improve the current SDR subsystems and have a minimum of four or six transmission and reception channel operating simultaneously in new frequency bands such as the Ka band (from 26.5 GHz to 40 GHz).

At the same time, and in relation to how the satellites operate, it will be necessary to work on integrating this layer with upper layers of various networks for Earth and satellite integration, with the clear objective of achieving total automation of the constellation start-up process with AI support.

h. Ultra low-power positioning systems for the Internet of Things

IoT sensors have experienced extraordinary growth in recent years, as have the associated density and use cases, which range from infrastructure control, tracking animals or objects and monitoring the environment, to smart agriculture and livestock farming, among other applications. The intention in many cases is that sensor batteries should last for years. In fact, the idea has been raised of not changing the battery throughout the sensors useful life. However, there is currently now widely accepted alternative to locating sensor very low power consumption, especially in outdoor environments or in regions a long way from urban areas. Nevertheless, implementing positioning functionalities in most sensor continues to be based on GNSS[57] chipsets that process the GNSS received, calculate the user's position and then send this position to a remote server, along with other data.

The concept of the Internet of Things is not just limited to terrestrial devices. These "things" can also be nanosatellites orbiting the Earth, which have their own positioning and associated communication needs Therefore, the IoT naturally includes Earth and Space. In particular, positioning nanosatellites faces a similar problem to positioning terrestrial sensors. Nanosatellites have power restrictions and, for many applications, do not require high-precision positioning. To put existing positioning solutions for Earth and space sensors into practice, and have better ones, a set of small-scale demonstrators will have to be developed to experiment with ultra-low consumption positioning and use architectures based on edge and cloud computing, as well as experiment with nanosatellite transmission of a positioning signal suitable for low consumption. That will also imply improvements in the use of activation protocols and random access.

i. Services for measuring, mapping and sharing use of the radioelectric spectrum in Catalonia

The radioelectric spectrum is a scarce asset that has to be shared between multiple users and applications. It will therefore be necessary to manage spectrum occupancy and supervision of possible sources noise, interference and unauthorised emissions. Public administrations must ensure that happens. Some applications and services, such as radio navigation (GNSS),

[57] Automatic network and, depending on the case, satellite constellation operation, with or without the application of AI.

communications with remote computers or EO-related ones are particularly sensitive, has they have to operate with very low signal power levels.

Some of these bands are subject to supervision by official bodies in certain geographical areas but that requires a big investment in supervision equipment and in the time dedicated to it. For that reason it would be necessary for us to have a low-orbit satellite supervision tool with a much broader scope, which would have a significant impact on an essential service for the country. Although the spatial resolution that could be achieved is not the best, it would enable more continuous tracking with a much lower response time. Using receivers loaded on nanosatellites to carry out this supervision of the radioelectric spectrum would be one of the solutions to this problem. So a CubeSat will be used that incorporates a multi-band receiver to analyse environmental noise and provide band occupancy studies.

An important research area is sharing the spectrum. This is an open question in the technological and regulatory spheres. Therefore a study will be carried out of the technological developments that could facilitate frequency coordination for sharing the spectrum, either by frequency diversity, geographical diversity, widening the channel, by defining transmitter power levels and receiver sensitivity, or by improvements in the filtering system, as well as incorporating AI in the terminals and dynamic frequency channel assignment.

j. Technologies geared towards Earth Observation

Policies and measures for adapting to or mitigating the effects of climate change, and their social and economic consequences in particular, are absolutely necessary but, at the same time, require multidisciplinary metrics and indicators that enable comprehensive monitoring, measuring and assessment with scientific rigour. So we need to equip ourselves with additional, more effective tools, or increase and improve the existing ones, to identify and monitor in a repetitive, stable and reliable way the state of, changes in, vulnerability of and effects on the territory as a decision support mechanism. In the near future, the main challenge in terms of Earth observation and geoinformation will be to support the United Nations Sustainable Development Goals (SDGs), in particular SDG 13 (Climate Action) and its interconnections. In that context, we need to create an Earth observation and geoinformation programme based on small satellites.

This programme will have various components. It will define the development of payloads, notably microwaves (microwave radiometers, GNSS-R and some kind of low-consumption radar) and multi- or hyperspectral optics (based on existing COTS[58] systems by means of their validation and demonstration in orbit.). It will also define the development of a programme for an In Orbit Demonstrator with earlier sensors and technologies, which will benefit from advances in inter-satellite and with-Earth communications (e.g. autonomous remote sensing on demand or risk monitoring) Instrumental networks, ground sensors and additional geodata are a key element of the “in situ” component of any satellite programme, for the calibration and validation of derived products and services, which are crucial for ensuring the quality and

[58] <https://www.webopedia.com/TERM/C/COTS.html>

integrity of all that is involved in the observation process. In addition, it will be necessary to define some test sites on land and sea which can be duly equipped and maintained over time.

Meanwhile, for nearly 15 years now, the occultations of radio signals transmitted by GNSS, from which information on vertical pressure profiles, temperature and atmospheric humidity is extracted, have been likened to weather forecasting models, with a very positive effect, that is, notably reducing forecasting errors.

In 2009, a group at the IEEC came up with a new concept for measuring atmospheric precipitation. The particular feature of this technique is that it is carried out in the same equipment as the GNSS radio occultations (GNSS-RO), and it is also possible to implement it in SDR loaded on satellites, as it is a GNSS receiver with firmware modifications. This new technique, called polarimetric radio occultation (GNSS-PRO), incorporates two linear polarisations in the receiver system. At present, no other technology can resolve the two variables simultaneously. The interest lies in the possibilities that the new set of data opens up for understanding its phenomenology and, above all, for improving the weather forecasting and climate predictions used to determine the local effects. They are therefore applicable to the activities carried out at the Meteorological Service of Catalonia and by other resources forecasting and management bodies, both public and private.

The objective of this activity is to design, implement, launch and start up a small CubeSat (or nanosat) constellation with GMSS-PRO technology, which will be able to disseminate its data to the whole world for meteorological and climate studies, and to improve weather forecasting, in coordination with the Meteorological Service of Catalonia. The global use of some unique data by meteorological services and climate study centres would put the spotlight on this space programme and put Catalan science and industry at the forefront of innovation in remote sensing in space by small satellites.

7.2.3. Talent and society

Talent management is one of the pillars of this Strategy and the entire technological environment developing right now in the country. For that reason, activities and programmes will be carried out that are geared towards attracting, generating and retaining all the talent with the capacities for developing solutions applied to NewSpace environments, while promoting access to these technologies for researchers, engineers and innovators as well as business people and entrepreneurs, with or without any previous link to the sector. In the end, we have to continually train new professionals that satisfy the country's social and business requirements. With regard to attracting and retaining talent, it will be vitally important to consolidate the Catalonia NewSpace ecosystem, so we can offer an ecosystem that is unique, attractive and leads the way on an international level.

