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Space missions
Past, current and future

New Space Economy

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Video

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Welcome!

« *We came all this way to explore the Moon, and the most important thing is that we discovered the Earth.* » - William Anders, Apollo 8

Welcome to this video. I am Chloé Carrière, and I will give you an overview of space missions, past, current, and future. Exploring space has always been part of the pioneering spirits of humanity. Nonetheless, it also helps us to discover the Earth and have valuable benefits. Here is the picture of the first Earth rise seen by Apollo 8 astronauts, who said, "We came all this way to explore the Moon.

Notes

Summary

0m 06s

What to expect:

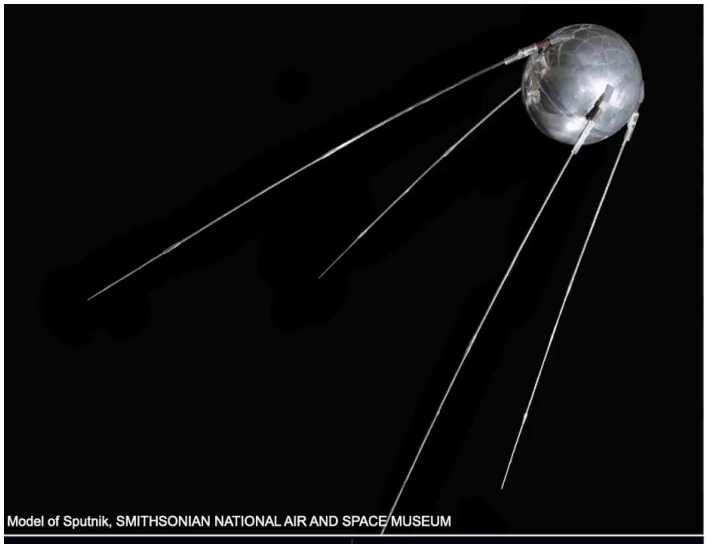
- **The path to LEO & GEO – historical point of view**
- **Current and future missions (LEO & GEO)**
  - Actors
  - Orbital stations
  - LEO and GEO for Earth
  - “New space” missions
  - Scientific missions
- **Return to the Moon**
  - Human
  - Robotic
- **Mars – an achievable objective**

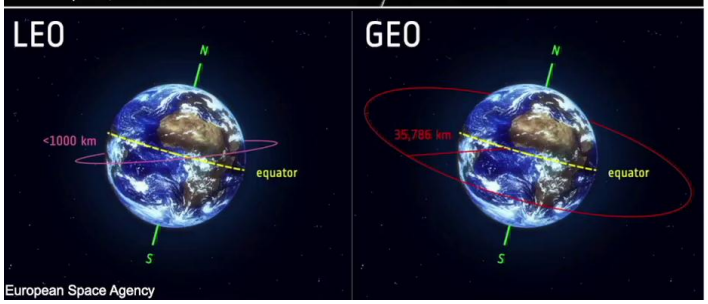
And the most important thing is that we discovered the Earth." To introduce you to this new field, we will divide this video into four parts, the path to LEO and GEO from an historical point of view, then the current and future missions in a nutshell. We will then move on to the topic of the return to the Moon, and finally touch on the ambitions for Mars. Let's get started.

Notes

Summary

0m 36s





1. The path to LEO and GEO

- **LEO:** Low Earth Orbit (160-1000 km)
- **GEO:** Geostationary orbit (3 km/s at 35 786 km)

- Sputnik I, October 4, 1957, Soviet Union
- First man in space – Yuri Gagarin, April 12, 1961
- First geosynchronous satellite, Syncom II, 1963
- 1969-1972: Apollo program on the Moon
- First international orbital station, 1998

