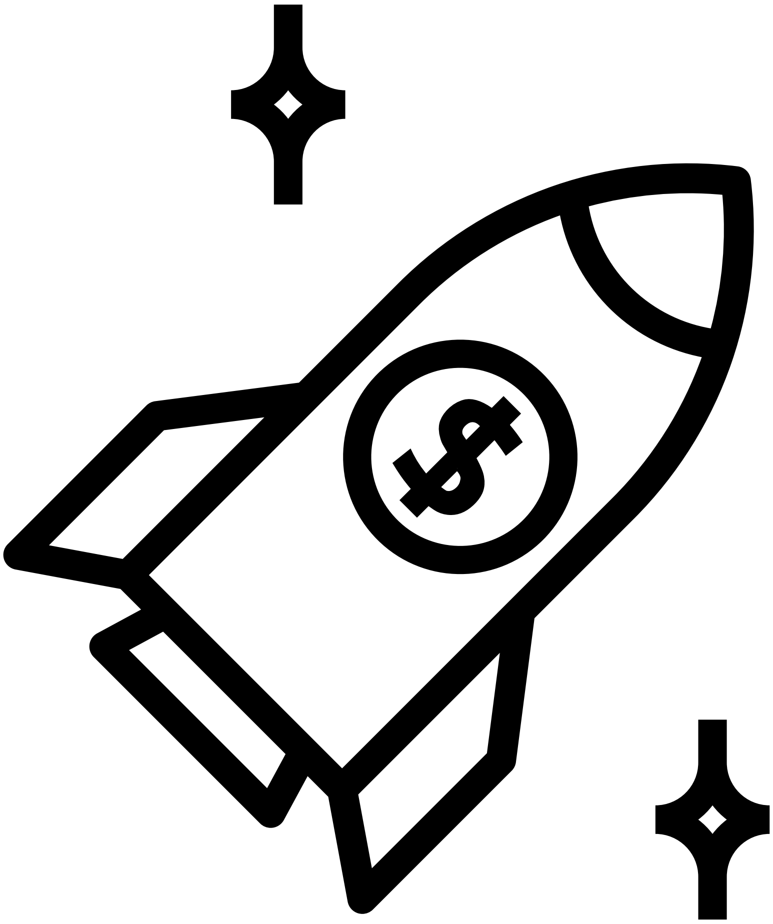
Fundación Innovación Bankinter
FTF Future Trends Forum
31 English version

Commercialization of Space



Commercialization of Space

FTF | Bankinter Innovation Foundation

Acknowledgements

We would like to express our gratitude to the journalist D. Javier Pedreira (Wicho), who wrote this report that captures the trend analysis and recommendations made by the experts who attended the Future Trends Forum (FTF).

We would like to thank the members of the *Future Trends Forum*, the attendees of the 31st conference and our collaborators for organizing and defining the methodology of the FTF conference:

Christopher Meyer

Clemens Hackl
Georg Seiler

Lastly, we would like to express our gratitude to the Bankinter Innovation Foundation for their commitment to our mission of promoting innovation in our society:

Bankinter Innovation Foundation

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The opinions expressed in this report are those of the author. They do not reflect the opinions of the experts that participated in the Future Trends Forum conference.

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Thank you so much
Bankinter Innovation Foundation

Index

Space as an Industry

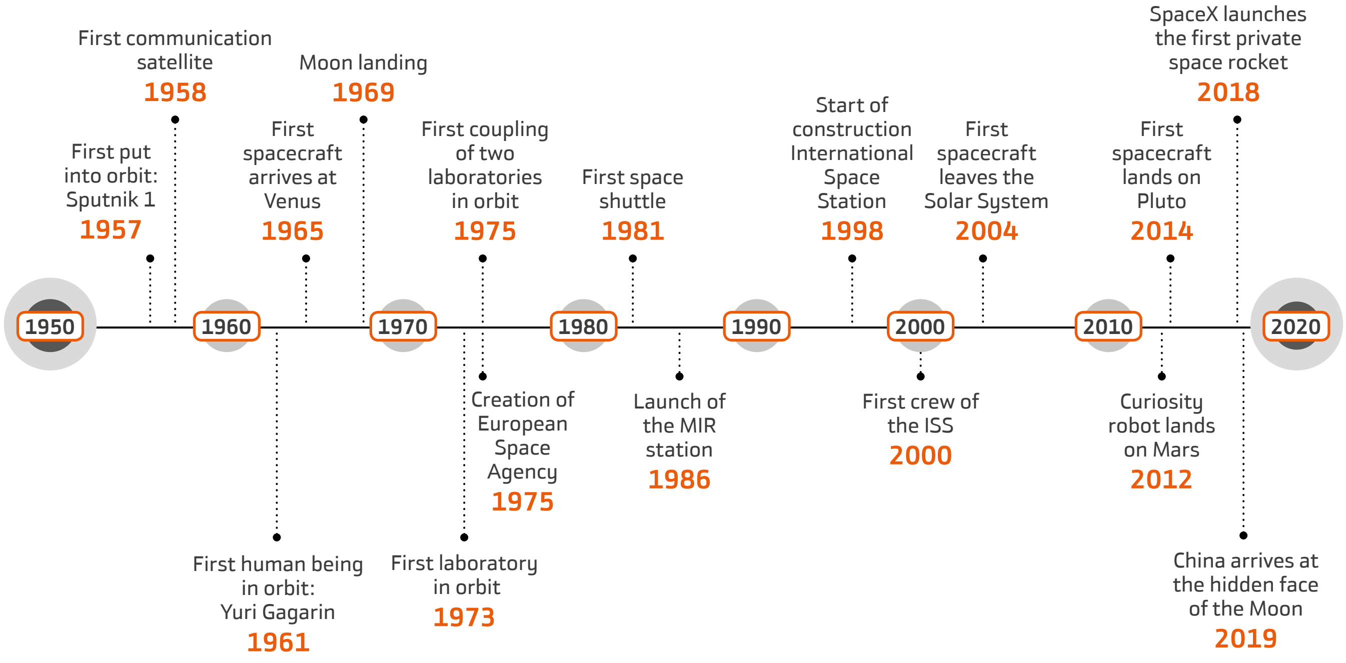
1.0

The Space Age

1.1

▸ **By the mid-20th century**, the then superpowers (the United States and the Soviet Union) had made their first forays into Space, signifying the beginning of the Space Age.

The main milestones are detailed below, and can be reviewed in greater detail on this page



1973

First laboratory in orbit

After both superpowers reached the Moon, they turned their attention towards Low Earth orbit. NASA built the Skylab Space laboratory, which was active for roughly six months between May of 1973 and February of 1974; the USSR built the Salyut and Almaz series Space stations, which were active from 1971 to 1986. The Salyut series stations came directly before the Mir Space station, which was in orbit from 1986 to 1996.

The end of this rivalry led to a period of initially hesitant collaboration. As part of the Apollo-Soyuz Test Project, a Soviet and American Space craft docked in orbit for the first time on July 17, 1975. To an extent, this project was the springboard for the agreement that led to the construction of the International Space Station (ISS). The United States and Russia are the main stakeholders, but the Space station is also supported by other agencies: the European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA) and Canadian Space Agency (CSA).

1998

Construction of International Space Station begins

In-orbit construction of the ISS began on November 20, 1998, when the station's first module, Zarya, was launched. The following month, the Unity module was launched and made the station inhabitable. However, a few years would pass before the ISS would become permanently manned.

At 9:21:03 (UTC) on November 2, 2000, the Soyuz TM-31 docked with the ISS. The former was manned by Yuri Gidzenko, Sergei Krikalev (for the second time) and William Shepherd. From then on, the ISS has always housed a crew.

Over time, the ISS has functioned as a laboratory, housing experiments in various scientific fields, due, above all, to the fact that it is a weightless (or zero-gravity) environment. It has also functioned as a testing ground for technology to be implemented in Earth as well as in Space.

2004

First probe sent to furthest planet in the Solar System

At the same time that man took to Space, many Space probes and Earth observation satellites, starting with Sputnik, were launched. Artificial satellites for commercial purposes, whose technology frequently served a military purpose in the past, were also launched.

