China Communications

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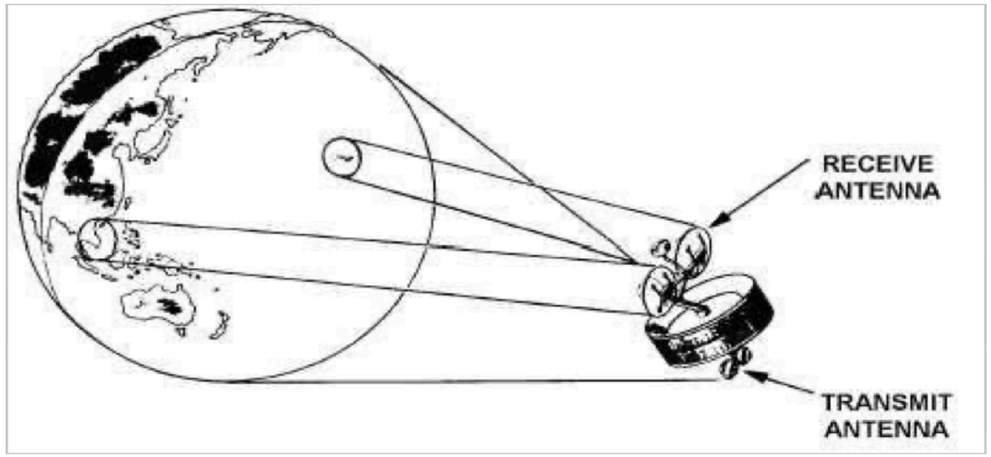
Chapter 6: Satellite Communication and Global Navigation

Introduction and Fundamentals

What is a Satellite?

- In the context of spaceflight, a satellite is an object which has been placed into orbit by human endeavor.
- Why is the above definition not quite accurate?
  - Because we also have natural satellites such as the Moon. To be more exact, the above definition is for artificial satellites.



Why Satellites?

Overview of global communication needs.

- Shortcomings of terrestrial coverage:
  - 4G or 5G networks relay on Earth-based transmitters and receivers.
  - Devices are unable to communicate in places where this infrastructure has not been established.

How can we communicate on an ocean voyage?

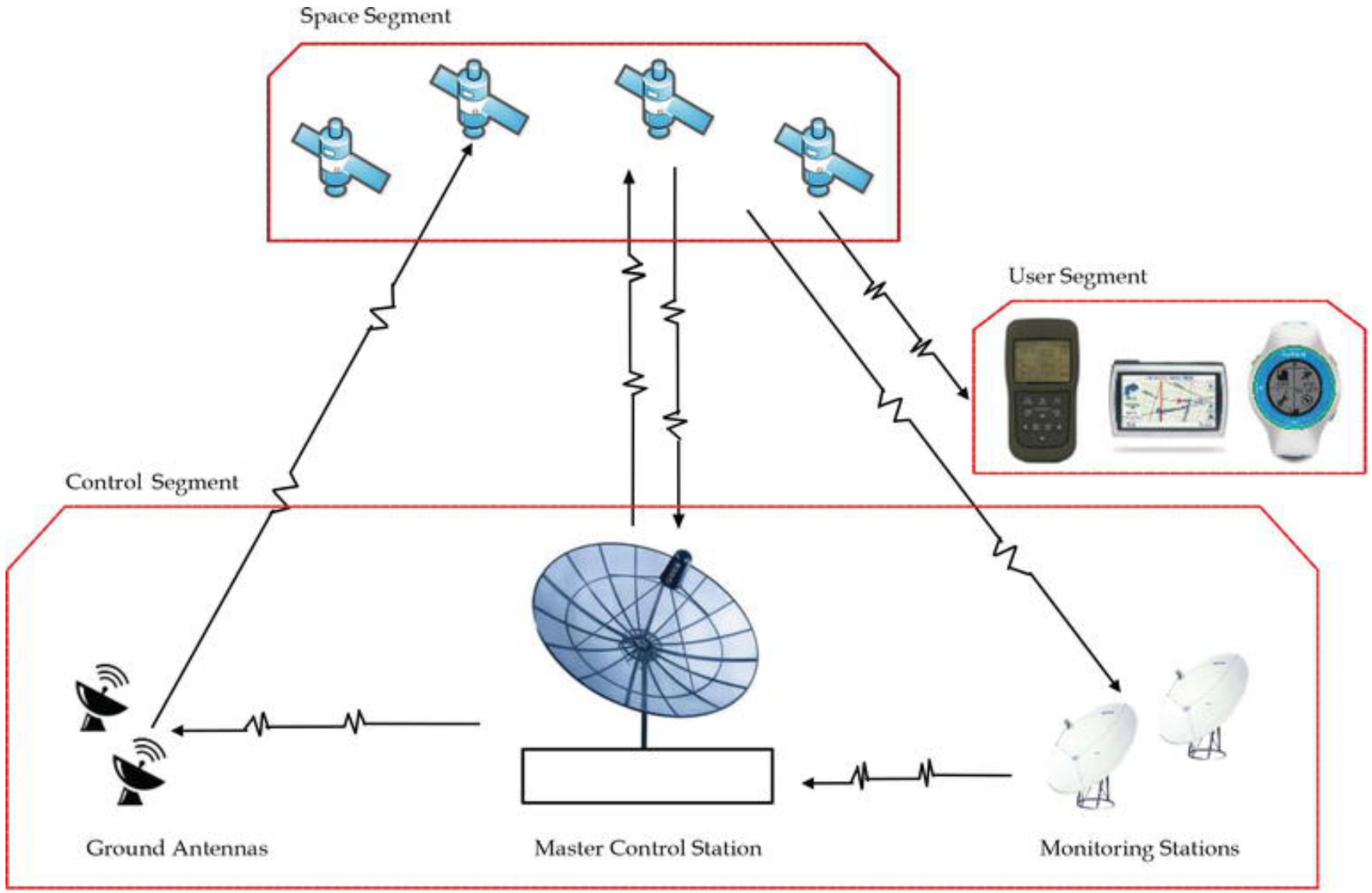
Why Satellites?