7.2.3.1. Generating, attracting and retaining talent in NewSpace technologies

a. NewSpace research talent programmes

In response to the needs of present and current professionals, initiatives will be promoted and given effective support to improve the training currently on offer, with specific courses,

seminars, masters, postgraduate studies and doctorates in the technological field linked to NewSpace. In this context, collaborative mechanisms between business and academia will be established to adapt curricula more to social and business needs and promote research and innovation geared towards providing technological solutions.

To that end, a specific working group will be set up comprising representatives of education and training centres, staff from knowledge-generating entities and heads of NewSpace technology and service user entities to exchange knowledge and experiences as well as establish suitable content and more effective collaboration mechanisms in order to promote top-quality professional programmes, mechanisms which involve the institutions and companies that use these technologies in their different fields of activity.

At the same time, work will be done to internationalise the education and training programmes in order to attract international students and establish relations with first class institutions and specific content by means of the Erasmus+ programme, through KA2[59] collaboration initiatives, the Horizon programme, though the Marie Curie actions comprising initial training networks (ETNs),[60] industrial doctorates (EIDs), joint doctorates (EJDs), and co-funding (COFUND) for predoctoral programmes, as well as programmes financed by the European Social Fund (ESF) and others that could be implemented in our system, with or without private sector participation, as far as researchers doing predoctoral training (R1 – First Stage Researcher) are concerned.

With regard to research and teaching staff linked to advanced digital technologies, especially NewSpace technologies, at the junior post-doctoral stage (R2 – Recognised Researcher) or the senior post-doctoral stage (R3 – Established Researcher), specific actions will be promoted in order to create our own programme, Catalonia NewSpace Talent. Based on successful models in our system, such as the current ICREA SENIOR[61] or ICREA JUNIOR models, this will leverage the co-funding opportunities offered by smart specialisation programmes and the European Social Fund, real co-funding options offered by universities and research and innovation centres, and actions linked to the Marie Curie programme[62] (part of the Horizon programme), in particular the COFUND scheme[63] for post-doctoral programmes, thus ensuring a greater presence of advanced digital technologies in general, and NewSpace technologies in particular, throughout our research and innovation system.

Likewise, by leveraging European funds linked to initiatives such as RIS3CAT, COFUND and private sector resources, and in the Catalonia NewSpace Talent programme, we will work on an initiative to attract digital talent that will enable permanent contact between companies and research and innovation centres, allowing investigative and innovative mobility modelled on Tecniospring, Beatriu de Pinós Empresa, Connect-EU, Marie Curie Incoming or Outcoming Grants or Torres Quevedo, in connection with incubators, innovation companies, and national and international research and innovation centres.

[59] <https://eacea.ec.europa.eu/erasmus-plus/actions/key-action-2-cooperation-for-innovation-and-exchange-good-practices_en>
[60] <https://ec.europa.eu/research/mariecurieactions/>
[61] <https://www.icrea.cat/es/la-seleccion-de-icrea>
[62] <https://ec.europa.eu/research/mariecurieactions/node_en>
[63] <https://ec.europa.eu/research/mariecurieactions/actions/co-funding-programmes_en>

b. Collaboration with the Barcelona Digital Talent alliance

To ensure the competitiveness of Catalonia and Barcelona as a pole of reference in advanced digital technologies in general, and NewSpace in particular, the Government of Catalonia, in collaboration with other public and private institutions, has launched the Barcelona Digital Talent[64] alliance with the goal of making Barcelona a space capable generating, retaining and attracting talent with the necessary capacities and knowledge for developing this new industry.

Barcelona Digital Talent is an alliance for ensuring Barcelona and the rest of Catalonia becomes a pole of digital talent in response to the lack of specific talent and the increase in technology-based companies looking for profiles with digital competences. Barcelona's experience is of interest to the rest of the country, so we will work with alliance partners in creating other poles in Catalonia with the capacity for replicating that experience and which can rely on alliances similar to the one described for Barcelona involving companies, public administrations and training centres.

This territorial digital component, which will be included in the Catalonia NewSpace Talent programme, will prioritise talent associated with developing the NewSpace ecosystem and spread this talent creation, retention and attraction factor throughout Catalonia. The work that will have to be done in this programme is threefold: promoting digital technologies around the country, existing professional profiles and identifying business needs. Similarly, training programmes will be designed and tailored to existing needs that will enable the well-qualified professionals to be trained, ranging from university courses to programmes for occupational training and vocational training in these knowledge areas. Finally, and in direct contact with companies and user institutions, emphasis will be placed on developing a professional career in NewSpace and on identifying Barcelona and Catalonia as an international reference point. It will be possible to co-fund these activities in collaboration with the Catalan Employment Service, by means of the innovative and experimental projects programme, exploiting funds from the European Social Fund, initiatives linked to the Erasmus+[65] programme and the private sector's own resources.

c. NewSpace entrepreneurial talent programmes

NewSpace will facilitate the generation of new services and applications that can be offered in different spheres of the productive and social fabric. That will require the emergence of new companies and entrepreneurial programmes whose objective is to implement and market these technologies in different sectors, as a point of renovation in our productive fabric, especially with regard to the knowledge generators, and a real professional development possibility for scientists and innovators in Catalonia. Accordingly, within the framework of the Government's Catalunya Emprèn[66] programme and the Xarxa Emprén network, projects will be promoted to foster entrepreneurial talent in the NewSpace environment, while prioritising technology in this sector in existing programmes for fostering technological development in Catalonia, such as the Innovate programme through the ACCIÓ start-ups or the AGAUR[67]

[64] <https://barcelonadigitaltalent.com>
[65] <https://ec.europa.eu/programmes/erasmus-plus/about_es>
[66] <http://catempren.gencat.cat/ca/inici>
[67] <http://agaur.gencat.cat/ca/beques-i-ajuts/pagines-especials/Innovacio/programa-industria-del-coneixement/>

Knowledge Industry programme. Likewise, close collaboration will be established with existing business incubators and/or accelerators in the country, such as the Mobile World Capital Barcelona[68] Collider programme[69] to boost entrepreneurial activities whose objective is to implement and market NewSpace technologies in different spheres, as well as others in the private sector like Seedrocket, Conector, Ship2B, Wayra or Bstartup, which also include public-private initiatives that could be very interesting for this Strategy.

d. Promoting NewSpace-related vocations

In a digital society, the education and training of present and future generations of users is an absolute necessity. Thus even the youngest students in primary and secondary schools have learn about, familiarise themselves and have contact with the latest technological tools, such as those in the NewSpace environment. The same goes for all the teachers responsible for teaching tech subjects.

Simulating vocations requires going back to the earliest stages of education, so it will be necessary to design an effective NewSpace vocational plan as part of the Government's STEMcat Plan[70], which includes actions in primary and secondary schools, talks, workshops, one-off activities in schools and preparing teaching and audiovisual materials for them that encourage children to think about the possibilities offered by global IoT services and processing images of the Earth, incorporating a gender perspective and training teachers to introduce this content.

Likewise, vocational training (VT) must ensure pathways directly linked to the needs of our social and economic fabric, with special emphasis on advanced digital technologies that do not currently feature in the intermediate and advanced levels of the VT family of ICT professions, apart from specific profiles such as cybersecurity or bioinformatics. Given the lack of digital talent that has been identified, a specific programme needs to be established in advanced digital technologies for the intermediate and advanced levels of VT that ensures students have better, fuller access to the job market and which makes the most of the potential now offered by dual VT (training plus paid work experience), among other aspects to be considered.