Over the past sixty years of the Space Age, we have been able to send probes to every planet in our Solar System and many of their moons. Pluto was the last that we reached (2014), but by the time the new Horizons probe had arrived at its destination, Pluto was no longer classified as a planet. It would be remiss of us not to mention NASA's Voyager probes that have charted a course for interstellar Space though–depending on your perspective–they may have already arrived. Initially, these probes simply flew past their subjects, recording data as they went. Later, we were able to place them in orbit and ultimately land them on their subjects. In some instances, we have even been able to place vehicles on celestial bodies, such as the Soviet Lunokhod that explored the surface of the Moon between 1970 and 1973. We have also brought back samples from the Moon, Space and asteroids, such as Itokawa. We have even placed a probe in a comet's orbit (the ESA's Rosetta probe) and a lander (Philae) on its surface.

However, we have not neglected our own planet. Many types of Earth observation satellites and scientific-satellite missions have revealed more about our home.

2012

The robot Curiosity lands on Mars

On August 6, 2012, NASA's Curiosity rover landed on Mars. In December 2018, NASA extended its initial, two-year mission indefinitely due to the vehicle's success. The rover has been tasked with studying the climate and geology of Mars and determining if, at any point in the past, the planet possessed the conditions necessary for harboring microbial life, such as water. The rover is also measuring radiation levels on the surface in preparation for possible manned missions to Mars.

Six years after Curiosity landed, the rover has been able to work without a hitch, though its wheels have become more worn than initially expected. This may lead NASA to convert the rover into a fixed observation platform until 2020, when NASA will send a new rover that is based on Curiosity's design. The European Space Agency, in conjunction with Roscosmos, is also expected to send its first Mars rover in 2020. It is named Rosalind Franklin, in honor of the British scientist that helped discover the structure of DNA. However, none of this would have been possible had it not been for this technology's predecessors. Sojourner, which landed on Mars on July 4, 1997, operated for 84 sols (Martian days) when it was only expected to last from 7 to, at best, 30 sols.

Then came Spirit and Opportunity. They landed on Mars in January of 2004 and operated until 2011 and 2018, respectively, far surpassing the initial estimate of 90 sols.

2019

SpaceX launches the first Space 2.0 manned capsule

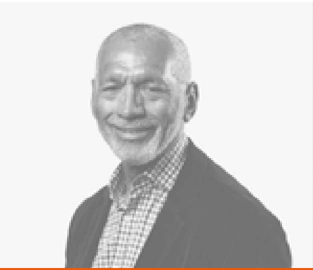
SpaceX revolutionized the Space launch market with the Falcon 9. It was the first rocket ever built with a reusable first stage, and it played a significant role in lowering launch prices. Now, the company's about to make history with the Crew Dragon manned capsules.

One of the capsules, which was unmanned, just returned from a test flight to the International Space Station. All the on-board systems were tested to prove that it can dock to the ISS and return automatically.

The capsule's life-support system was also tested; this functionality is not included aboard the Dragon cargo capsule, which regularly provides services to the ISS.

Given the highly successful results, everything is ready for the launch of the first manned Crew Dragon capsule to the ISS. All that is left is another test flight to check the escape system.

This will be the first manned capsule developed by a private company that goes into orbit and a great milestone in Space exploration.



Duration: 10:26min

Charles Bolden
President of The Bolden Consulting Group LLC and Former NASA Administrator

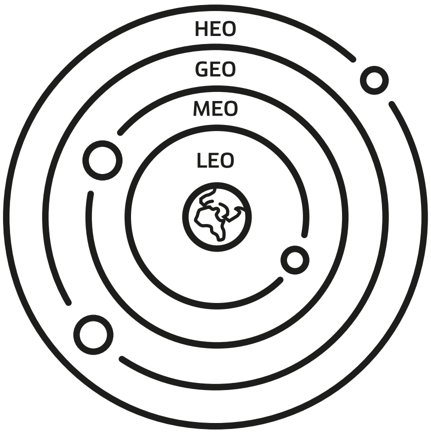
Video:
What we do in Space is to improve life on Earth

Orbits

1.2

In order to understand the Space Industry and business opportunities in Space, one must understand the playing field: orbits, how they are defined and what ventures are suitable for each orbit.

The main orbits are as follows:



Each orbit is described in detail below.

Sub-orbital Space flight

Sub-orbital launches are those whose payload generally reaches a maximum altitude of 100-150 kilometers and then falls in a matter of minutes. The edge of Space is located at 100 kilometers from the Earth's surface.

These launches serve a primarily scientific purpose; experiments are conducted and technology is tested. NASA has tested the parachutes for the next vehicle that will send to Mars' surface.

This is also the orbit in which companies are working to commercialize Space tourism for the first time on a large scale–to the extent that you can create a large market for tickets of upwards of $100,000. Jeff Bezos' Blue Origin and Richard Branson's Virgin Galactic are conducting test flights with their respective Spacecraft. Perhaps we will see the first instances of commercial Space travel in 2021.

This orbit may also be leveraged in high speed, inter-continental travel–a 90-minute trip from Europe to Australia, for example. Though this possibility has been discussed–and Elon Musk says that the rocket his company is designing could serve this purpose–one thing is certain: in this field, no real bets have been placed to date.

Low Earth orbit (LEO)

This is the first step in leaving Earth and remaining in Space. LEOs have an altitude that ranges anywhere from 200–2,000 kilometers above the Earth's surface. They do not have to be circular, but typically they are or are near circular.

The large majority of satellites in Space, no matter their purpose, are found in this orbit. The ISS and its predecessors have all been located in LEO. The only humans to have ever left lander were those aboard the Apollo 8 through Apollo 17 missions to the Moon. However, they never landed there.

Aside from orbital altitude, one must also consider orbital inclination. They span from zero degrees (following the path of the Equator) to polar orbits that are near 90º and, as their name indicates, extend from pole to pole. Inclination dictates which parts of Earth fall under an orbit.

The altitude, and therefore velocity, of a satellite determine the time it takes for a satellite to orbit Earth and return to a set point. The greater the altitude, the slower the satellite. This time period is now as the satellite revisit period. This is an important metric to take into consideration when building a satellite that measures, for instance, air pollution. Systems of two or more satellites are often employed in the same orbit to reduce the revisit period. This metric plays a key role in the construction of satellites that are designed to transmit voice and data communications across Earth. In LEO, many satellites (tens, hundreds or even thousands) are needed to ensure constant coverage.

Altitude also has a significant impact on the quality of data collected by Earth observation satellites. The closer a satellite is located to Earth's surface, the better the image quality of whatever the satellite is measuring at the time. However, a lower altitude means greater atmospheric friction and, therefore, a shorter life for the satellite, as it is drawn ever close to the Earth's atmosphere and ultimately consumed by it. Satellites use their motors to counteract the effects of atmospheric friction and maintain altitude. Yet when they run out of fuel, they inevitably fall. In fact, once or twice a month, the International Space Station uses its motors or those of any vessel docked to it to increase the altitude of its orbit. Even at 500 kilometers above the Earth's surface, atmospheric friction causes the ISS to drop roughly one kilometer per month. If it weren't for these maneuvers, the ISS would have burned up in Earth's atmosphere a long time ago.

Due to the popularity of this orbit, it is extremely important that Space debris reduction strategies be employed and that satellites possess enough fuel to leave their orbits ad safely return to Earth's atmosphere to be destroyed.

Medium Earth orbit (MEO)

This orbit is roughly above 2,000 kilometers and just shy of the 36,000 kilometers altitude of geostationary orbits.

Telecommunications and navigation satellites typically occupy this orbit. Common examples are the Beidou systems satellites, GPS, Galileo, Glonass and India's IRNSS. Geotdetic satellites and those that measure Space weather also occupy MEO. Depending on a satellite's altitude, its revisit period can range anywhere from 2 to 24 hours. Telstar 1 was the first commercial, telecommunications satellite and was launched into MEO. Its minimum altitude is 952 kilometers and its maximum is 5,933 kilometers. It orbits at Earth at 45-degrees and has a revisit period of 2 hours and 37 minutes.