Benefits of satellites over terrestrial communication: coverage, reliability.

- Universal Connectivity: The hardest-to-reach places on Earth can still be covered.
- Connecting moving vessels: Moving aircraft and maritime vessels can get connected.
- Enhancing disaster response and recovery: Maintaining communications after natural disasters or political conflicts.

The Satellite Communication System

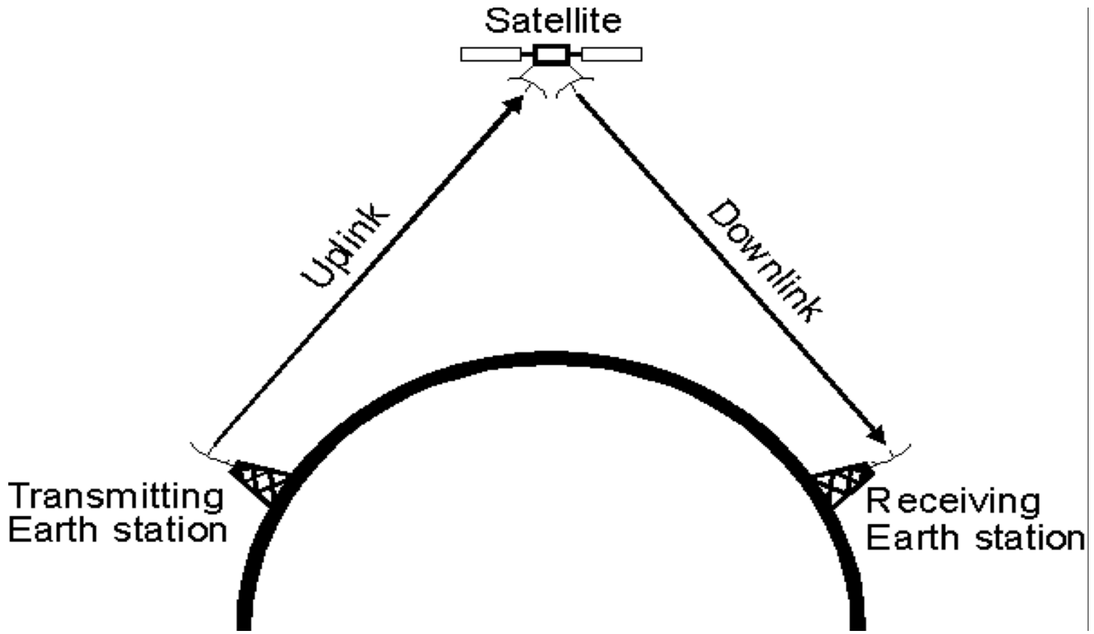
- Space segment
- Ground segment
- User segment