Finally, with a view to democratising the space that NewSpace is seeking to occupy, another benchmark programme will be promoted based on current best practices, in collaboration with the public and private players, training centres, research and innovation centres, business associations, social entities, and service and application users of NewSpace. This programme will focus on doing free courses adapted to the needs and capacities of each student, taking advantage of existing educational technologies such as massive online courses, as well as other activities that could be done in the physical world, based on collaboration with the corresponding authorities, the network of ICT points,[71] the Catlab network,[72] or cooperation with the technology parks and training entities in Catalonia.

[68] <https://mobileworldcapital.com/es/>
[69] <https://thecollider.tech/es/>
[70] <https://projectes.xtec.cat/steamcat/categoria/pla-stemcat/>
[71] <http://www.punttic.gencat.cat/>
[72] <http:/catlabs.cat/>

e. Enhancing the role of women in the NewSpace sector

The extremely low presence of women in the technology sector is well known. According to data from a study drawn up by the Catalan Women's Institute (ICD in Catalan),[73] women only occupy 30% of the jobs in the ICT sector in Catalonia. Bearing in mind that the November 2018 report of the European Centre for the Development of Vocational Training[74] forecast that 84.5% of job vacancies would be in the technological field in 2025, the low presence of women in the sector implies an enormous risk of exclusion from the labour market for reasons of gender in the very near future, as well as a considerable loss of talent that the country can ill afford, even less so at a time of crisis like the present.

In higher education, there are four times more men than women doing university courses related to information and communication technologies. Take, for example, informatics engineering, a necessary type of digital training in the NewSpace field and a particularly unusual case as there is only one woman for every ten men studying this in Catalonia. Bearing in mind that a sixfold increase is expected in the number of LEO satellite launches in the next five years, it is easy to envisage the potential growth of the sector and the associated services that stem from it, even more so if we take into account aspects such as global warming and its implications for Catalonia Given the goal of becoming a pioneering centre on an international scale, it is clear there will be a significant professional shortage, which will mean practically full employment in the sector. We are therefore faced with a scenario where women are not sufficiently represented in every ICT sector, especially in decision-making positions, and they have a minimal presence in the careers that would qualify them for this sector. However, there is room for intervening in this trend so there is enough supply for everyone.

In this context, there are various reasons why it is important to work towards increasing female presence in the sector:

- To comply with Article 32 of Act 17/2015, of 21 July, on Effective Equality between Men and Women, which establishes measures for ensuring equality in access to work, training, professional training and promotion, and also working conditions.
- Because there are huge opportunities for finding work in the ICT sector in general and for women in particular, given the lack of skilled professionals for these occupations. Consequently, these days, in view of labour market trends. technological qualifications for women are their best guarantee of getting a job.
- Because a plural vision always enriches the exercise of professions, and ICT professions are no exception. Incorporating a woman's perspective is necessary for building a full and egalitarian future. In fact, the female vision creates a powerful differential: according to Forbes magazine, businesses and/or projects run by women have been more successful in overcoming crisis situations.

There are basically two critical points here. On the one hand, the lack of technological vocations among girls, something which needs to be stimulated from school, including by

[73] <http://dones.gencat.cat/ca/detalls/Noticia/Dossier-TIC-2019>
[74] <http://www.cedefop.europa.eu/>

means of specific actions which arouse girls' interest in technological careers and encourages them to do scientific-technical courses at university. On the other hand, the difficulties in highlighting and exercising female leadership in the sector, which requires enhancing the participation of women at senior management level in organisations and companies in technological spheres and showcasing, even with specific funding, innovative start-ups created and led by women that are part of the digital technologies sector in general and NewSpace in particular.

Catalonia is aware of this situation and is implementing the ICT Plan for Women,[75], driven by the Ministry for Digital Policy and Public Administration, which provides the protection of institutional framework to boost the presence of women in the ICT sector.

In that regard, one objective of the NewSpace Strategy of Catalonia will be to develop an action plan for boosting the role of women in the NewSpace sector within the framework of the Government's ICT Plan for Women and in collaboration with existing initiatives promoted by a wide variety of entities.

7.2.3.2. Creating a NewSpace Observatory

NewSpace is an emerging sector, both from a technological point of view and rolling out services perspective, so it is very important in the initial development stages that all the players in the ecosystem have reports on sector's evolution and trends, as well as the level of development and success cases on a local and international scale. Communication and dissemination of NewSpace is also very important among non-specialists, mainly collectives outside the ICT sector but who could have a direct relationship with it at any time, focussing on raising their awareness of the use of associated technologies and data which are very useful for other players in training on the fundamentals of solutions and services for NewSpace environments and on the availability of use cases and examples of success cases that demonstrate the benefits and impact that the associated technological development can have in the different productive sectors.

With this twin objective, a Catalonia NewSpace ecosystem observatory will be set up, based on a multidisciplinary working group, to research the regulatory (and, if applicable, ethical) impacts, define the analysis and statistics associated with the use of LEO satellites, produce reports on the situation on the ground, and establish guidelines on publishing the best practices in this field and also sharing this knowledge and work with other national and international bodies.

Specifically, the NewSpace Observatory's priority action areas will be to:

- **Identify, catalogue and analyse the trends,** evolution, technological development and roll-out of NewSpace on a local and international scale.

[75] <http://smartcatalonia.gencat.cat/web/ca/projectes/ciutadania/detalls/article/donaTIC.cat>

- **Identify and select good practices** based on the pilot tests, use cases and projects developed in the NewSpace field in Catalonia.
- **Draw up reports compiling knowledge of NewSpace,** as an instrument for publicising and promoting NewSpace among different collectives and productive sectors.
- **Raise public awareness** by developing outreach materials and activities targeted at the general public and the media, so they know the impact of NewSpace on their everyday lives and on preserving their well-being.

7.2.4. Infrastructures and data

Infrastructures, and the data they enable to be generated, are one of a country's most important assets when it comes to putting together a sectoral strategy. Infrastructures not only give a country visibility on an international level, they also enable new technologies to be tested and validated, and, therefore, create an environment with the capacity to attract projects, public or private, as well as technology manufacturers. In addition, the data enable progress in activities focused on R&D&I and provide new services and solutions for the country, putting the Government in a leading position on a European level

At present there are various entities, research and innovation centres and companies in Catalonia that have their own infrastructures for developing experimental and validation activities for advanced NewSpace technologies. That said, there is no overall conception of infrastructures on a Catalan level, a situation which, unfortunately, is repeated in other sectors and fields. This Strategy will therefore promote the creation of a single infrastructure catalogue with all the assets that, together, add value to Catalonia NewSpace Technology, as well as the creation of the Catalonia NewSpace Lab, a distributed NewSpace experimentation laboratory that will have LEO satellites and access to satellites in other orbits (MEO and GEO) through collaboration agreements with their operators, as well as infrastructures that are interconnected and integrated with the Montsec ground station.