Geostationary and geosynchronous orbits (GEO)

The two terms are often confused even though, technically, they are different. For all intents and purposes, satellites in geostationary orbit remained fixed above a specific location on Earth's Equator and from down on Earth, they appear to be fixed in the sky. Satellites in geosynchronous orbit appear to be in motion even though they never lose site of a specific point on Earth. These orbits are ideal for telecommunications because they allow telecomm satellites to provide a specific geographic location with constant coverage. They are also useful for Earth observation satellites, such as the famous European Meteosat satellites, because they allow for permanent observation of a specific location on Earth.

Given Earth's rotational velocity, these types of satellites must be located at an altitude of 35,786 kilometers. Furthermore, to prevent interference, these satellites cannot be too close together. That is why every launch must be approved by the International Telecommunication Union.

Today, there are slightly less than 450 satellites in these orbits, though some are inactive. Ideally, a satellite in GEO should have enough fuel to ensure that it can be sent into a higher, graveyard orbit upon completing its mission and that it will not interfere with other satellites once it stops operating.

High Earth orbit (HEO)

Simply put, these orbits are found at a higher altitude than GEOs. Their defining characteristic is that their orbits exceed 24 hours and the part of Earth that they observe moves westward. In reality, HEO is rarely used.

Out of orbit

Objects in this category do not revolve around Earth. They may be heading to the Moon, Mars, a different celestial body or any of the Lagrange points in the Earth-Sun or Earth-Moon systems.

These five points occur because the competing gravitational forces of the Sun and Earth or the Moon and Earth essentially counteract each other and immobilize small objects, such as Space observatories or probes. These objects do not need to consume fuel. Lagrange points can occur between any two celestial bodies of substantial size.

For example, the ESA-NASA Solar Heliospheric Observatory is located at the L1 Lagrange point. The Gaia observatory is at L2, and the James Webb Space Telescope will also be located there someday. Recently, China has placed the Quequiao satellite at the Earth-Moon L2 point so it can relay communications from the Chang'e 4 mission, the first landing on the far side of the Moon.

For now, the Moon, Mars and other celestial bodies have been the furthest destinations that we have reached. The New Horizons probe broke its own record, having already studied Pluto during a flyover on July 14, 2014; the probe visited Ultima Thule (an object located in the Kuiper Belt) on January 1, 2019.

New Horizons does not posses fuel to enter into orbit around Pluto, Ultima Thule or any other target. In terms of fuel consumption, each orbit is more costly than the last. Regarding the trip to Pluto, scientists needed to strike a balance between a reasonable time frame (9 years after launch) and fuel consumption. Without the right amount of fuel, the probe would have traveled so slowly that many of those involved in the mission would have died before the probe reached its destination.

In discussing commercial Space exploration, asteroids of the asteroid belt are an attractive destination. Hypothetically, they could be an almost unlimited source for certain raw materials. Yet for now, we do not possess the technology for building a ship with the carrying capacity that would make such a trip worthwhile. We neither have the robots that would be capable of carrying out the mining project nor the manned ships that would transport miners.

For now, Space remains the realm of science, and there are few opportunities for commercialization, apart from those that may be derived from the data collected by probes, rovers and Space observatories.

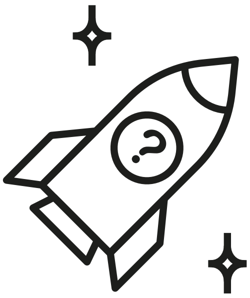
Space as an Industry

1.3

Space-related businesses generate roughly $260 billion annually. According to estimates from Bank of America Merrill Lynch, investment in Space will increase eightfold, reaching roughly $2.7 trillion.

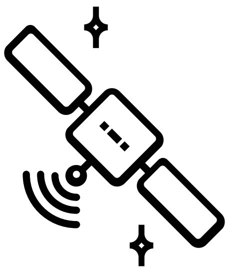
This growth will be driven by the construction of reusable rockets, the ever-increasing demand for Internet access in remote parts of the world (~4 billion people without Internet today), the growing demand for mobility and the increasing desire to monitor the environment, which includes weather forecasting needs. Investment is divided into three parts:

Rockets



Rockets must be built in order to launch the wide variety of satellites, probes and ships into Space. Without rockets for transport, it does not make much sense to build any type of satellite, rope or ship.

Satellites



Next comes the construction of satellites of all types, including those for Earth observation and communications, to name a few, as well as Space probes, cargo vessels and manned ships.

Control systems

These satellites and probes require control systems and infrastructure that ensure that tools and vehicles are effectively used once in orbit.

Richard Pournelle
Senior Vice-President of Business Development at NanoRacks

Video:
It is getting easier to reach Space

Duration: 10:42 min

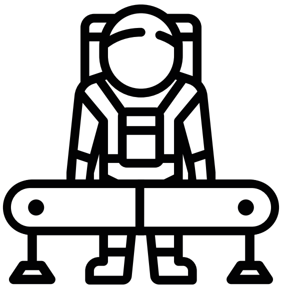
For now, governments are the majority stakeholders in Space and often hire traditional, large, aerospace firms to design, build and launch their projects.

We must wait and see what slice of the $2.7 trillion pie will go to private companies. It is estimated that between June 2017 and June 2018, private companies invested $3.4 billion in Space. According to analyses this figure will increase as technology becomes more advanced and costs as reduced. We will be able to build satellites and launchers at prices that were inconceivable not so long ago.

In fact, a growing number of companies, that are entirely outside the traditional aerospace sector are entering the market and risking their investment capital on projects without any type of government support.

Space Industry Applications
1.4

Manufacturing



Space allows for certain conditions that would impossible to replicate on Earth–above all, microgravity which allows us to build products without the supports that would be required on Earth. We can achieve optimal designs and even create things that would be impossible to build due to Earth's gravity. Microgravity also allows materials to uniformly mix, reducing impurities. This can be achieved to an even higher degree when conducted in a vacuum. For example, fiber optics, protein crystals and even metal alloys were created in a small, electric oven aboard the ISS.

Manufacturing in Space could generate roughly 320 million euros per year.

Perhaps the most practical example that we have seen to date was built by the US company Made in Space. They created the Additive Manufacturing Facility, a 3D printer installed in the ISS in order to build parts and test new ideas and concepts concerning manufacturing in microgravity. Yet their plans are far more ambitious; they are partnering with Northrop Grumman and Oceaneering Space Systems to develop Archinaut. This module would be mounted on the exterior of the ISS and would be able to manufacture, assemble and repair structures and machines. In addition to a 3D printer, the module would possess three robotic arms for manipulating the pieces that it builds.

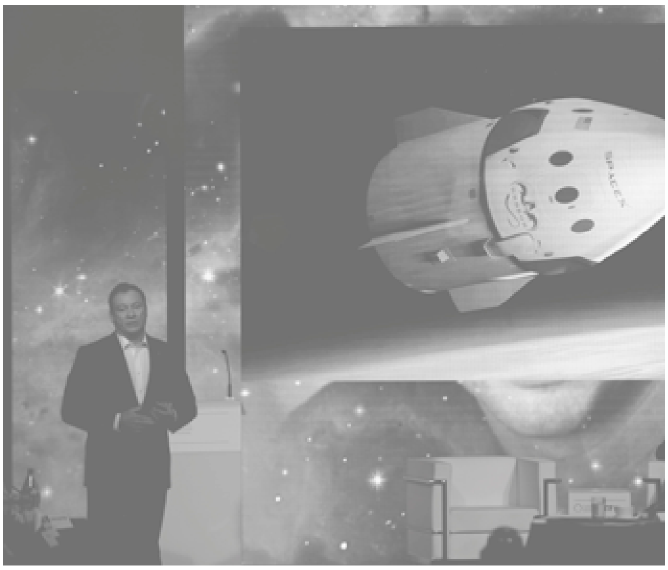
The main roadblock is that sending raw materials into orbit remains quite costly. Therefore, it is difficult to justify these processes. However, as launches become cheaper in the future and–even further down the line–we are able to extract raw materials from asteroids, things may change.