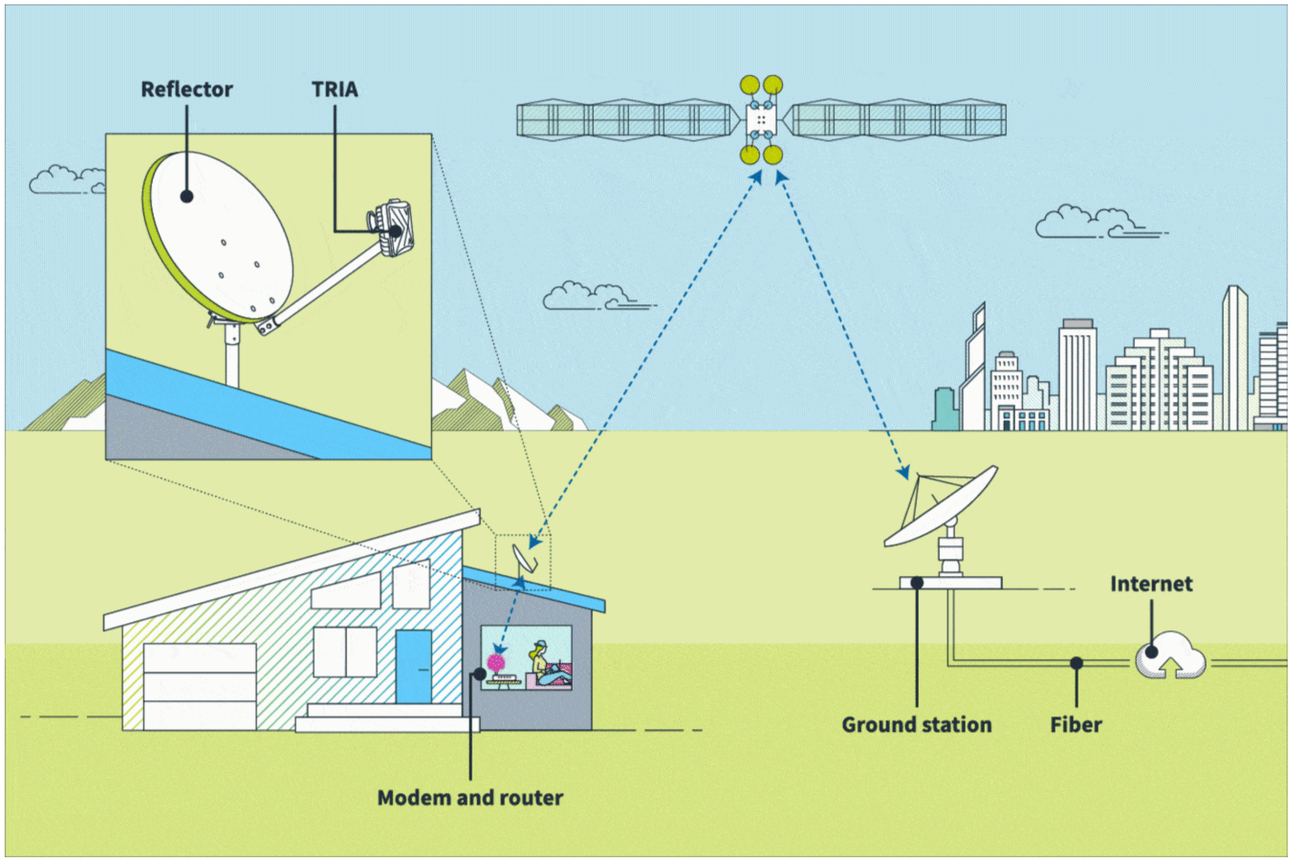
How Does Satellite Communication work?

A communications satellite act as a repeater

- Ground stations to satellites
- Satellite relaying
- End user communication



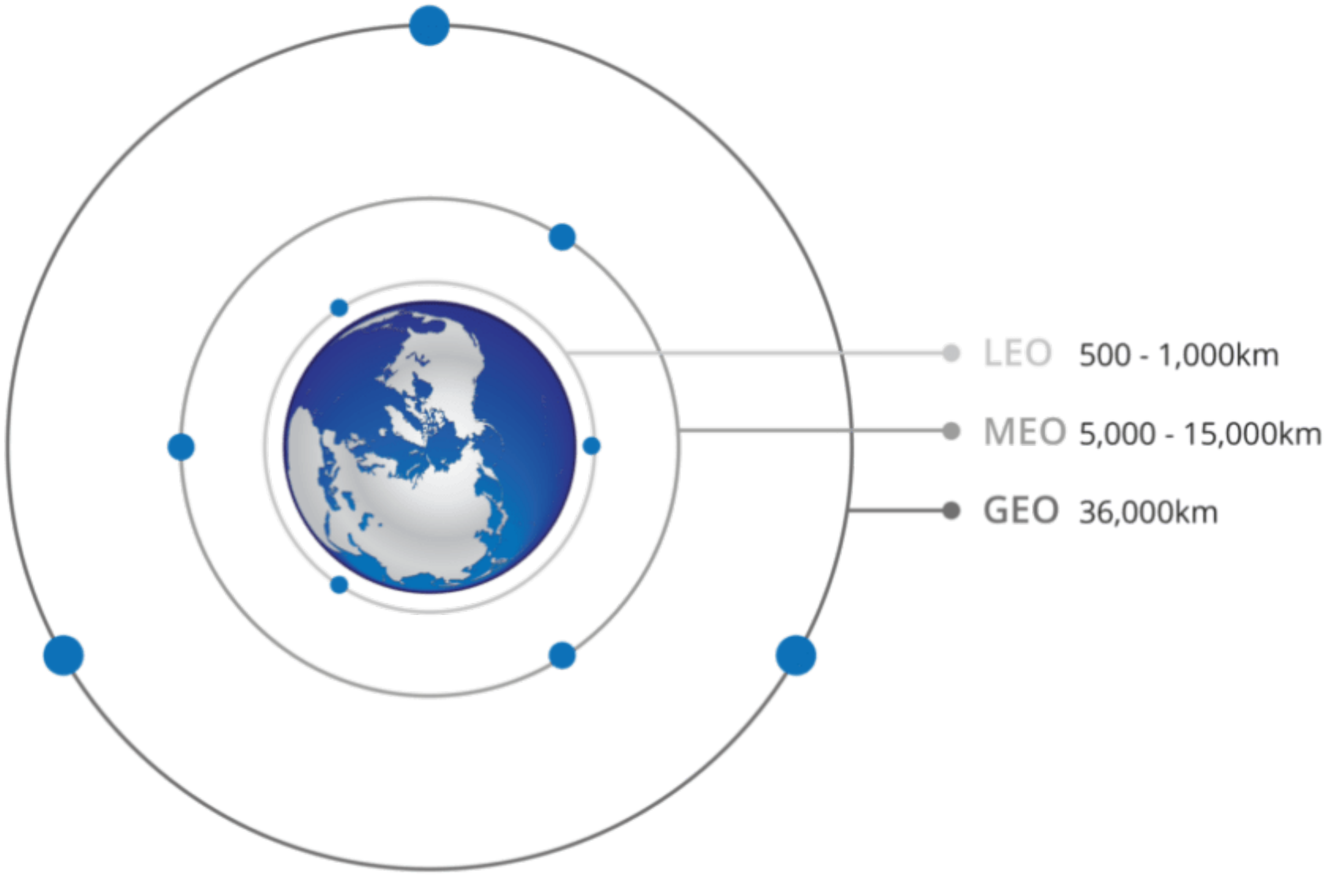
How Does Satellite Communication Work?