The **Catalonia NewSpace Lab** will be a working, sharing and testing environment open to ideas and initiatives from elsewhere with the general goal of driving the technological sector and offering access to experimental infrastructures, facilities and data generated by NewSpace and LEO satellites. Likewise, it will encourage business and public administration participation by cooperating in application development pilot tests, with a view to providing solutions to social and industrial problems in the short and medium terms.

The specific objectives of the **Catalonia NewSpace Lab** are to:

- Provide a real experimental environment where advanced internet and NewSpace solutions are tested and validated before they go into mass production.
- Ensure that big companies that supply technology and advanced services, and companies belonging to technology-user sectors such as transport, livestock farming, agriculture, fishing and logistics, among others, have the possibility of testing their solutions, interacting and working together with the technology supply chain (companies, start-ups, R&D&I centres, universities, and so on).

- Provide research and innovation centres, universities, incubators, accelerators and start-ups with an environment for speeding up the proof of concepts (POCs) they carry out and direct access to industrial clients, as well as facilitating the link between challenge generators and solution providers.
- Provide an environment concentrated in a specific physical environment, where the various global players in the NewSpace value added chain can be found, so they can interact and generate synergies.
- Provide a link with incubators, accelerators and local investment companies that can contribute towards developing an innovative culture, encourage the creation of new companies and make it possible for new technologies to be incorporated more quickly into the various productive sectors, starting with the big companies linked to the NewSpace sector.

From an infrastructure analysis perspective, a rigorous assessment will also be required to evaluate the technical, legal, commercial and economic feasibility of establishing a reference space at Lleida-Alguaire Airport where private LEO launchers could be located, thus enabling more agile and ongoing satellite launch missions from Catalonia.

7.2.4.1. Consolidating the ground station at the Montsec Astronomic Observatory and providing a service to the satellite and nanosatellite market

The communications station installed at the Montsec Astronomic Observatory (OAdM-IEEC) by the UPC in collaboration with the IEEC, in 2018, provided an opportunity to test the suitability of using this infrastructure to establish a base for satellite communications. The conditions of that environment – free of electromagnetic (EM) noise, logical access (it is connected to the fibre-optic open network XOC) and services which ensure the secure, uninterrupted operation of the facility – are excellent. The current station, with antennas for the amateur VHF/UHF and S bands, serves, with prior agreement, public-private consortiums for research projects in the framework of contracts with ESA or with the European Commission linked to the Horizon programme. This communications station currently has a remote control system that enables various passes to be programmed and configured, remote commands to be uploaded, downloaded data to be saved locally and downloaded to the remote control centre in real time or deferred, depending on broadband availability However, the control software is designed so it can control more than one station at a time.

The Montsec station has to be one of the most important tools for giving the country's R&D&I centres, universities and businesses the capacity to develop innovation projects and cover the entire vertical structure in marketing satellite services: from construction, operations, downloading and processing data to exploiting and selling it to the end user. Moreover, it should be borne in mind that having access to a communications and control station located in Spanish territory is a requirement for obtaining a licence to manufacture and launch new satellites. Therefore, improving and boosting the Montsec station, despite it not being at a high altitude, is a strategic question for the NewSpace sector in Catalonia, especially for those industries specialising in manufacturing and integrating satellites and in the Earth segment and operations.

The feasibility of exploiting a communications station at Montsec for industrial purposes is also clear, given the international context. The current situation in the Earth segment is being transformed so the growing number of LEO satellites can be served. There are nearly 350 station providing coverage to the nanosatellites presently operational, of which 200 correspond to the SatNOGS[76] project (UHF/VHF) and 65 to RBC Signals,[77] which basically takes advantage of the underused capacities of the big stations to sell them as a service to nanosatellites. This solution of reusing satellite stations in the hands of big operators is not viable in the medium term, given the forecast growth of the NewSpace sector, and there are already around 200 additional stations at the design or development stage, mainly in the American market, which are destined to expand existing capacities.

For those reasons, we will have to consolidate the OAdM-IEEC/UPC communications system as a strategic infrastructure for serving the Catalan nanosatellite market and apply various activities to its operations:

- Adapt the current station so it has the capacity to transmit in the commercial band S and X (and Ku and Ka in the future).
- Create a new station capable of serving microsatellites and nanosatellites with flight sector support, data reception and processing, and data distribution to user functions.
- Facilitate their integration into global-scale networks as a node, which will give access to resources shared with other operators, expanding their market and operational performance.
- Carry out TM/TC communications for the new station simultaneously with different satellites in low orbit.
- Have one or more groups of antennas with multiple beams and electrical beam steering capacity so each beam can continue tracking a particular satellite.

7.2.4.2. Roll-out of an experimental LEO structure

One of the most important activities that will have to be undertaken within the NewSpace Strategy framework, in the field of technological structures necessary for strengthening the sector in Catalonia is the definition, design, launch and deployment of an initial experimental infrastructure of nanosatellites/CubeSats in low Earth orbit (NewSpace), which will make it easier to validate new services and applications on the data generated by satellite payloads. This infrastructure, and the data generated, which at present can only be acquired through external providers, and are not always adapted to the needs that both the public and private sectors have, will be a vital part of the **Catalonia NewSpace Lab** and the results achieved later.

[76] <https://satnogs.org/>
[77] <http://rbcsignals.com/>

This small constellation, comprising a reduced set of satellites with intermittent visibility at the Montsec ground station (the best orbits for maximising coverage and visibility over Catalonia will have to be identified and defined) will enable the roll-out of pilot tests and validation of new applications and new services developed in Catalonia.

Deploying NewSpace missions will involve carrying out tasks associated with selecting the provider and who is in charge of providing the service from the satellite. Carrying out missions and also generating pull activity around CubeSat construction and launches, will enable us to attract and grow technology-based companies focused on preparing missions and, at the same time, contribute towards ensuring Catalonia becomes a technological pole of reference in the European reference sector.

7.2.4.3. Data access and sharing

Data are the essential component of NewSpace. Regardless of the complexity there is in designing a mission, from its conception to the end of the satellite's useful life, the most important thing are the data it generates and can obtain, once processed. These data, from elements related to the Internet of Things (IoT) and also Earth Observation, will be useful for different sectors in a cross-cutting way, as well as the Government, which will be able to be more proactive in unforeseen situations that affect Catalan territory, or create new services that will eventually give value to citizens. The amount and diversity of the data will contribute to a considerable degree to the quality and excellence of the results obtained. Accordingly, there is a very close link with the use of artificial intelligence, which ties in with the Government's determination to align the various strategies developed and that will enable close collaboration between initiatives generated through the NewSpace Strategy of Catalonia and those envisaged in the Catalonia Artificial Intelligence Strategy, approved in February 2020.

One of the main objectives is to make it easier for the data generated from the **Catalonia NewSpace Lab**, and obtained from the experimental satellites launched, to be open data. That should encourage innovation and the creation of new applications and services in this field. However, even if those data are made public through the data processing centres where they are stored, it will be necessary to ensure the quality and validity of the data obtained. One of the most important points regarding data use a will be the capacity to correlate them with data from other services and/or technologies (e.g. Earth Observation (EO) and IoT data). Therefore, the necessary software will be provided so third parties will be able to access them, bearing in mind these will never be personal data. The **Catalonia NewSpace Lab** will promote the production and donation of public and private data as a fundamental right that people have and as a quality, socially beneficial legacy.