First things first, what is LEO and GEO? Leo means low Earth orbit that could translate to the environment located between 160 kilometres and 1,000 kilometres above the Earth's surface. GEO means geostationary orbit. Satellites located in this orbit circle the Earth above the equator at the same rate as Earth rotation. They are therefore always above the same point of the surface of the Earth. Back in the 1950s, the context of the Cold War gave birth to the space race. The Soviet Union was the first to send a human-made device in LEO in 1957 called Sputnik I. Closely followed, the first man in space, Yuri Gagarin, that circled the Earth one time in 1961. Two years later, the first geosynchronous satellite, Syncom II, was sent by NASA for telecommunications proof of concept. The Moon is until this day the furthest human has travelled. The Apollo programme run by NASA has allowed 12 men to walk on the Moon between 1969 and 1972. The end of the Cold War then opened the door to international collaboration in space with the construction of the International Space Station that started in 1998.

Notes

Summary

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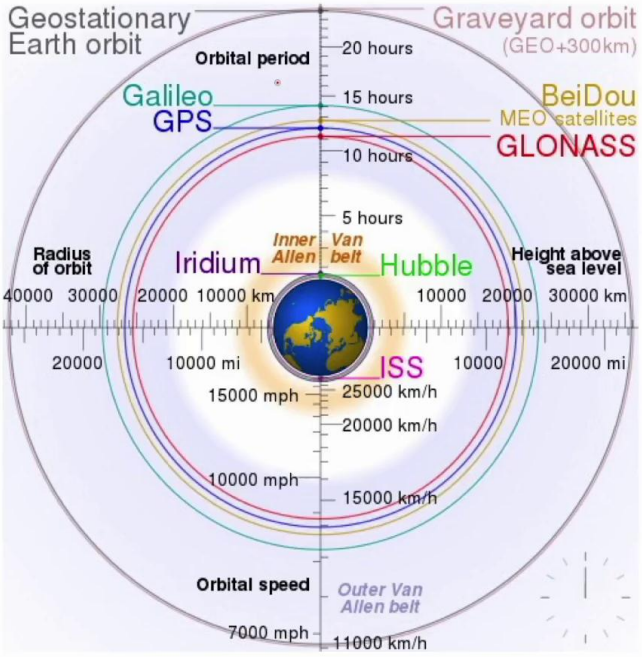
2. Current and future missions (LEO & GEO)



Orbit size comparison, Wikipedia, Low Earth Orbit

Now that we understand how we have access to LEO and GEO, what is the status of these missions? What is planned? Currently, there are several satellites, telescopes, stations orbitting our planet. Around a few hundred kilometres, we have the ISS telecom satellites, or, for instance, the Hubble space telescopes. The GPS satellites are located way above, around 20,000 kilometres. It's important to note that military missions will not be treated in this video but are also key actors in LEO orbits.

Notes

Summary

2m 22s

2. Current and future missions (LEO & GEO)

- Old Space (non-exhaustive)

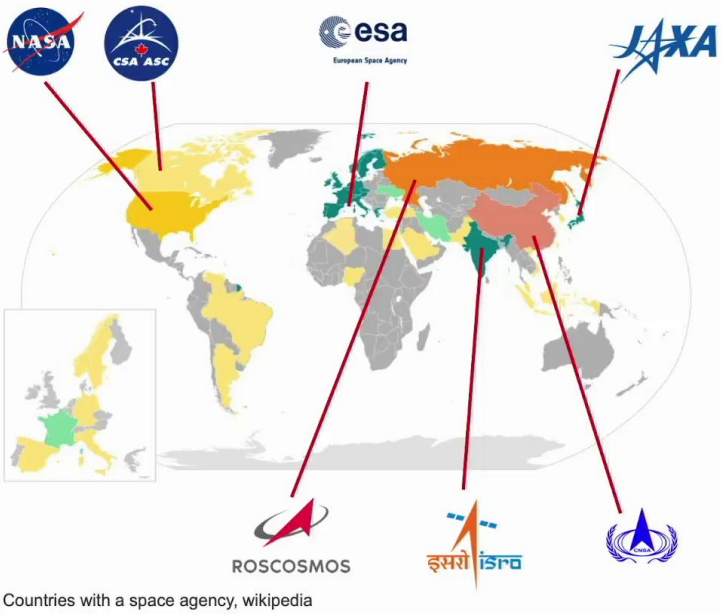
BOEING arianeGROUP eutelsat iridium

- New Space (non-exhaustive)