Satellite Orbits

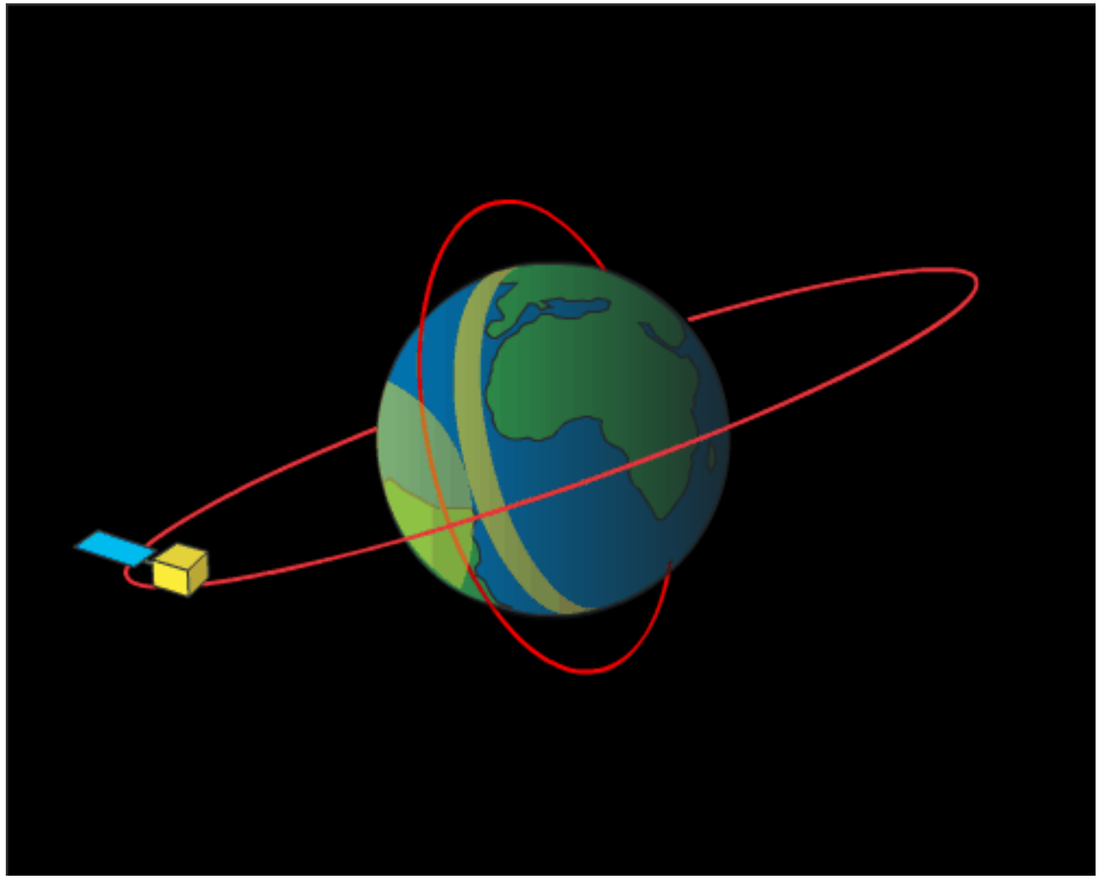
Type	LEO	MEO	GEO
Description	Low Earth Orbit Equatorial or polar orbit	Medium Earth Orbit Equatorial or Polar orbit	Geostationary Earth Orbit Equatorial orbit
Height	100-500 miles	6000-12000 miles	22,282 miles
Signal Visibility / orbit	15 min	2-4 hrs	24 hrs
Advantages	Lower launch costs Short round trip signal delay Small path loss	Moderate launch cost Small round trip delays	Covers as much as 42.2% of the earth's surface Ease of tracking No problems due to doppler
Disadvantages	Tracking antenna required Short life, 5-8 years Encounters radiation belts	Tracking antenna required Larger delays Greater path loss than LEO's	Large round trip delays Weaker signals on Earth

Satellite Orbits



Satellite Orbits

Polar orbit and geostationary orbit



Satellite Orbits

- Question:
  - Why are different orbits used for different applications?