By way of example, in what is called the "territorial ecosystem", the synergy between the IoT and EO will also be strengthened. The sensorisation capacity of biophysical, meteorological and other parameters at ground level is a real support for the validation (and even calibration of EO information, if applicable) of derived products based on images, as is the possibility of using models or simulations, of great interest as decision support tools in the short and medium terms.

7.2.5. Adoption of NewSpace services

Until now, access to space has been limited to the space agencies of various countries or continents, and a small set of public and private players who have sufficient resources to assume the cost of space missions running to tens, or even hundreds, of millions of euros. However, the arrival of technologies linked to the NewSpace sector and the possibility of working with much lower orbits, much smaller and cheaper devices, and a development time of under a year, have changed the rules of the game and opened the door to new players, until now excluded from the big space missions of the last 60 years.

One of priority action areas of the NewSpace Strategy of Catalonia will therefore be to boost and accelerate the processes for adopting NewSpace services in various industrial sectors of Catalonia, as well as in government, which has to lead and drive the use of technologies associated with this concept.

7.2.5.1. Public administration as a pioneer in applying NewSpace services

The goal of the Government of Catalonia is to have a smart, efficient and transparent administration with personalised, proactive, digital public services, which simplifies the relationship with citizens and optimises management by means of automated processes.

The use of data generated by pilot tests deployed in NewSpace experimental infrastructure as well as around all the ecosystem that will make up the Catalonia NewSpace Alliance, and, therefore, obtained by means of the different applications and services developed to be used by the public administration and players linked to this Strategy, will offer direct and indirect benefits to the general public and the country's social and productive fabric, based on the Government's determination that, apart from respecting certain exploitation agreements, an open vision of the results achieved that encourages cooperation, entrepreneurship and the resolution of social challenges will prove effective. Direct benefits include all those derived from services that resolve challenges and needs that have a direct impact on the administration and managing the territory. That management will be more effective and proactive and will result in an indirect benefit associated with a better quality of life for the citizens of Catalonia and an increased capacity to react to adverse phenomena around the country. With this aim in mind, a series of programmes will be developed that will enable them to be effectively adopted. Those programmes are:

a. Opportunity-detection programme

In order to encourage public administration use of services and applications based on satellite data, a first line of action will be to launch a programme to detect and analyse cases of use and opportunities for improvements in various Government departments and bodies but also in the other public administrations around our country and which represent the interests of citizens as well as local, county and provincial councils, among others. This programme will work with a perspective geared towards missions that address the search for solutions to specific problems. Most of the use cases have been identified previously, during the preparation stage of the Strategy, although a more specific and precise analysis will be

required to determine what benefits these types of technologies could bring people and the Government by applying them to specific needs around the country.

b. Development of mission-oriented pilot project use cases

Bearing in mind the different points dealt with in this section, the various Government ministries and areas will be pressed to identify and develop proofs of concept and pilot tests that use NewSpace data and technologies, supported by the application of artificial intelligence (AI) and with the desire to improve digital services for the country's citizens.

In this context, an inter-ministerial working group will be set up and coordinated by the Ministry for Digital Policy and Public Administration, which will be tasked with identifying, prioritising and driving the roll-out of technologies and obtaining data linked to NewSpace in Government bodies and departments.

Some use cases that could derive from applying NewSpace technologies to public administrations are outlined below:

Monitoring buoys, emergency sensors and remote infrastructures: the location of certain infrastructures, such as reservoir control, fire watchtowers, emergency buoys at sea or first aid points on roads or mountain paths makes it difficult to establish the necessary communication network for them to be properly controlled and monitored. Therefore, deploying satellites with IoT technologies that enable coverage to be provided for these infrastructures offers the possibility of monitoring them and rolling out new ones in areas where it would not be feasible at present. Mobile calls for help or monitoring people and vehicles in emergency situations, and areas not covered by conventional technologies, would also benefit from them.

5G broadband coverage: deploying satellites with 5G technologies would make it possible to extend current and future terrestrial coverage by the 5G network, offering the possibility of connection in rural and remote areas. Satellite infrastructure offers the possibility of creating an internet system with worldwide coverage connected to any point on Earth, thus achieving one of the goals of 5G (continuous connectivity).

Light pollution: thanks to calibration and multisensor detection, the airborne approach offers the operational capacity of obtaining physical measurements with a very high resolution. However, night flights are very restrictive in terms of air navigation and environmental limitations, which complicates, temporal resolution and reactive response, if required. Very sensitive sensors are therefore needed to compile night-time radiation from space. Image capture at night from the current satellite platforms offers products with a very low spatial resolution to be turned into information to support municipal decision-making.

Urban climate and heat control: the airborne hyperspectral sensor in the long-wave infrared bands offers us the possibility of estimating the real temperature at very high spatial resolutions. Despite that, night flights, which give us optimal conditions for comparing the relationship between air and surface temperatures, are too restrictive, in terms of air navigation and environmental limitations, to be able to offer feasible and viable resolutions and response

monitoring in time. From space, heat information provides decametric spatial resolutions in the best cases (if not, hundreds of metres) and temporal resolutions a long way from the necessary requirements for offering useful products as end-user decision support tools, to supervise and apply urban policies, evaluate the results of actions taken, etc.

Urban green spaces: thanks to the ICGC's photogrammetric cameras, the airborne approach offers the operational capacity to obtain high-resolution (40 cm) urban green vitality indexes. Despite that, the viability of an airborne system leads us to be restrictive with regard to the temporal resolution and response time in an area where the status in different seasonal or phenological resolutions is paramount. Urban green should be "useful" as an Earth Observation product, if the GSD[78] is below 1-2 metres (tree level), for sharing this information with other geoinformation layers in order to generate decision support tools, especially in the case of thermal behaviour and 3D urban modelling based on photogrammetry or LIDAR technology.[79]

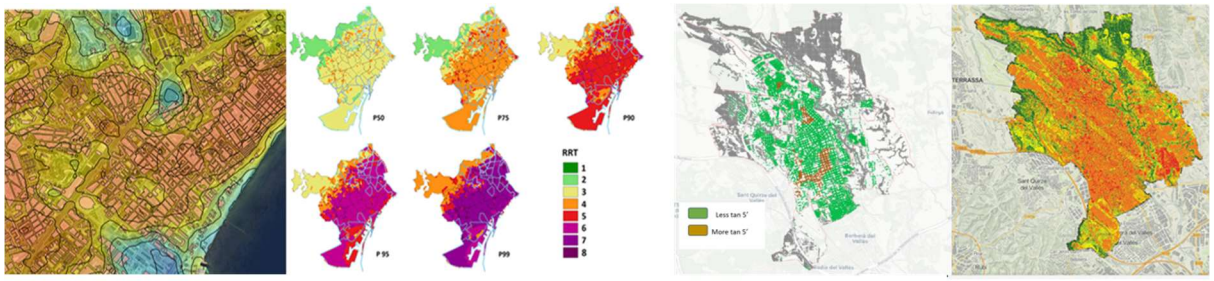

Figure 7.1. Examples of products or services developed by the ICGC or with their coordination on the climate and urban green spaces.