SPACEX BLUE ORIGIN Virgin GALACTIC

- In Switzerland (non-exhaustive)

Picterra astrocast



Countries with a space agency, wikipedia

Let's now have a look at the actors of LEO and GEO. Of course, the main actors are still the governmental agencies. This map represents the countries with a space agency, main ones being NASA, CSA for Canada, ESA for Europe, JAXA for Japan, CNSA for China, ISRO for India, ROSCOSMOS for Russia. Of course, those are not the only ones. In addition, since the Apollo programme, private companies have taken part in the lunar adventure. On one hand, old space companies are the ones which have started in this period to develop infrastructures with the aim to generate profit. We can name Boeing, Arianespace, Eutelsat, or Iridium. On the other hand, new space is embodied by companies such as SpaceX, Blue Origin, or Virgin Galactic. It is a new generation of entrepreneurs who took advantage of the laborisation of space with the aim to lower the costs and evolve in a dynamic market. These types of companies are not only in the US. We can name Picterra, for instance, in Earth observation or Astrocast, in IoT Networks, two Swiss startups among many more.

Notes

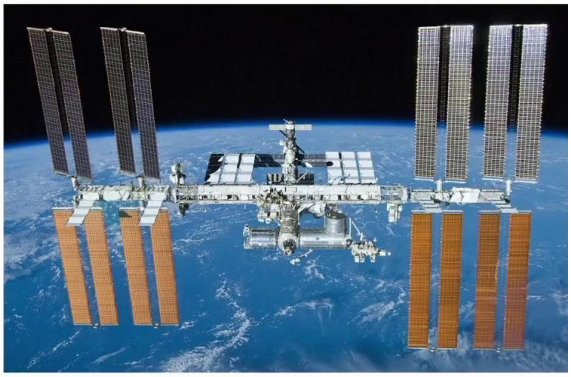
Summary

2m 55s

2.a Orbital stations

- Shuttle-Mir program
- International Space Station
  - Now accessible with private companies
  - Potential privatisation
- Tiangong 1 & 2
- Gaganyaan, crewed spaceship under development
- Towards space hotels?

Tiangong fully assembled, Alejo Miranda/Shutterstock



International Space Station, NASA

Let's now move on to the missions in these environments. First, orbital stations. This trend started with the Salyut Space Station from the Soviet Union in the 1970s. Going by the Shuttle-Mir programme to then end with the International Space Station. Most of the crewed space exploration is taking place there. The programme is likely to run until 2028. Nonetheless, from 2024 onwards, we may witness a privatisation of the station now that it is accessible with private launchers. The concept of space hotels is one that may become more and more real in the next 20 years. Nevertheless, all the stations are currently in construction. After two tests, the CNSA is starting to assemble the Tiangong station with one module already in orbit, and may open its door to other contributors. The Indian Space Agency is also working on a crewed spaceship, Gaganyaan, that may lead to an orbital station of their own.