Duration: 11:15 min

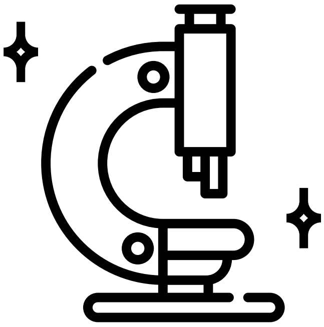
Jason Dunn
Co-Founder and Director of Made In Space

Video:
How can the Space Industry solve the problems of tomorrow?

According to the IDA study, Market Analysis of a Privately Owned and Operated Space Station manufacturing in Space could generate roughly 320 million euros per year. However this figure is quite speculative, given that very little has taken place to date. In fact, this figure stems from the hypothetical construction and launch into orbit of a private Space station that would be up and running as early as midway through the 2020 decade.



Research



Since the dawn of the Space Age, we have been studying Space-related topics and have even done so from Space itself. Sputnik 1 made possible the study of the density of the furthest reaches of Earth's atmosphere as a result of the effects of friction on the satellite's orbit. Radio signals propagated from the satellite were also used to study the ionosphere. Satellites, probes and the tools and systems are aboard are often built to conduct scientific research in Space.

Space research is a €73 billion market in 2019. By 2040, it is estimated at €160 billion.

Government agencies, including Space agencies, have historically been some of the primary customers. Others have been universities and large laboratories across almost every scientific field: astronomy, materials science, biology etc.

Yet, due to the popularity of CubeSat and decreasing launch costs, more companies are interested in launching their own experiments into Space in order to develop new technologies and sell them to other companies or simply to conduct research. These micro-satellites are built with standard parts, making them quite affordable comparatively. Firms such as NanoRacks help institutions and other companies design their own experiments and satellites as well as put them in orbit. These companies are further widening this market segment.

At any rate, it is most likely that government funding will continue to dominate basic research. These investments currently amount to 73 billion euros annually and are expected to reach 160 billion euros by 2040. However, we must keep in mind that this funding also goes towards Space exploration.

Álvaro Giménez
Managing Director CSIC Foundation and Former ESA Director of Science

Video:
The benefits of Space for scientific research

Duration: 1:56 min

Observation

This is another field in which various Space agencies have been involved, almost since the beginning of the Space Age. In fact, the first weather satellite, NASA's TIROS-1, was launched in 1960. More weather satellites were subsequently built, together with those that measured vegetation cover, the level and temperature of oceans, rivers and lakes, the thickness of polar ice caps and the levels of greenhouse gases and air pollution. Data from these satellites is also used to prevent and mitigate the damage from natural and man-made disasters.

Observe other parameters such as the vegetation cover of the planet, the level and temperature of seas, rivers and lakes, the thickness of the polar ice cap, the presence of greenhouse gases and atmospheric pollution.

The current Space observation market is worth €20 billion. Growth is estimated at 18% year on year.

But the majority, if not all, of Earth observation satellites and instruments currently in orbit were government funded, which means that their data can be accessed free of charge. Thus, the business opportunity lies in processing this data and offering services based on it. These services advise farmers on when to cultivate crops. They allow us to study growth patterns in cities to determine the best site for a future shopping mall. We can subsequently monitor the use of its parking lot (as long as it is above-ground) to assess its profitability. We can study the placement of icebergs in oceans to determine optimal shipping routes. These are but a few examples.

In recent years, and due once again to decreasing launch costs and satellite-construction costs, many companies have entered the market. DigitalGlobe, ImageSat International and Planet Labs are launching their own fleets of satellites into Space to collect data that these companies later sell. Planet Labs, for example, can take daily photographs of the entire surface of Earth thanks to its satellite constellation. This information, supplied on a daily basis, could be quite valuable.

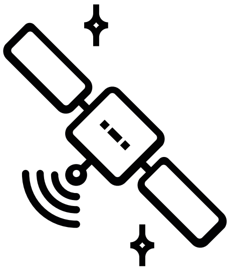
This market is estimated tow be worth roughly $22 billion today and grow at an annual rate of close to 18%.

Duration: 12:35 min

Marco Brancati
Chief Technology Officer at Telespazio Group

Video:
The opportunities of Earth observation

Communication



This is yet another field in which Space technology has historically been leveraged. Signals from telephones, radios and televisions as well as, to an increasing extent, data signals are sent via satellite. Though these connections are made wirelessly, we must acknowledge that underwater cables that run across the world are chiefly responsible for these types of communication. However, Space technology plays a key role in communication when remote parts of the world must be reached. It would be otherwise impossible to communicate with these regions due to the costs of building infrastructure on Earth.

Signals from telephones, radios and televisions as well as, to an increasing extent, data signals are sent via satellite.

Traditional telecommunications companies have always been active in this field, and, in fact, AT&T launched the very first telecommunications satellite, the Telstar 1. There are a growing number of new companies that are willing to stake a claim in the market and launch their own satellite constellations to bring Internet access to remote regions as well as to aircraft or maritime vessels that would otherwise remain isolated. In this context within the Space Industry, the reduction in launch costs and satellite-construction costs are also two key factors that pave the way for new companies to enter the market.

The demand for data transmission is predicted to grow with the increase in usage of mobile devices, autonomous vehicles and devices that are connected to the Internet of Things. All signs lead to communication as one of the largest sector within the Space Industry in coming years.

Duration: 2:27 min

Antonio Abad
Chief Technical and Operations Officer at HISPASAT.

Video:
Satellites will have a fundamental role in connecting 'not connected' people

Defense

Defense has been a priority throughout the Space Age. In fact, the design for the first rockets was based on that of intercontinental missiles. Even if we refuse to delve into the fact that the Outer Space Treaty prohibits arms in Space, military needs have historically been a clear driver of the Space Industry. Governments, via traditional aeroSpace firms, have liberally invested in the construction of spy satellites and military communication networks. GPS, which seems so normal today, was originally a US-government project that would provide the military with a system to determine the location and local time for armed forces anywhere in the world.

It seems unlikely for 'new Space' companies to enter the market through these types of projects. Nevertheless, there are certain services that private companies, such as Thales Alenia, can provide in terms of security, especially where governments are lacking in infrastructure.

This market size is €22 billion approximately.

Since traffic in Space is increasing, companies could provide governments with data on all launches. Initiatives like the Space Data Association could be of interest to the military. They share data on commercial-satellite orbits as well as their radio-frequency use; the military would not need to worry about collecting this data itself. This data helps prevent collisions and close calls between satellites. The military could use commercial satellites to obtain additional bandwidth. They could install transmitters in commercial satellites or even rent channels, transmitters or entire satellites. In fact, the United States Department of Defense obtains 80% of the capacity that it needs through an annual investment of close to $1 billion. The military could also turn to pseudo-satellites from the private sector: planes, balloons or airships that fly at altitudes of 20-50 kilometers. These vessels can provide communication and observation services, private reconnaissance, drone control, anti-interference technology and protection against nuclear radiation.

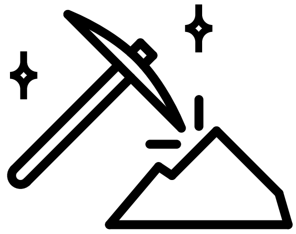
According to SpaceNews, roughly 11 billion euros will be set aside for the United States in 2019. According to Deloitte, global revenue in 2017 equaled 605.6 billion euros. Therefore total market value is estimated at more than 22.5 billion euros.

Eduardo Bellido
CEO at Thales Alenia Space Spain

Video:
The role of companies in defense operations in Space

Duration: 9:23 min

Mining

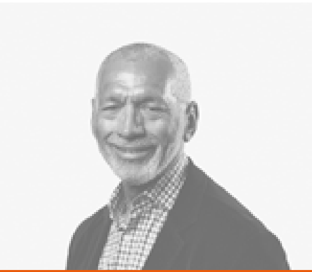


The idea essentially consists of extracting the raw materials found in asteroids. This sounds a bit like the Space-tourism pipe dream of the past but could be even more far-fetched. We have never been able to bring any materials back down to Earth to be processed, apart from a few hundred kilograms of samples from the Moon and milligrams of particles collected from the tail of a comet and an asteroid. Nor are we able to build a mine near or on the surface of an asteroid.

In fact, other companies have since absorbed Deep Space Industries and Planetary Resources, both founded in 2012. They were created in response to an announcement from the Obama Administration regarding a NASA mission to study methods for redirecting asteroids.