Ground covers and detecting changes: the ICGC's collection of photogrammetric cameras and hyperspectral sensors offers a set of optimal data for analysing and producing geoinformation on cover changes. The main challenge today is the capacity to process all the information on AI or architectures to produce more reactive, up-to-date products in time. On-board AI capacities will be useful on a VNIR[80] scale for providing temporal information (especially seasonal, more useful than from airborne platforms), processing capacities for more effective updating of the ground cover and detecting changes. The satellite payload and terrestrial reality for recovering the soil's biophysical parameters should be an operational innovation to support better knowledge of the impacts of climate change and the state of the covers.

Precision agriculture: the ICGC's airborne assets of photogrammetric and hyperspectral sensors offer precision agriculture data difficult to improve on (over 20 years of FARMSTAR campaigns). The Copernicus data offers additional or primary information with very good, competitive and complementary temporal and spatial resolution in agronomic assimilation models. The dedicated wave bands between red and near infrared, and the extension to

[78] <https://en.wikipedia.org/wiki/Ground_sample_distance>
[79] <https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Space_Optoelectronics/LIDAR_Systems>
[80] <https://en.wikipedia.org/wiki/VNIR>

SWIR[81] with a better spatial resolution than Sentinel-2,[82] should be well-received in the research field for producing better agronomic models and AI training data.

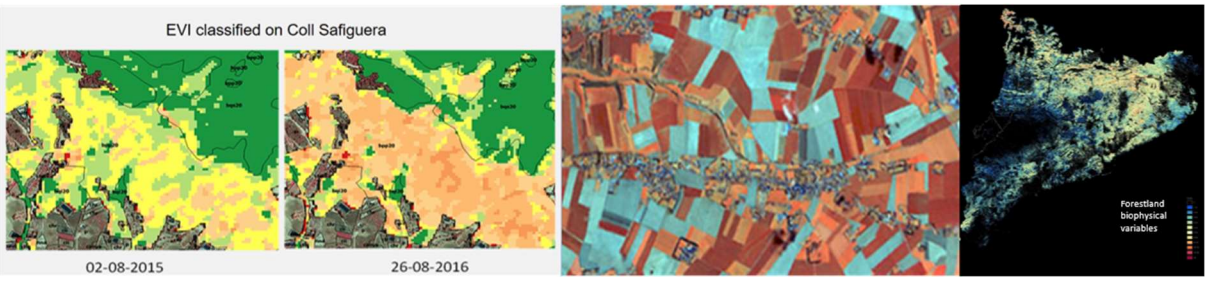

Figure 7.2. Examples of products or services developed by the ICGC or with their coordination on precision agriculture and the state of the forests.

Forest fires: the ICGC's airborne assets offer full and optimal capacities for obtaining precise geoinformation on the state of the forest mass. A key factor is the capacity for generating information based on LIDAR data and/or 3D photogrammetric models of the forest structure. Copernicus data offers a supplement or alternative, with very good temporal and spatial resolutions. The extension of good-resolution data in terms of the access time and spatial resolution in SWIR and MIR, better than those of Sentinel-2, would be extremely useful in analysing the severity of forest damage and its recovery. The complementary nature of these temporal and spatial resolutions of meteorological measurements and soil moisture, together with the additional ICGC layers of the forest structure (with LIDAR), would enhance risk and propagation models and simulations, which are very useful for preventing, controlling and mitigating the effects produced by the forest fires which the country suffers every year.

Bodies of water: a very demanding area in terms of temporal resolution/reactivity and spectral resolution as regards the need for spectral bands and regions. The ICGC's airborne resources are limited in terms of revisiting requirements (viability) but excellent as regards spectrality, spacial resolution and reactive potential. Efforts must be made to avoid "radiometric pollution" in the coastal area and in general the transitional area between the surface and submerged part of a body of water, which is where most interest is concentrated with regard to water quality, the impacts of climate change, etc., in order to generate effective decision support tools.

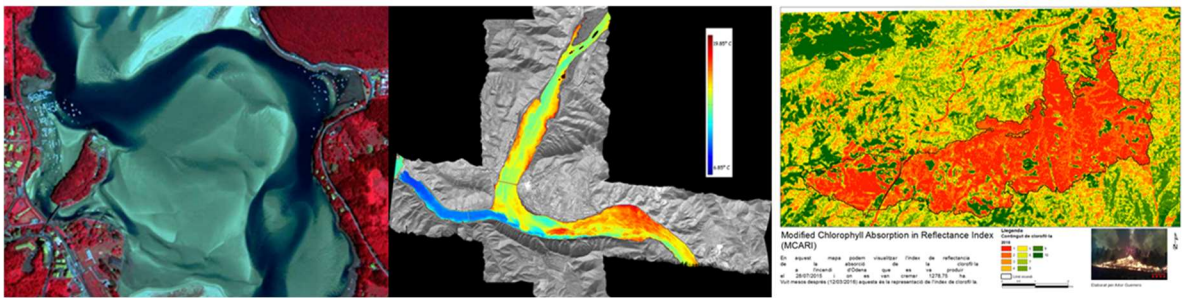

Figure 7.3. Examples of products or services developed by the ICGC or with their coordination on forest fires and bodies of water.

[81] <https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Shaping_the_Future/New_Generation_Short_Wave_Infra-Red_SWIR_Immersed_Grating_Phase_1>
[82] <https://sentinel.esa.int/web/sentinel/missions/sentinel-2>

Natural dangers: very demanding in terms of temporal/reactive resolution and spatial resolution. The ICGC's airborne capacities are reactive but limited or restricted by the weather conditions, while in terms of revisiting time/reactivity and meteorological conditions (optical systems), today's satellites cannot offer an integral response. In this context, high review/access times are critical and very high spatial resolution (<3-4 m) is essential as a final decision support tool. Response time in the value chain, from capturing EO data and extra geoinformation to supplement them, to generating the required information and knowledge is the most important challenge in this field of action.

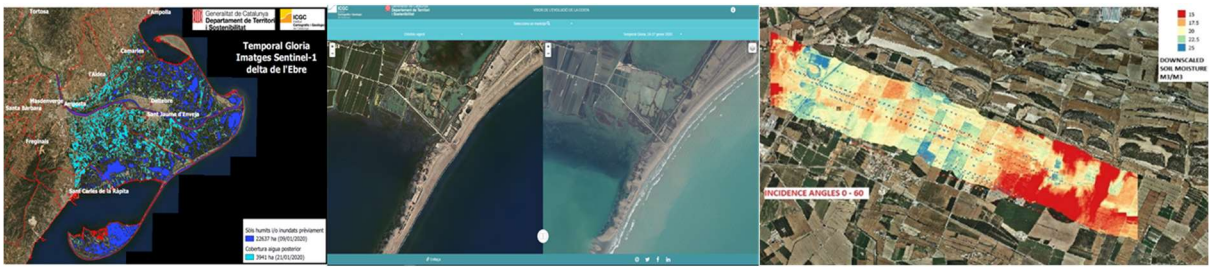

Figure 7.4. Examples of products or services developed by the ICGC or with their coordination on natural disasters and soil moisture.