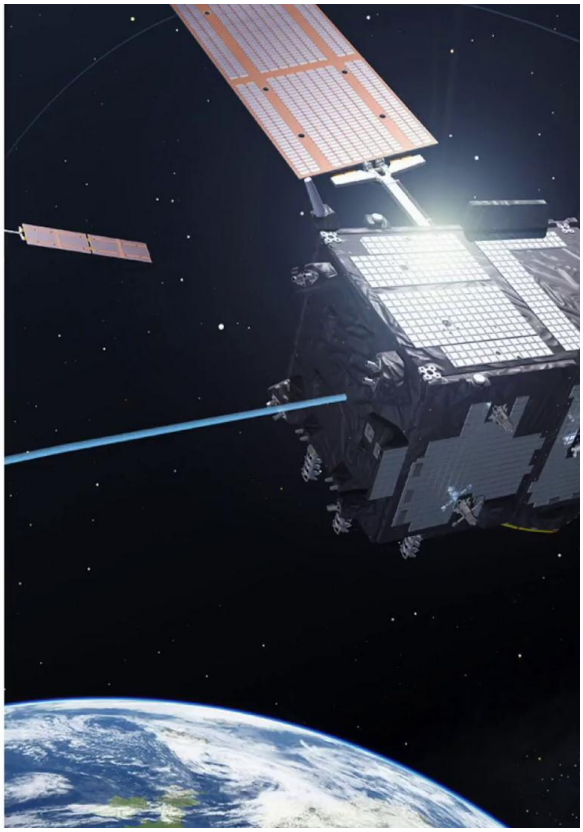
Notes

Summary

4m 09s

2.b LEO & GEO for Earth

- **Communications:** telecom satellites and constellations
- **Earth observation** satellites
- **GPS**: precise navigation
- **Future missions:** IoT constellations, space debris removal, etc



Galileo, European GPS, ESA

Satellites are also becoming more and more numerous in orbit for three main purposes: communications, Earth observation, and navigation, what we call GPS. It will be very time-consuming to name all missions currently in orbit. But we can say that this environment that was mostly governmental is becoming more and more private with the arrival of IoT constellations, for instance. With more than 7,000 individual satellites in space at the end of April 2021, according to UNOOSA, the question of space debris is becoming a rising issue.

Notes

Summary

5m 10s

2.c ”New space” missions

- New launchers → smash the prices to access LEO
- New space companies raised **$25.7 billions** in the last decade
- **Activities:**
  - Cubesats for secured clouds, IoT, Earth obs.
  - Reusable launchers
  - Space tourism
  - In-orbit operations
  - Other applications: additive manufacturing, etc.
- LEO, the new Silicon Valley?
  - In 2040, the space sector could generate up to **$2 700 billions***

* Merrill Lynch, Bank of America

Reusable boosters, Space X

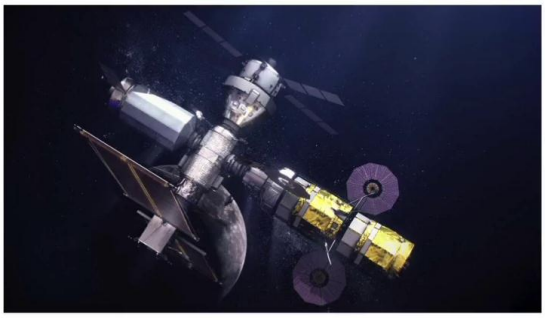
This is mostly due to the arrival of missions by new space companies. With a construction of new partially reusable launchers, access to LEO is becoming less and less expensive, fostering their activities. In the last decade, new space companies have raised US$25.7 billion, and the sector is expected to generate up to US$2,700 in 2040. The main activities these companies develop are linked to the Internet of Things, secured networks, Earth observation. Space tourism has also kicked off this year with two touristic flights by Blue Origin and Virgin Galactic. Many more applications are also being developed, such as the use of additive manufacturing in orbit. With a multiplication of space missions in LEO, regulations will need to be established so that the space sector can thrive but protecting Earth and our space environment, therefore minimising the environmental impact.