Exploration

Exploration, our desire to reach the furthest limits of Space, has been a key activity since nearly the beginning of the Space Age–even though we did not reach the final planet in our Solar System until July 14, 2014. Well, that is how Pluto was classified at the time, when the New Horizons probe was launched. Close to 57 years had passed since the USSR put Sputnik 1 into orbit.



Duration: 3:07 min

Charles Bolden
President of The Bolden Consulting Group LLC and Former NASA Administrator

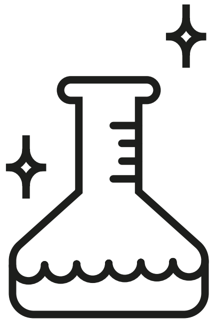
Video:
The potential of Space exploration is unlimited

In this facet of the Space Industry, income stems from the construction of a variety of probes, launches and the monitoring of missions from Earth. Similar to research, Space exploration has always depended on government funding. National governments, through their corresponding Space agencies, have financed every mission, and there are no signs of change in the near future.

73 billion euros are invested on annual basis. This figure is expected to grow to 160 billion by 2040. However, research programs with closer ties to Earth as well as Earth observation satellites also receive this money.

Current investment in Space exploration is worth €73 billion. Growth estimates point to €160 billion by 2040.

Pharma



Traditionally, world superpowers and Space agencies have experimented with chemical synthesis in orbit. The results are far different from those obtained on Earth and often impossible to achieve under the effects of gravity.

For companies such as Space Pharma, life sciences in orbit or in microgravity are a not-so-distant revolution. They call it 'the fourth Space revolution,' in which they seek to build remote-controlled miniaturized laboratories in satellites or Space stations where they can produce molecules far superior to their equivalents on Earth. The business model lies in the fact that these molecules are much more efficient. With just one gram of these Space-produced substances, we can produce a kilogram of material on Earth, a 1,000 to 1 return on investment.

Yossi Yamin
Chairman & R&D CEO at SpacePharma

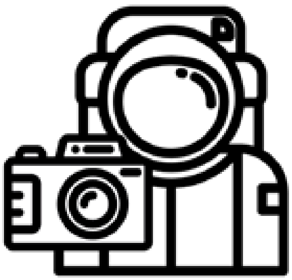
Video:
A laboratory in the Space for health on Earth

Duration: 11:25 min

The idea is to set up miniaturized laboratories on satellites or space stations, where they can remotely produce these molecules, which work much better than their terrestrial counterparts.

We need to ensure that we can implement those ideas and assess their potential turnover.

Tourism



The perpetual promise. So far, only seven people–all quite rich–have been able to buy their own ticket to the International Space Station. The first was Dennis Tito, who spent seven days on board between April and May 2001. The most recent tourist was Guy Laliberté, who spent several days in Space in September 2009. Trips to the ISS were suspended after NASA retired Space shuttles in 2011; Soyuz crew capsules became the only means of transportation to the ISS. Since then, all seats have been taken by astronauts from the agencies that work in the ISS.

However, 2019 may be the year that will see a reduction in Space tourism prices from several million euros to 'just' a couple of hundreds of thousands. Companies such as Blue Origin–owned by Amazon's founder Jeff Bezos–with its New Shephard's first manned flight or Virgin Galactic –owned by Richard Branson–with its SpaceShipTwo flight will soon offer trips to Space. Travelers will experience zero gravity for a few minutes before coming back to Earth. Let's not forget that back in 2004 SpaceShipOne reached Space twice, which led us to believe that these types of flights were just around the corner. 15 years have passed, and we're still waiting, even after a fatal accident.

We'll still have to wait a little longer to see Space tourists in orbit again, whether aboard the ISS or private Space stations (sort of like Space hotels) that companies such as Bigelow Aerospace and Axiom Space want to build. Not only do they need to build these Space hotels, but they will need to use Spacecrafts to reach them as well. Bigelow has a head start thanks to their experience with the Bigelow Expandable Activity Module, which has been in the ISS since 2016.

Only seven people, not astronauts, have been able to go to Space.

If everything goes according to plan, both Boeing and Spacex are just a few months away from launching their manned Spacecrafts CST-100 Starliner and the Crew Dragon. Both companies have signed contracts with NASA to transport crew members to the ISS, but they are free to charter commercial flights as well.

Given its prices, the market is quite small. Provided that everything goes well and tourists can actually start flying to Space, it is estimated that the market will be worth about $1.3 billion five years from now.

Estimates point to €1.15 billion market volume in 5 years.

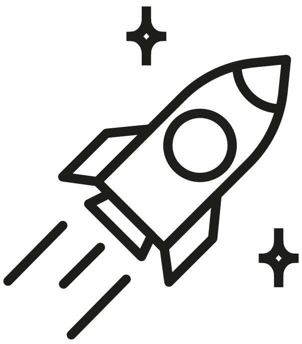
It will also be difficult to make progress within the next few years because developing manned Spaceships is expensive and complicated. Therefore, that segment of the market will be intriguing but small.

Michael López-Alegría
Former U.S. Navy Test Pilot and NASA astronaut, consultant, public speaker

Video:
The factors that drive a commercial space station

Duration: 14:53 min

Launch



The launch industry has traditionally been dominated by large, well-established companies from the aerospace industry. They build according to specifications from governmental bodies even if they subsequently use their rockets for commercial purposes.

However, both this area and satellite manufacturing have experienced significant changes in recent years. The main disruption is caused by SpaceX, founded by Elon Musk in 2002. Since 2010, it has been successfully using its Falcon 9 rocket (whose first stage is reusable) among other developments. The company has significantly reduced launch costs and become quite agile. In 2018, 21 launches were successfully completed. The company boasted the most launches in 2018 and is also willing to revolutionize the segment of heavy launchers with the Falcon Heavy (operational in 2019) and Starship/ Super Heavy, their super heavy launcher, in the long-term. Blue Origin, Jeff Bezo's company, is also working on a heavy launcher. The New Glenn, whose reusable first stage will allow for a reduction in launch costs, will not be operational until 2021.

The idea is to offer more affordable launches.

On the other side of the market, another company is rewriting the rules. Rocket Lab promises frequent–though not necessarily cheaper–launches in their Electron rocket. Any client who has a satellite of up to 225 kilos to launch into low Earth orbit can have an Electron rocket almost immediately. The company can produce up to one rocket per week in their factory. The Electron rocket was operational in 2018 and the company's 2019 goal is to increase their launch cadence to a maximum of one per month. This will be easier to accomplish once they open their second launching facility in the United States; the first is in New Zealand.

According to some estimates, the market may surpass €10 billion by the end of 2019.

The fastest-growing segment is, in fact, launchers for small satellites. There's a myriad of companies working on their own launchers, such as PLD Space in Spain. Their Miura 5, whose first flight test is scheduled for the end of 2021, has been picked by the European Space

Agency as the future European microsatellite launcher. There are also dozens of Chinese companies working on this segment, now that authorities have opened up the Space industry.

With 114 orbital launches in 2018–the most since1990- this segment of the Space industry is worth $27 billion. Launch costs are falling, and estimates show that demand will continue to rise because there will be an increasing number of customers that can afford launches. Estimates vary, but some say the segment could grow eightfold by 2040 (Bank of America Merril Lynch) or twofold (Morgan Stanley).

It is estimated that the market could be worth over 10.3 billion euros by the end of 2019.

New opportunities in Space commercialization

2.0

On November 28 to 30, 2018, experts in Space commercialization attended the Bankinter Innovation Foundation's Future Trends Forum in Madrid. They identified the following as the most viable, future business endeavors: the creation of a LEO market, the expansion of Internet connectivity via satellite to the entire world, the democratization of Space access and the collection and leveraging of Earth observation data.

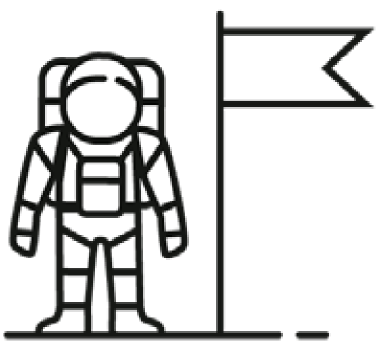
The most viable areas of the Space commercialization were identified.