Frequency Spectrum for Satellites

– **L-band**	(1.5 – 1.7 GHz)	**Mobile Satellite Services (MSS)**
– **S-band:**	(2.0 – 2.7 GHz)	**MSS, Digital Audio Radio Services (DARS)**
– **C-band**	(3.4 – 7.1 GHz)	**Fixed Satellite Services (FSS)**
– **X-Band**	(7.25 – 8.4 GHz)	**Military/Satellite Imagery**
– **Ku-band**	(10.7–14.5 GHz)	**FSS, Broadcast Satellite Services (BSS)**
– **Ka-band**	(17.7 - 21.2GHz and 27.5 – 31 GHz)	**FSS Broadband and inter-satellite links**

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Case Study

An Use Case

Huawei Mate 60 Pro

- Huawei Mate 60 Pro is the world’s first satellite calling phone.
  - It provides:
    - satellite call
    - short message
    - image sending feature
    - at anywhere on the earth

A Real Case

- In Oct. 2023, Kou Chao and his three colleagues were stranded in the uninhabited area of the Kunlun Mountains due to a vehicle breakdown.

- Using the “Beidou Satellite Messaging” function on their Huawei phones, they sent a distress signal. The local fire department successfully located them, leading to their rescue.

China's Lunar Exploration Program

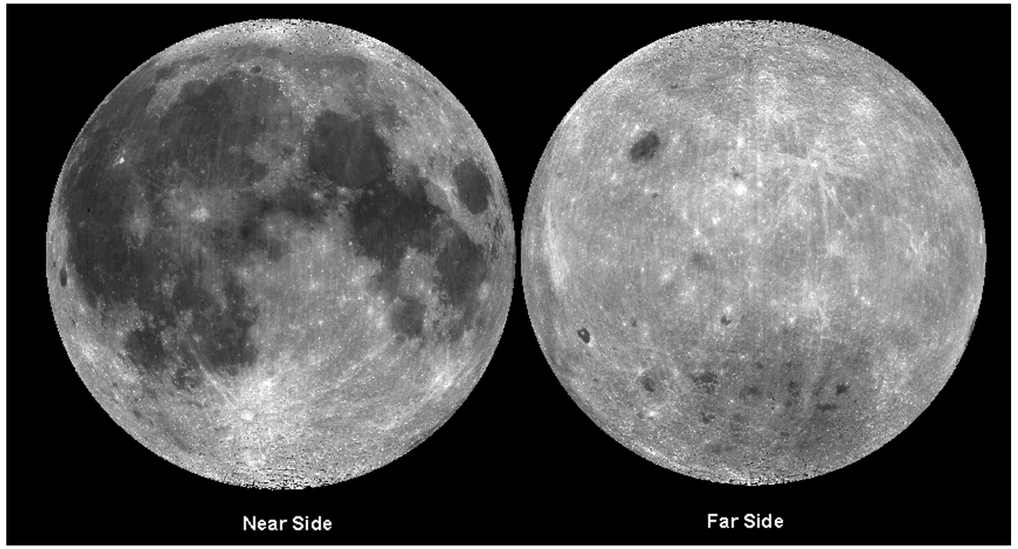
- The Chinese Lunar Exploration Program (CLEP; Chinese: 中国探月工程; pinyin: Zhōngguó Tànyuè Gōngchéng), also known as the Chang'e Project.
- Phase I (robotic): Orbital missions
- Phase II (robotic): Soft landers/rovers
- Phase III (robotic): Sample-return
- Phase IV (robotic): Lunar robotic research station
- Crewed mission phase: a crewed lunar landing mission in the 2030


1959
1969
1970
DFH-1
China's 1st satellite
2000
2003
CCTV4

An Use Case

Far side of the moon

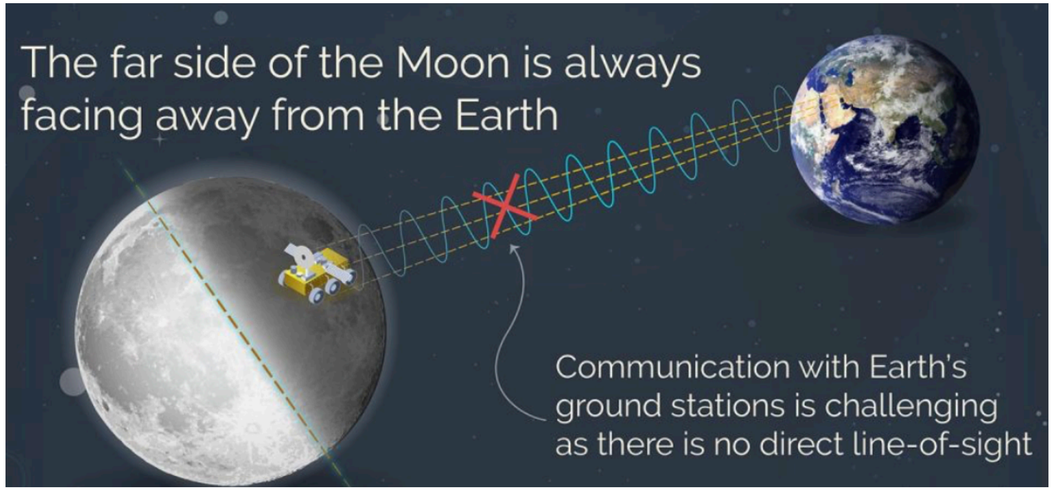
- The far side of the Moon is the lunar hemisphere that always faces away from Earth.
- China’s Chang’e-4 returned the first detailed images of the far side of the moon in 2019.