In order to involve the developers, entrepreneurs, start-ups and SMEs in the Catalan NewSpace ecosystem in creating new technological solutions, we will also promoted open innovation initiatives, for example, the **Catalonia NewSpace Challenge**, which connects the needs raised by the public administration with the solutions put forward by the NewSpace ecosystem. To that end, the Government of Catalonia will give access to data generated by the experimental infrastructure deployed under the NewSpace Strategy of Catalonia with the objective of developing new proofs of concept and innovative solutions in response to the challenges posed.

c. Innovative public procurement as a way of developing the NewSpace sector

The European Commission, through its framework research and innovation programme Horizon 2020, and initiatives linked to the European Institute of Innovation and Technology (EIT)[83], especially the EIT Digital Community[84], has developed various innovative public procurement projects in recent years, particularly in the health sector. Those are in addition to the public initiatives regularly carried out in our system by means of public procurement. This approach, for pre-commercial public procurement too and still at the development stage, constitutes an essential element for the future of NewSpace in our country, not only for the public funds involved but also for the mobilisation of existing technologies in the productive fabric, the impulse to proofs of concept in different fields and the participation of all the players in the research and innovation system.

With the aim of turning Catalonia into a pole of reference in the NewSpace sector as well in the coming years, the NewSpace Strategy of Catalonia and Advanced Digital Technologies Programme will give priority to innovation projects in Government departments that respond

[83] <https://europa.eu/european-union/about-eu/agencies/eit_es>
[84] <https://www.eitdigital.eu/>

to the administration's challenges (mission-oriented projects) and are developed in collaboration with all the players, public and private, in the research and innovation system (i.e. double use, where the resulting technology can be transferred to the private sector). Accordingly, the priority will be to ensure the entities responsible for the projects will have facilities, prototypes and/or innovation projects in relation to NewSpace, in particular if those projects have been developed within the framework of European initiatives and those funded by programmes linked to RIS3CAT similar ones.

The ultimate goal is that the solutions and applications related with NewSpace have an impact on the different areas of government and give a response to both current needs as well as new services and future projects in the various ministries and departments.

7.2.5.2. Developing NewSpace in strategic sectors

The use of data coming from different payloads located in satellites will give rise to new applications and services geared specifically to the needs of certain economic sectors that are key for the development of our society, such as agriculture, livestock farming, logistics and mobility, among others. However, given the NewSpace economy is also a new economy that is growing, various technological waves are forecast, which makes ongoing cooperation between the players in the ecosystem.

Thus a sectoral galvanisation programme will be promoted to attract business and social challenges that will enable the development of specific services and solutions that are adapted to current needs. For that, co-creation activities will be carried to generate ideas that will bring the supply and demand of different sectors together in a single space to analyse potential use cases, showcase success cases and identify proofs of concept to be carried out, taking advantage of existing programmes or new options that might arise. In that context, connection activities can be developed in the form of a business-science forum, meetings with science or companies, or by means of the connection with clusters and associations that ensure maximum sectoral representation and effectiveness, together with the support of various Government ministries and local administrations promoting sectoral-type initiatives.

It is therefore a question of identifying the main cases of applying NewSpace in each sector, telling companies about them (the Observatory will do that) and supporting them throughout the implementation process. As regards implementing this sectoral galvanisation programme, priority will be given to applying NewSpace to the sectors identified in Section 2.4 of the Strategy, although this does not exclude developing strategic projects in other spheres of action.

7.2.6. Legal framework

Another key element for the success and sustainability of the NewSpace Strategy of Catalonia involves developing a set of regulations that can provide legal stability to rolling out the Strategy and its ecosystem.

7.2.6.1. Legal framework

Having a legal framework will help public sector consumption of new data services, as well as the incorporation of businesses and more critical mass in the NewSpace sector, which will in turn help to generate positive effects on GDP, be a source of employment, enable the development of new knowledge and satisfy the beneficiaries of the results obtained. To put it another way, the Government will have to create a satellite policy that ensures the existence of a market, at least at the outset, and is a seed for the viability of the ecosystem with solid links in the country. That satellite policy has to make a decisive contribution to reversing social inequalities, removing geographical barriers, fostering connectivity between citizens and overcoming, as far as possible, many of the current everyday problems around the country. Well designed, the policy could undoubtedly give Catalonia a competitive advantage over other territories still to make a firm commitment to NewSpace in particular, and the application of digital policies in general.

Mission insurance represents a big challenge for NewSpace. Due to the use of new technologies and the risk involved in launching a space mission, the cost of insuring it is usually very high. Promoting a favourable regulatory framework in this area will prove a very beneficial tool for the NewSpace sector and be an incentive for businesses and projects to establish themselves in Catalonia.

This legal framework linked to the NewSpace Strategy of Catalonia will consist of two main tools: a regulatory norm and the administrative structure in charge of applying it.

The norm, with the force of law and passed by the Catalan Parliament, will have to cover in one document the specific development, in space matters, associated with promoting and regulating NewSpace in Catalonia, based on all the Government's powers. Those competences will serve to regulate, drive, develop and foster business as well as research and innovation activities in this sector. In this context, bearing in mind the characteristics of NewSpace and the direct link with developing other areas of the digital society, it would be appropriate to include the competence and regulatory development of NewSpace in a regulation with a very broad scope.

The Government's basic competences, which are necessary for properly organising the sector are those outlined in Section 5.1.3 Existing legislation and regulations in Catalonia referring to education, culture; access to information and communication technologies; managing local competences; activities for boosting industry; transport and communications infrastructure; planning, organising and promoting economic activity; and research, development and innovation

With regard to shared competences or needs for which the Government has no powers, depending on the current version of the Statute of Autonomy of Catalonia, which includes the outer space objects register, suborbital flight options, ownership of certain infrastructures or facilities, or subscribing to certain international agreements, a suitable policy for collaboration with the pertinent bodies of the Spanish State will be necessary, so it would be useful to have

a single interlocutor with the negotiating capacity and sufficient technical knowledge to interact with their Spanish counterparts.

7.2.6.2. Specific administrative structure

It is also felt there is a need for an administrative structure that would enable NewSpace activity in Catalonia to be administered properly. An analysis of comparative law shows that most norms related to space activity have at some time been associated with setting up an organisation tasked with centralising all aspects of its compliance, with defining a competent business promotion and being responsible for the promotional, monitoring and control activities related to companies that wanted to carry out their business activity in the NewSpace sector, in the broadest and most integrated way possible. In Catalonia's case, given the diversity of sectors interacting with technologies derived from NewSpace and their relationship with digital technologies, this activity could be done by a specific structure or a programme or agency created for that purpose, with a networking operational structure coordinated from the Government.