Opportunities

2.1

It goes without saying that none of these opportunities can truly exploited without proper financing, which is why the experts discussed funding possibilities for each business opportunity mentioned above:

- **A sustainable, LEO market**: the majority of experts agreed that it would be possible to fund ventures in this realm. Some expect this to be challenging, while others do not share this opinion.
- **Colonization, mining and agriculture in Space:** most experts clearly stated that it would be impossible to secure funding within the next 10 years.
- Contrary to other ventures, **satellite connectivity** is a well-established market. However, it is always possible for a disruption to flip this market on its head, where semi-decent ideas can easily attract funding.
- Opinion is split regarding the **democratization of Space access**. Most experts see it as possible but difficult to finance, while others think we will have to wait a decade for funding and that, even then, it will not be highly likely.
- Out of all the business opportunities discussed, experts agree that **data processing** is the easiest to finance, slightly less difficult than Internet connectivity via satellite.



At any rate, positive returns are the main goal for any investor in Space commercialization. This is the case no matter the type of investor or their motivations: a venture capital fund, an investment firm or a millionaire that may not even care if they end up making money, just to name a few examples. They are the lifeblood of this entrepreneurial ecosystem; without them, nothing is possible. Yet if they keep their investments in the market, they may afford it stability.

It is necessary to provide stability to the market.

Governments can incentivize private investment.

Governments can lend a hand by promoting private investment through trying to guarantee regulatory stability. They can become involved by attracting newcomers and by even agreeing to pay above-market prices to guarantee market stability at the very beginning.

Private companies, on the other hand, must be able to keep a cool head in the face of (definite) adversity and strive to optimize processes and shorten production cycles.

Duration: 17:46 min

Roberto Battiston
Former President of the Italian Space Agency (ASI)

Video:
The new space economy

2.1.1 LEO market
Creating a market in low Earth orbit

The group of experts at the Future Trends Forum identified numerous, future business opportunities in the creation of an LEO market:

- Develop capacities as well as the infrastructure that would be necessary in order to establish R+D programs in LEO.
- Develop a Space tourism industry that goes beyond the suborbital-flight market currently occupied by Blue Origin and Virgin Galactic. Companies could build private Space stations like those planned by Bigelow Aerospace. The firm's BEAM module has remained docked to the International Space Station since the summer of 2016 and has proven to be quite a viable option, so much so that the ISS has decided

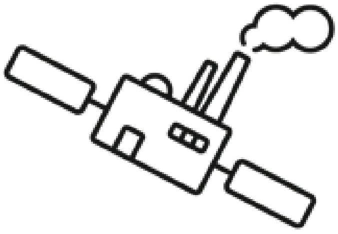
to keep the module for storage use. Occasionally, experiments are conducted inside.

- Offer services to governments and Space agencies to take the burden off them regarding some tasks. For example, Northrop Grumman and SpaceX already carry out supply missions to the ISS; Sierra Nevada Corporation will join them shortly. Soon, private companies will transport crews to the ISS. Throughout 2019, Boeing and SpaceX are expected to launch manned capsules. There may be other business opportunities in the construction of service satellites that would supply fuel to satellites already in orbit or that would eliminate Space waste. The business of satellite and probe launches is becoming increasingly open to private companies. Rocket Lab and Space X are carving out their niche in a market that, historically, has been dominated by large, mature aerospace firms.
- Cut the costs of electronic parts and encourage the standardization of the CubeSat for the development of smaller satellites. These are opportunities for a growing number o academic institutions and even NGOs to reach Space by launching these small devices. They could do so, either from Earth or from the ISS. In the latter case, they could use the NanoRacks launchers aboard the Space station. They could also design and develop experiments to be conducted aboard a Space station or satellite. Our experts believe that is this a tremendous opportunity by which academic institutions can attract their students to STEM (Science, Technology, Engineering and Math) fields. Companies could participate in this sector of the market by creating the tools that academic institutions would need to develop and launch their miniature experiments and satellites. Companies could also get involved by providing funding through their corporate social responsibility initiatives.
- There may also be a place for advertising in LEO. Academic initiatives could need sponsorship, or it could be as simple as launching products to be consumed in orbit. Brands could appear on the surfaces of rockets, Space stations or satellites.
- The greatest challenge would be that of creating demand for all of these products and services. The first step would be to clearly communicate the value proposition in each of the aforementioned opportunities to potentially interested parties as well as the key characteristics of those sectors of the market.
- In order to achieve this level of communication, one must be able to not only identify the existing products and services in the market but also impartially seek out new ones, assess them and determine where they would be of use. It also crucial that one examines entry costs, both regarding the launch and final location of projects.

It is important to assess the access costs both in terms of the launch and the platform in which the projects would be installed.

- These entry costs are not financial, though those are certainly important. Rather, they refer to the potential difficulties that stem from a regulatory framework that does not always make things easy. NanoRacks saw this firsthand when it began working on the launch to the ISS of an experiment created by Chinese universities.
- In this context, governments would need to encourage and facilitate investment. Ultimately, they must step aside once the market is sufficiently mature.

2.1.2 - Manufacturing
Creating new materials and building structures in orbit



Even though it could be included in the previous section, experts at the Forum wanted to emphasize the possibility of developing automatic Space factories that are able to manufacture medication or its molecules in a free-fall environment that allows for the creation of molecules that are impossible to create on Earth. The same thing could happen with 3D printers, which could obtain results, otherwise impossible on Earth under the effects of gravity. These are a few business opportunities in that field. We could even consider food production as a solution to additional demand.

Development of automated Space factories.

In that case, we would need to take into account the possibility that the public might be reluctant to consume these products, replicating the rejection of genetically modified products. That would require additional awareness-raising efforts to convince potential stakeholders, whether they are companies that will produce the goods or people that will consume them.

Duration: 3:35 min

Jason Dunn
Co-Founder and Director of Made In Space

Video:
Manufacturing in Space to protect the Earth

2.1.3 - Global connectivity
Building Earth's communication infrastructure from Space

There are around 4 billion people, a little less than half of the world population, without access to telecommunications services, whether that is voice or data. Therefore, the opportunity to provide them with coverage services is a great business opportunity.

Additionally, this population is evenly distributed around the world, particularly in Africa, South America and Asia, so governments across the globe could be interested. Because we will need to comply with the regulations of each country, this endeavor will either make life easier or be a potential source of problems.

This market can be covered either by medium Earth orbit satellites or by GEO satellites. GEO satellites are good for data or TV broadcasting systems that don't entail great interactivity or are not in real time. Because they are at an altitude of more than 36,000 km, signals take longer to come and go, causing delays of about one quarter of a second. For services without that latency, the solution is to use medium Earth orbit satellites because they are at a lower altitude and delays are virtually imperceptible. Satellite constellations are then necessary to offer permanent coverage, since they cannot remain above a specific area like GEO satellites.

In the last few years, High-Altitude Pseudo-Satellites (HAPS) have become increasingly popular, such as Airbus' Zephyr, an electric plane with solar panels designed to stay in the air over a specific area. There are also projects to set up similar platforms using airships. They are cheaper to deploy than satellites and there are fewer delays in communication, not to mention the fact that they can land in order to be repaired and maintained. Unfortunately, they have not undergone significant testing.

The possibility of giving global coverage represents a huge business opportunity.

We also have the option of combining satellites in different orbits with HAPS for deployments that are faster and/or that are better suited to meet the needs of some areas that are hard to reach via satellite. These areas don't have enough user density to justify the investment.

In order to be competitive in this market, it is important to ensure that both the cost of the user terminals and the price of services are affordable, since many of the potential users will be in developing or third-world countries. The need to lower costs is an additional challenge. So is the collection system, because often times there will be no infrastructure to support it.

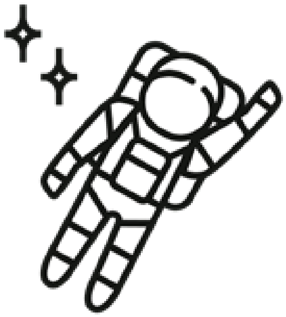
Duration: 14:24 min

Juan Tomas Hernani
CEO at Satlantis

Video:
Space is digital

2.1.4 - Access to Space

Democratization of access to Space



Today, it is expensive to access Space to put a satellite in orbit, send a probe out into the Solar System or conduct experiments in low Earth orbit or beyond.