An Use Case

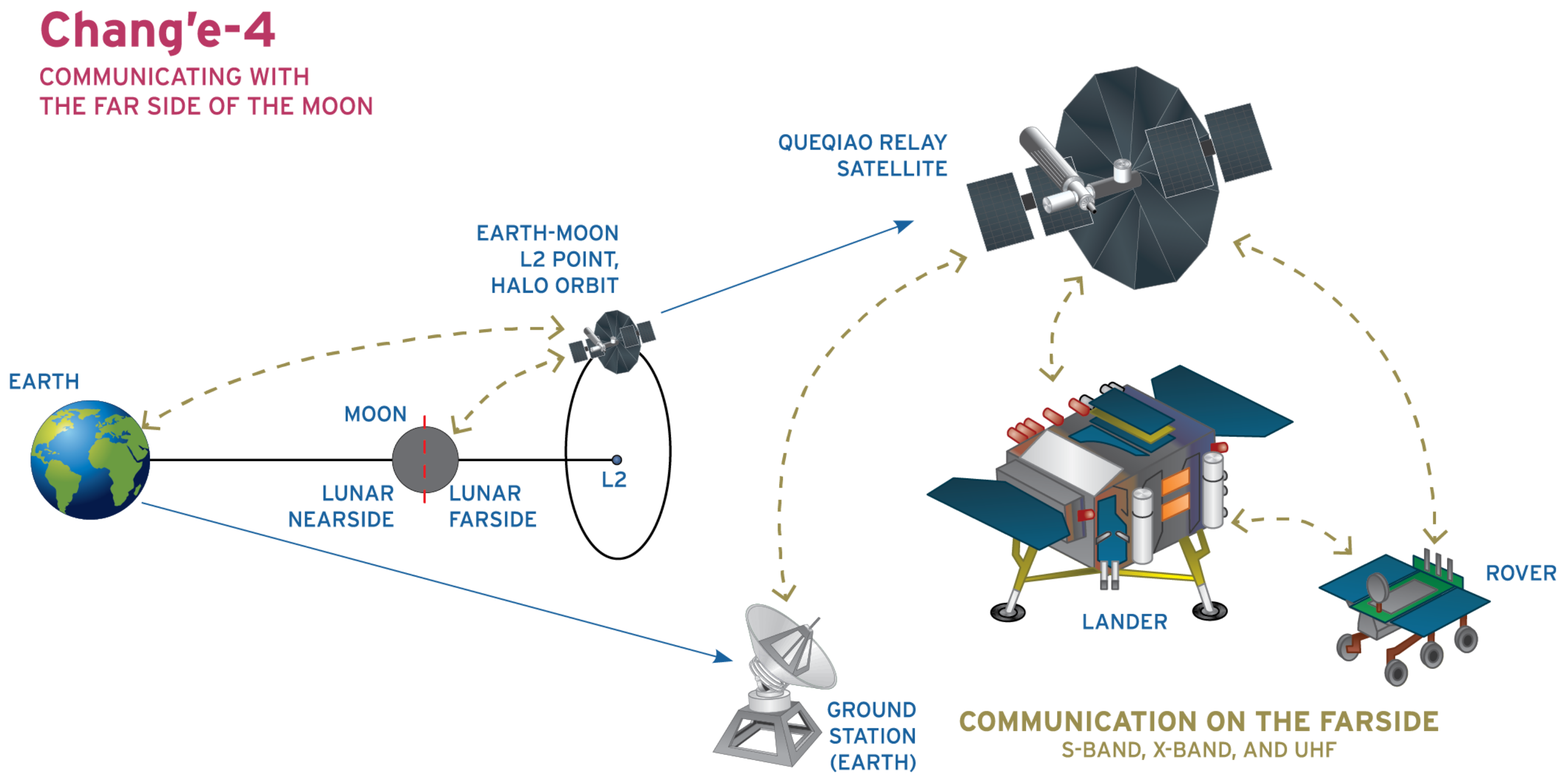
How to return the images from the far side of the moon?

- There is no direct line-of-sight.
- Direct communication with the experiment will be impossible.
- A relay satellite is necessary to solve this problem.