Notes

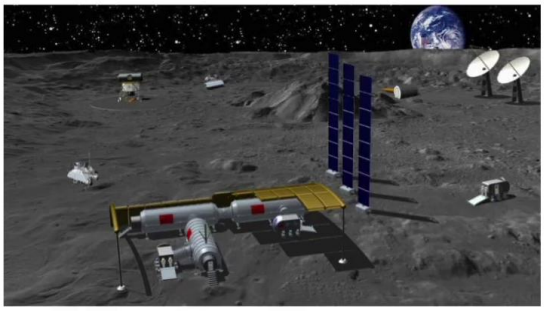
Summary

5m 49s

3. Return to the Moon



Lunar Gateway, NASA



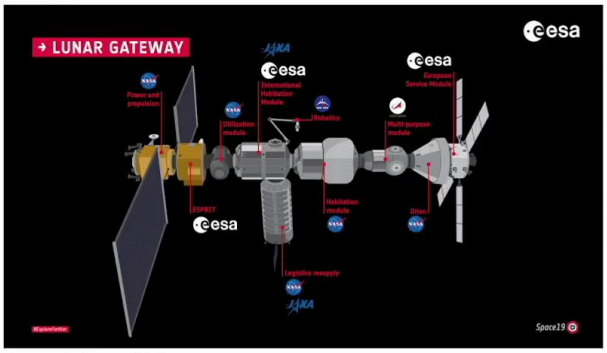
Render of a conceptual Chinese lunar base, CAST

Other missions present in LEO, GEO are with a scientific purpose, and mostly run by governmental agencies. One of the best example is the Hubble Space Telescope. One of the biggest missions highly anticipated by scientists is the James Webb Space Telescope to be launched this year. These missions that do not aim at generating profit do help several fields of science. The science on board space stations have allowed the creation of several technologies with an economic opportunity. With the current trends, LEO, GEO may become the next Silicon Valley. How about our neighbours? The last time humanity stepped on the Moon was in the context of the Cold War, and it is likely that there will be once again the competition between two superpowers that will bring us back there between China and the USA.

Notes

Summary

6m 52s



Lunar Gateway, ESA

DearMoon, SpaceX

3.a Return to the Moon
→ Human

- Two programs from space agencies with the goal to establish an outpost on the Moon, likely in the South Pole
- Moon Village
- Supported by New Space companies
  - SpaceX, commercial human lander
- Space tourism possibilities
- Collecting and using resources

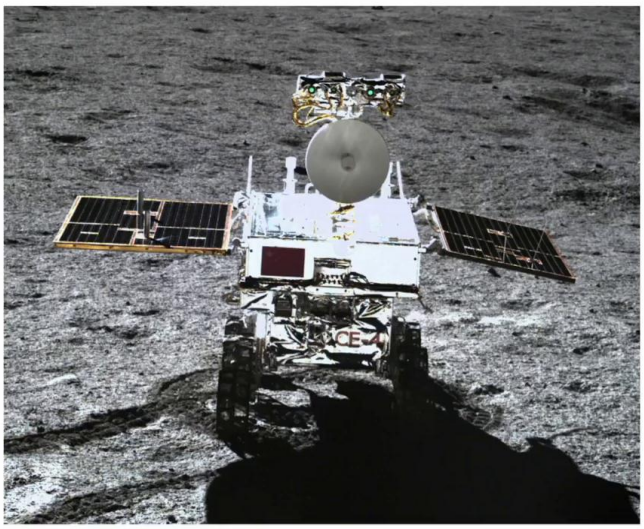
Two programmes are currently being constructed to go back to the Moon, the Artemis programme from NASA alongside ESA, JAXA, and CSA, and a Chinese programme that may attract the Russians. Both programmes are aiming to build an outpost in the South Pole, and NASA wants to build a station around the Moon. Of course, Artemis is supported by private companies such as SpaceX. SpaceX was mandated to design and build a commercial human lander. This momentum for the Moon is an opportunity for private companies to maybe collect and use resources. And why not developing space tourism there?