Space has 1,500 million potential users.

Whoever is able to lower the costs will have a great business opportunity. Experts at the Forum believe there might be as much as 1.5 billion potential users distributed among institutes and universities, companies and entrepreneurs, governments, research institutions, critical infrastructure operators (whether they are governmental or not) and even individual citizens who want to enjoy Space tourism. The factors that might affect it are:

- The need to educate people so they are aware of the numerous new opportunities and the fact that prices are going down.
- Availability of infrastructure that promotes innovation and convinces the interested parties that Space is no loner unattainable.
- Access to launchers. Companies such as SpaceX, Rocket Lab or PLD Systems are already selling or are developing launchers that have more affordable prices and/or lower waiting times. They are demonstrating how valuable this segment of the market is.
- Alternatively, another option is to grant access to data generated in Space to ensure more people can use them.

However, Esther Dyson said during the Forum that one of the challenges humanity is facing is that of transcending national borders to understand, once and for all, that we are a planet; maybe achieving Space democratization is the first step.

2.1.5 - Data leveraging

Capitalizing on data collected in Space

Satellites and different types of sensors are now providing a growing amount of data. They revisit areas of interest more frequently, which allows us to track change. It is also of note that data quality is constantly improving.

These developments allow us to customize data depending on the type of user and the specific data application, which may be:

- Infrastructure protection
- Management and protection of natural resources
- Financial assessments
- Study of demographic patterns
- Insurance
- Monitoring Space, both from a civil and military point of view.

The quality of the data obtained is increasing.

This data, in turn, can be leveraged as a product for users or as the foundation for applications that create added value.

Experts estimate that the current market for this segment is worth around $3.8 billion annually, but it could easily reach $7 billion in a not-so-distant future (5 to 10 years).

According to experts, the greatest challenge is to identify new possibilities for data processing or new, possible uses for data to expand the database of potential customers.

Javier Ventura
Head of the Galileo Navigation Science Office and Advisor to the Director of ESAC at the European Space Agency

Video:
Space must be regulated so it can offer great opportunities of application

Risks of the new opportunities in Space commercialization.

2.2

2.2.1 - Legal risks

Experts have agreed that the lack of updated global Space legislation might pose a serious problem that could inhibit the development of the Space Industry.

An updated global spatial law is necessary.

It is true that the Outer Space Treaty from 1967 exists and that we subsequently created the Rescue Agreement in 1968, the Space Liability Convention in 1972, the Registration Convention in 1975 and the Moon Treaty in 1979. All of these were developed within the framework of the United Nations COPUOS, the Committee on the Peaceful Uses of Outer Space. However, these agreements are non-binding and have different levels of accession. Additionally, they are almost 40 years old, which means that the social, political and, above all, technological reality has significantly changed since then. These agreements are also reached by consensus, which is increasingly harder to find.

Among the things that need regulation are political law for each country (jurisdiction concerning vertical Space, satellites, platforms and Space vehicles), relations among countries concerning jurisdiction, the use of satellites, communications, espionage and even the way to proceed in the event that we come into contact with aliens.

Yet there are problems that we need to solve more urgently, such as limitations regarding technology exportation, which hinder (if not prevent) cooperation among companies from different countries; China is a clear example of an emerging power in the Space market with whom we must find a way to collaborate.

We will also need to implement regulations on the use of the radio spectrum, which is a scarce commodity and will be increasingly demanded due to the increasing amount of satellites in orbit. There is a technological solution that might help in this regard: optical data transmission, which still needs time to become the standard even though it is already working very well in systems such as the EDRS from the European Space Agency.

Duration: 11:46 min

John Logsdon
Professor Emeritus Space Policy Institute, George Washington University

Video:
Legislation in Space

Forum experts talked about several goals for governmental agencies and legislators in order to promote the commercial use of Space. They deem that it is necessary that governments at least:

- Do not hinder.
- Facilitate the exportation of products and technologies and its regulation.
- Promote cooperation among people, institutions and countries.
- Facilitate access to already acquired knowledge.
- Provide security for private resources.

It would also be ideal if they:

- Clearly supported initiatives.
- Provided funding.
- Supported innovation.
- Participated in international cooperation.
- Provide access to their infrastructures and talent related to Space.

In order to do so, they have a set of strengths and resources such as vast experience in working in Space and developing collaborations with other governments and agencies. They also have the possibility of creating, implementing and ensuring compliance of regulations and laws, such as the one about allocating funds to these sorts of initiatives. Last but not least, they have facilities, staff and knowledge they have been accumulating over the last fifty years of Space exploration.

These are the objectives for government agencies and legislators to promote commercial use of Space.

Working with them entails a number of risks, such as the lack of flexibility typical of governmental bodies, the unpredictable nature when the people in charge are replaced, different interests that are not aligned with those of the industry, little flexibility when adapting to new players and, sometimes, the lack of necessary funding to work properly.

2.2.2 - Business risks involved in commercializing Space

The first problem is the lack of human capital, both for engineering positions and for management positions. How can we attract that talent? How can we prevent those people from going into other markets where they can make more money and gain more acknowledgment?

Another problem is that we need to be able to develop business models that convince investors, legislators and potential employees about doing things on the low Earth orbit. There are new viable business models in satellite constellations, because there have been investments of millions of dollars that so far have done absolutely nothing, not even launching a satellite. We also need to evaluate if there can be a business model in the moon or beyond the low Earth orbit.

Cynthia Bouthot
President at Space Commerce Matters

Video:
Why should companies go to Space?

Duration: 13:09 min

We need to develop business models that convince investors, regulators and potential employees.

2.2.3 - Organizational risks involved in commercializing Space

On the one hand, it is necessary to have increasing access to Space in order to prevent delays in the availability of launches from damaging the willingness of companies, institutions and other types of organizations of developing commercial activities in Space. That capacity has to be affordable as well.

At the same time, that increase in capacity is going to cause more problems with Space debris, which will require an international coordination and surveillance effort in terms of compliance with the agreements. In fact, Javier Ventura says it is a problem to comply with the protocols on Space debris (since missions are more expensive) if others do not do it, no one forces them to and the agreements from the beginning of this decade are non-binding, as John Logsdon says.

It will require an international coordination and surveillance effort.

It would also be important to achieve an increasing level of coordination when organizing activities involving several players in the market.

Esther Dyson
Chairman of EDventure Holdings

Video:
Investment in Space

Duration: 5:48 min

2.2.4 Cybersecurity

The on-board computers are a substantial change in the design of rockets, spacecraft, satellites, space probes, and their control systems. They control everything instead of the more or less sophisticated automatisms of yesteryear; It has a lot to do, in fact, with the miniaturization that Esther Dyson talked about.

And this is both an advantage and a disadvantage. An advantage because it allows us to design rockets, spacecraft, satellites, space probes and control systems that are increasingly sophisticated and "smart", increasingly capable of doing more things and, in many cases, of getting out of trouble almost by themselves.

All these systems are susceptible to a possible cyber attack.

But as Ram Levi reminded us, it is also a problem because it opens all these systems to a possible cyber attack.

According to Levi cyber attacks are becoming much more sophisticated not only with a monetary objective but sometimes with a political objective. And that too can spread to Space because Space, for definition, it is global, it is interconnected. And everybody see the advantages it has. But it is controlled by computers, you can not launch and operate a satellite without a computer based on a ground station. And this presents vulnerabilities, because we have to use devices standard commercial in order to reduce costs. With what that, no matter how hard a company strives to maintain robust and adequate cybersecurity protocols, if your supply chain is not secure, then everything your effort will be in vain. And secure a supply chain it's totally different from securing the systems of the company; It is something that must be kept in mind.

According to Levi we have to change our way of think. As Walt Disney said, "If you can dream it, you can do what". The hackers say "If you can dream it, you can hack it.