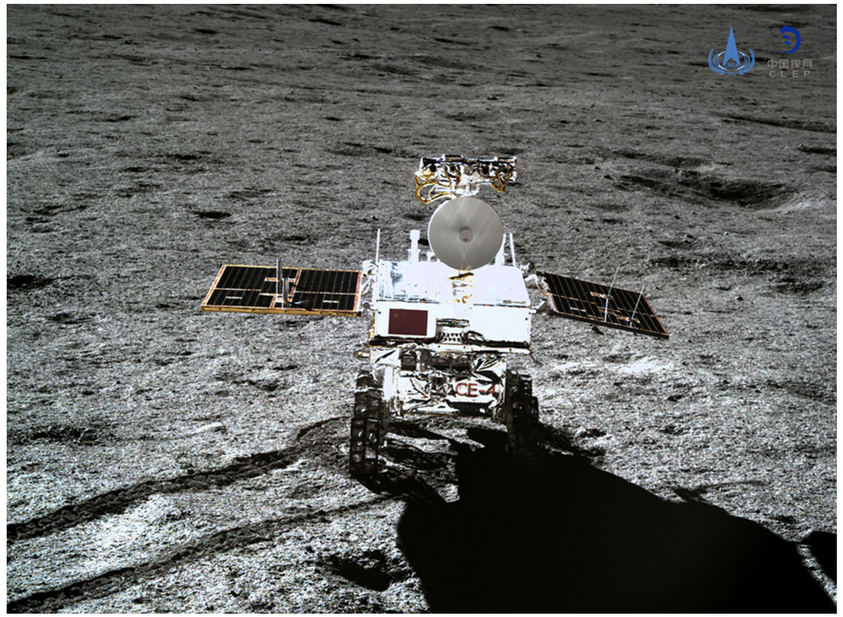
An Use Case

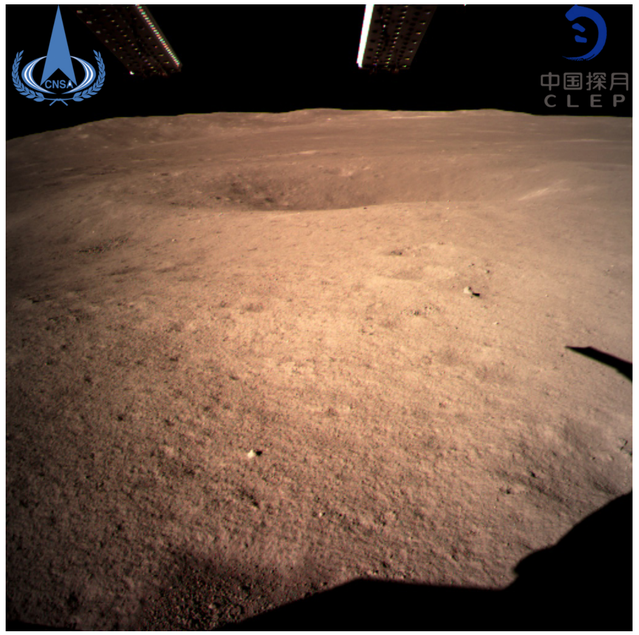
Queqiao relay satellite

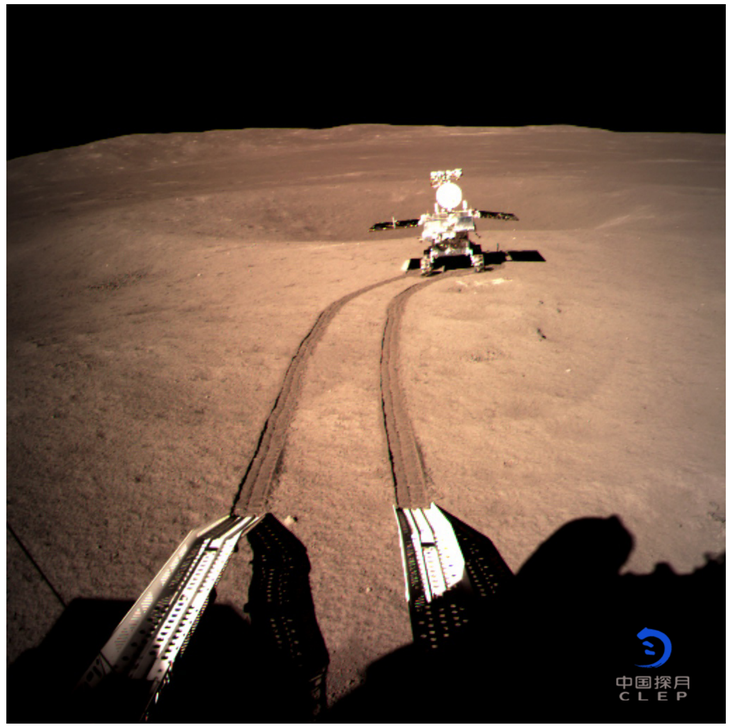


An Use Case

Images of the moon’s far side



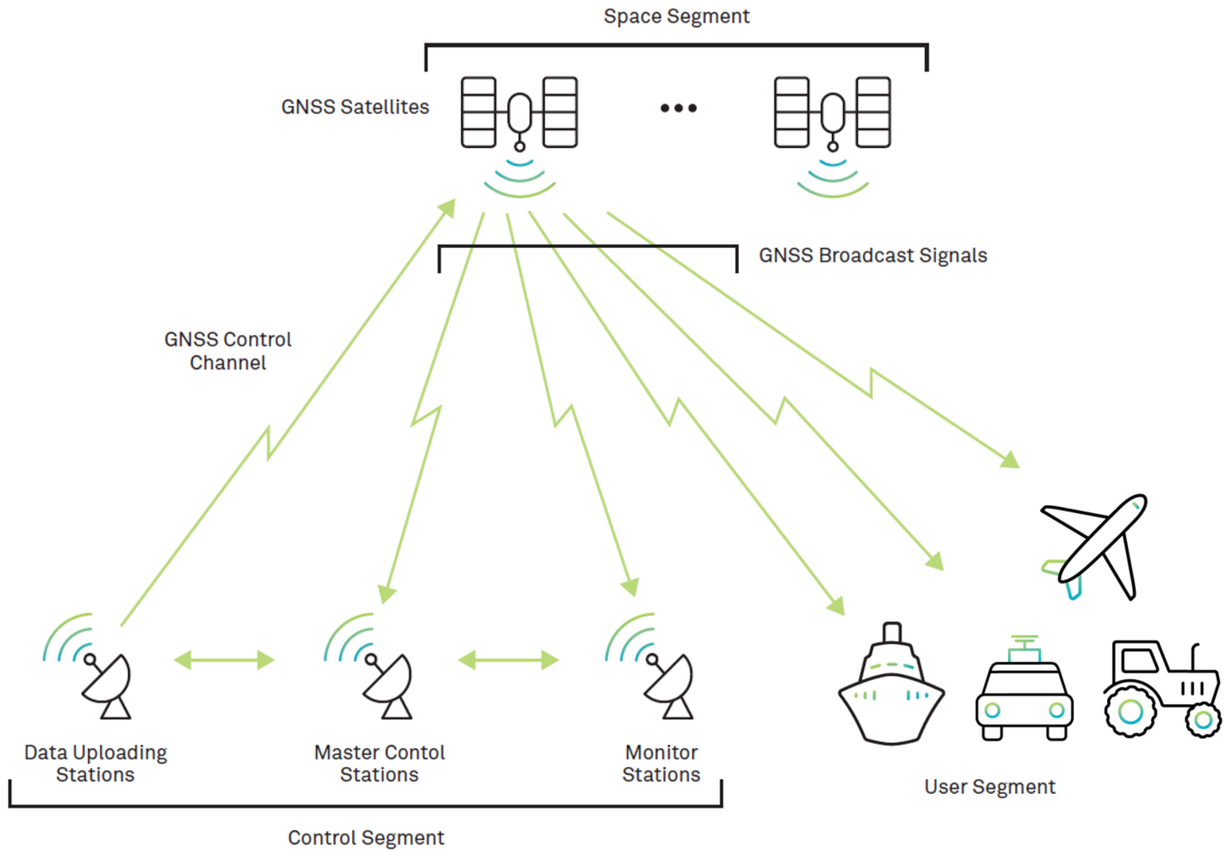




Global Navigation Satellite Systems (GNSS)

What is GNSS

- A global navigation satellite system (GNSS) is a network of satellites broadcasting timing and orbital information used for navigation and positioning measurements.
- Space segment: broadcast signals that identify which satellite is transmitting and its time.
- Control segment: master control, data uploading, and monitoring.