The basic goals associated with this regulatory framework and its administration are to:

a. Improve the quality of people's lives.
b. Support the economy, business and science by creating a new, sustainable and competitive industry, around a knowledge-based society, that promotes creativity, innovation, entrepreneurship and public-private business projects in the space sector and the NewSpace sector in particular.
c. Promote a secure and stable ecosystem that offers support to space activities.
d. Ensure proper financial support and investment with an interest in this field.
e. Create the necessary facilities and infrastructure with sufficient funding for launching them and keeping them operational.
f. Connect with smart city management and e-government.
g. Provide economic and financial support for diversification and the development of new markets.

8. Conclusions

NewSpace is part of a new economy based on the democratisation of space and that is producing a notable transformation in the space sector all over the world. Catalonia must develop and implement a strategy for that which enables it to turn this transformation into an opportunity for the country, as well as an important contribution to society and its business, social and economic fabric.

In that regard, Catalonia has the knowledge and the capacities that make it an ideal country to become a top player in the NewSpace sector. Among other virtues, the country has some excellent research and innovation teams in the NewSpace field, experience in launching missions and designing payloads, its own ground station, ample experience in generating added value based on data captured on the Earth from platforms in space, and very extensive knowledge in the telecommunications field, with various well-established, skilled and experienced research centres. It also has excellent positioning as a country for attracting national and international investment and talent, an important network of innovative start-ups, and a first-rate digital ecosystem, plus the privilege of having Barcelona as Mobile World Capital and the venue for the main global tech fairs. All in all, an advanced ecosystem that can help to make it attractive for specific private capital to complement all the activities carried out from the public sector and existing start-ups.

Giving an impulse to NewSpace is a priority for the Government of Catalonia, which wants to support the roll-out of this new economy to make Catalonia a pole of innovation, leadership and attraction of talent and companies, an international benchmark. With this goal in mind, the Government is driving the NewSpace Strategy of Catalonia, which will implement a programme of specific actions to strengthen the Catalan NewSpace ecosystem and lead the generation of knowledge, its social and business application and the creation of new solutions based on data provided by the use of technologies based on the NewSpace concept, with the objective of fostering economic growth, improving people's lives, having a cutting-edge public administration supporting R&D&I and the use of this new set of instruments and digital technologies.

The NewSpace Strategy of Catalonia is coordinated by the Catalan Ministry for Digital Policy and Public Administration, in collaboration with the Ministry of Territory and Sustainability and the Ministry of Business and Knowledge, and also with participation from the other ministries.

The Strategy involves rolling out a multi-sectoral, cross-cutting plan focused on the needs of the public administration and the impact on people, businesses and a host of entities, prioritising spheres such as territorial management, agriculture, livestock farming, hydrography, cartography and public services management, among others. It will be implemented through an action plan based on the following areas:

- **Ecosystem:** promoting a broad-based governance model in various areas that supports the development of a coordinated NewSpace ecosystem which is connected to the world and includes all the players in the value chain.

- **Research and innovation:** fostering research and innovation by applying specific instruments and establishing synergies between different government ministries, universities, specialised research and innovation centres, organisations making intensive use of the data generated by satellites, and the private sector.
- **Talent and society:** creating, attracting and retaining specialised talent that drives the development of new services and solutions in the NewSpace sector, and training professionals from other sectors to cope with their impact.
- **Infrastructure and data:** having experimental satellite infrastructures in place that enable new solutions and technologies to be validated, and having new data available to facilitate secure, open and transparent access.
- **Adoption of NewSpace services:** promoting the use of new services and data facilitated by NewSpace as an engine for innovation in the public administration and in strategic sectors that are key for the country's future development, both traditional and emerging ones.
- **Regulatory framework:** having a structure within the public administration that provides a legal and regulatory framework applicable to NewSpace.

The NewSpace Strategy of Catalonia must be shared by all Catalan public administration and private sector players as well. Not only does NewSpace represent a new technological sector but also a new economic sector that requires a new regulatory and legislative framework that will have a cross-cutting impact on diverse productive and social sectors.

9. Initials

BEC	SMOS Barcelona Expert Centre
CalPoly	California Polytechnic State University
CIDAI	Centre of Innovation in Data Tech and Artificial Intelligence
COTS	Commercial Off-The-Shelf
CREAF	Ecological and Forestry Applications Research Centre
CSIC	Higher Scientific Research Council
CTO	Chief technology officer
CTTC	Catalonia Telecommunications Technology Centre
DIH	Digital Innovation Hub
DLR	Deutsches Zentrum für Luft-und Raumfahrt (German Aerospace Centre)
EAC	European Astronauts Centre
EC	European Commission
ECSAT	European Centre for Space Applications and Telecommunications
EEB	Department of Electronic and Biomedical Engineering
EO	Earth Observation
ESA	European Space Agency
ESA BIC	ESA Business Incubation Centre
ESAC	European Space Astronomy Centre
ESEC	European Space Security and Education Centre
ESOC	European Space Operations Centre
ESRIN	European Space Research Institute
ESTEC	European Space Research and Education Centre
EU	European Union
FQA	Quantum Physics and Astrophysics
FSS	Federated Satellite Systems
FYS	Fly Your Satellite
GEO	Geostationary orbit
GNSS	Global Navigation Satellite System
GNSS-R	GNSS-Reflectometry
GNSS-RO	GNSS-Radio Occultation
GPS	Global Positioning System
GRSS	Geoscience and Remote Sensing Society
HEO	High Earth Orbit
IA	Artificial Intelligence
ICCUB	Institute of Cosmos Sciences – University of Barcelona
ICE	Institute of Space Sciences
ICGC	Cartographic and Geological Institute of Catalonia
ICM	Institute of Marine Sciences
ICTs	Information and Communication Technologies
IEEC	Institute of Space Studies of Catalonia
IEEE	Institute of Electrical and Electronics Engineers

IFAE	Institute of High Energy Physics
INTA	National Institute of Aerospace Technology
IoSat	Internet of Satellites
IoT	Internet of Things
ISL	Inter-Satellite Link
LEO	Low Earth Orbit
LoRa	Long Range
M2M	Machine to Machine
Mbps	Mega bits per second
MEO	Medium Earth Orbit
MIMO	Multiple-In Multiple-Out
MWC	Mobile World Congress
NASA	National Aeronautics and Space Administration
NB-IoT	Narrow Band - Internet of Things
OAdM	Montsec Astronomic Observatory
OISL	Optical Inter-Satellite Link
R&D	Research and Development
R&D&I	Research, Development and Innovation
RF	Radio frequency
SAC	Statute of Autonomy of Catalonia
SDGs	Sustainable Development Goals
SDR	Software Defined Radio
SMOS	Soil Moisture and Ocean Salinity
SWOT	Strengths, weaknesses, opportunities, and threats
TEDAE	Spanish Association of Defence, Aeronautics and Space Technologies Companies
TM/TC	Telemetry and Telecommand
UAB	Autonomous University of Barcelona.
UB	University of Barcelona
UHF	Ultra-high frequency
UN	United Nations
UPC	Technical University of Catalonia
VHF	Very-high frequency