Notes

Summary

7m 48s

3.b Return to the Moon → Robotic



Yutu-2 by Chang'e 4, CNSA

- **5 robotic missions** by China
  - Dark side of the Moon (Chang'e 4)
  - Return of samples (Chang'e 5)
  - Chang'e 6, 7 and 8
- **Luna program**
  - Luna 2, first space probe on the Moon
  - Luna 27, resources prospection
- **Chandrayaan-3**, **Lunar Polar Exploration** by ISRO and JAXA
- **Mining resources** by private space
  - Moon's extractable resources amounts to USD 16,000,000,000,000,000*

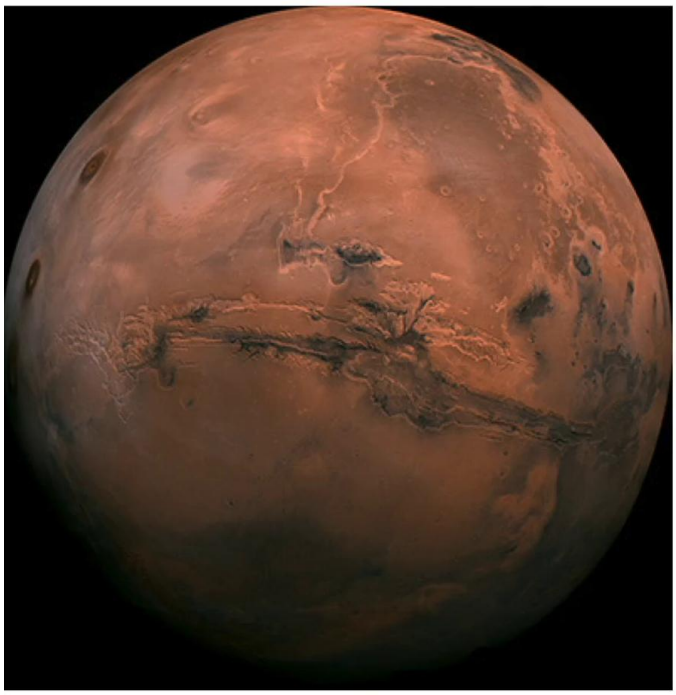
* Estimated by Moon Express

Three agencies have been active in the robotic lunar exploration: Russia, NASA, and China. With five successful missions, one on the dark side of the moon and one returning samples, China is at the top of its technological field. Russia is still active with its Luna programme. ISRO is planning to send two rovers, one in collaboration with JAXA to become the fourth country able to land rovers on the lunar surface. Lunar rovers and robot technicians are becoming of high interest to private companies. They're seen is an efficient way to mine resources on the moon. An estimation done by Moon Express amounts the value of these resources to US$16 quadrillion, an opportunity that private companies will likely seize. This is of course a rough estimation that still needs to be proven as the access to the resources will be a challenge. Nevertheless, it is important to note that exploitation of lunar resources poses ethical and political challenges that will need to be addressed in the coming years.

Notes

Summary

8m 31s



Mars, NASA

4. Mars, an achievable objective?

- **Robotic:** only NASA / CNSA as of now
  - Latest missions: Perseverance, Zhurong
- **Next missions:** return samples
- **Human exploration: the next frontier**
  - Unlikely in the next 20 years
  - SpaceX leitmotiv: Starship
  - Is it profitable?

Starship, SpaceX

Humanity also has the ambition to reach for Mars. The robotic ambition has of course been reached with a few rovers on the surface of the planet, especially with the latest ones, Perseverance and Zhurong. Only NASA and CNSA have successfully landed a rover on the Red Planet until now, which is why it makes it extremely unlikely that we'll be sending humans in the near future. The next challenge for the robotic exploration will be to return samples. However, a few of the new space companies still have Mars in their visas, the main one being SpaceX, currently developing its Starship, a spaceship meant to bring 100 people to Mars. Although this is an attractive thought, many challenges still remain unanswered for us to travel to our neighbour. And from a business point of view, the challenge doesn't seem very profitable. But who knows? You may find the next opportunities.

Notes

Summary

9m 48s

Thank you for your attention!

Seize the opportunity!

This video aimed to give an overview of current space missions and the trends that we will witness in the coming years. To summarise it in one sentence, the space sector is currently blooming. It's just the time to seize the opportunity. Thank you all for your attention.

Notes

Summary

10m 47s