Ram Levi
CEO of Konfidas

Video:
Security in Space

Duration: 2:17 min

Space Commercialization in Spain

3.0

According to figures published in 2018, it is worth slightly more than 800 million euros (having doubled in just 10 years) and employs roughly 3,500 professionals. The Spanish market is the fifth largest in Europe.

The Spanish Space Industry is the fifth largest such industry in Europe. It is worth slightly more than 800 million euros.

In 2017, Spain assumed presidency of the ESA's Council of Ministers and will occupy this post until 2019. This is an opportunity for the country to contribute not only to the ESA but also to the development of the Spanish Space Industry; in these two years, negotiations will take place concerning the EU's 2021–2027 investments. The majority of the roughly 12 billion euros will go through the ESA.

Between 2017 and 2019, the ESA hopes to make progress in the development of the Vega-C and Ariane 6 rockets. They are slated for launch in 2019 and 2020, respectively. The ESA also hopes to launch the ExoMars 2020 mission (barring any delays) as well as define and develop new Sentinel satellites. Other key activities for the ESA will be to further collaborate with NASA as well as participate in defining and developing a new Space station that will most likely orbit the Moon.

Early into the presidency, the Spanish Government decided to increase its financial contribution to the ESA to 1.5 billion euros during the 2017–2024 period. This figure exceeds Spain's previous contribution by 600 million euros. These investments will allow the Spanish Space Industry to participate to a greater extent in the ESA's optional programs and favorably position Spanish companies so that they have a better chance of participating in other programs, such as those managed by the EU (Copernicus or commercial projects). This is good news for Spain because, **for more than 20 years, the country has seen returns that have exceeded its contributions to the ESA**.

The Spanish Space Industry's recent successes include the launch of the PAZ satellite, which makes Spain the third country in Europe with its own capabilities in Space for observing and monitoring natural resources, territory, infrastructure, security, defense, borders and humanitarian crises on Earth. Our country should also be recognized because the CHEOPS Space observatory was built in Spain.

Spain is one of the few countries capable of designing, building and operating fully functional satellites; this capacity is worth leveraging in seeking out new business opportunities. In fact, Spain is ranked seventh among countries that build satellites.

Spain also has experience in developing instruments for satellites and probes.

Spain also has experience in developing instruments for satellites and probes, such as TWINS (Temperature and Winds for InSight) on the NASA's InSight probe. This suite of instruments was developed by the Centro de Astrobiología (CAB) of the National Institute of Aerospace Technology, INTA Yet this is not the first time that the CAB has completed a project of this nature. In fact, TWINS is based on the design of the REMS weather station on the Curiosity rover. INTA forms part of more than 10 international, Mars exploration projects.

Another milestone for the Spanish Space Industry is that the EU decided to place the Galileo **Security Monitoring Centre (GSMC) in Spain**. Perhaps, this success is twofold because the European GNSS Service Centre (GSC) was already in Spain. It is very uncommon for two centers to be found in the same country. Spain also has a 20% stake in the EU Space Surveillance & Tracking (SST) program.

Another achievement is the fact that the **ESA chose** PLD Space **to design a European launcher for micro-satellites** (<300 kg); the Miura 5, rocket has a reusable first stage and represents the industry's push towards reducing launch costs. This is the first time that the ESA has put out an RFP for a commercial launcher outside of its fleet. PLD Space is also involved in developing what will be the European Spaceport for small satellites with sun-synchronous and polar orbits.

Other noteworthy Spanish companies involved in Space commercialization activities include:

- Deimos Imaging, currently a subsidiary of the Canadian UrtheCast Corp., is a **Spanish company that specializes in Earth observation systems as well as remote-sensing products and services**.
- GMV is a multinational company that contains private, Spanish capital. It specializes in **providing Space agencies, European institutions and satellite operators and manufacturers with support services, systems and products.**
- Hisdesat, is a **government satellite services operator** that works primarily in the areas of defense, security, intelligence and foreign affairs.
- Hispasat, satellite telecommunications operator.
- Indra, has a division that specializes in the use of **Space technology in military operations**.
- Sener provides **engineering services**, produces equipment and integrates systems.
- Zero 2 Infinity, is developing a rocket that is launched from a balloon.

However, Spain's role in Space 2.0 is not just driven by large companies. A group of young programmers recently won one of the competitions at the 2018 NASA Space Apps Challenge hackathon.

Yet there will be some obstacles. People in the industry are skeptical and new companies are lacking investment. The startup-financing model is only working in the US.

As a result of the current state of affairs, people have begun to discuss the need for a Spanish Space Agency. On the one hand, it would centralize decision-making concerning Space, which would optimize and simplify processes. On the other hand, some say that the current level of investment makes the agency redundant. The Centre for the Development of Industrial Technology (CDTI) **has been working in this capacity since 1986.**

No matter the outcome, it is evident that we must be able to adapt to these changing times. We need to seek out new countries and clients as partners. We need new business models that allow the Space Industry to collaborate with other industries that, historically, were quite distant. We also need to keep our foot on the gas because there is room for improvement; even though Spain has been doing well in recent years, its share in the world market is less than its economic output.

Challenges in Space Commercialization

4.0

The arrival of "Space 4.0" will lead to multiple challenges and a paradigm shift in our understanding of Space. Those of us who want to work in Space commercialization should take the following into account:

- We must try to create a Space value chain and reduce the costs of Space access. Those seeking to exploit the market must work towards developing a wide array of accessible infrastructure that allows us to create Space businesses. The goal is to create products and services that allow us to build the Space Industry.
- Therefore, it is mandatory that we be disruptors and promote innovation. We need to push traditional companies to adapt to this new model.
- We cannot forget that a viable business model is necessary, even if it is just for the long term.

The idea is that we significantly lower the price of Space systems in a number of ways: reducing the cost of launchers, leveraging economies of scale by launching constellations instead of individual satellites and making progress in standardization, reducing the weight of satellites and their consumption as well as reformulating the design and manufacturing processes through reduced production cycles.

Regulators need to–at the very least–eliminate unnecessary barriers, even though their ideal goal should be to support the development of the Space Industry by ensuring stability, supporting innovation and promoting the creation of a talent base.

Charles Bolden also thinks it is essential that NASA maintain its headship because the administrator of this agency is the unofficial leader of the remaining Space agencies.

Companies and organizations that already work in Space commercialization must be able to adapt to changes while maintaining necessary profit margins. Therefore, they must support innovation and somehow convey the interesting things they're doing to try to attract talent. They have an edge because their financial resources allow them to acquire other companies that do interesting things; yet it is essential that they ensure that these companies' talent and know-how survive the acquisition. They also need to make an effort in terms of lowering prices so they attract an increasing number of clients. They must adapt to these clients' demands, present customer-centric business strategies and identify new opportunities.

- 1.Business opportunities. Currently, the Space Industry is being developed in several fields, but the Future Trends Forum experts have agreed that new business opportunities will arise in the sustainable market in the low Earth orbit: manufacturing in Space, global Internet connectivity via satellite, democratization of access to Space and use of data obtained through satellites. **What will be the business models that will capitalize on these new business areas?**

- 2.Drivers of Space commercialization. So far, governments and Space agencies were the leaders in the Space Industry, but as a result of new business opportunities, companies must now take the lead. **How should governments facilitate access to Space for private companies? What is the new role of Space agencies?**

- 3. There are still many things to consider in Space commercialization, particularly regarding global risks of its development from multiple standpoints: legal, regulatory, corporate, organizational and in terms of cybersecurity. **What will be the global regulation for Space businesses? Who should regulate them? Who should organize them? How can we make sure that Space businesses are safe?**

- 4.Investment. Space activities generate roughly 260 billion dollars annually. According to estimates from Bank of America Merrill Lynch, by 2045, investment in Space will increase eightfold and reach 2.7 trillion dollars. It is also estimated that between June 2017 and June 2018 private investors provided the Space Industry with around 3.4 billion dollars; this investment is only expected to grow. **How can we fund Space commercialization? How can governments promote and guarantee private investment in Space?**

- 5.Spain. Spain has a business volume of about €800 million; this figure has doubled in the last ten years. The business network employs near 3,500 technicians. **What is Spain’s role in the new era of Space commercialization? How can Spanish companies seize opportunities in this new industry?**

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