- User segment: receives satellite signals and outputs a position based on the time and orbital location of at least 4 satellites.



GNSS Applications

- Location – determining your position in the world
- Navigation – identifying the best route from one location to another
- Tracking – monitoring an object’s movement in the world
- Mapping – creating maps of a specific area
- Timing – computing precise timing within billionths of a second

Types of GNSS

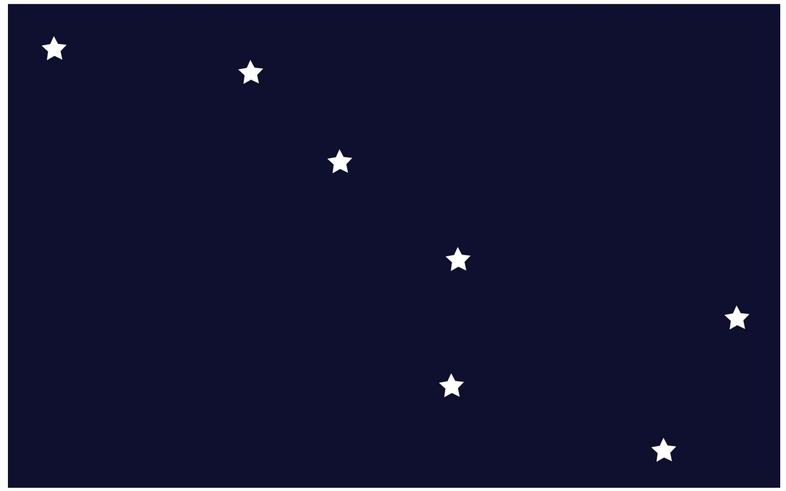
- Global Positioning System (GPS): United States
- BeiDou: China
- GLONASS: Russia
- Galileo: European Union
- QZSS: Japan
- IRNSS/NavIC: India

Comparing GNSS constellations

	Operator	Coverage	Altitude (km)	Satellites in Orbit
GPS	US Space Force	Global	20,180	31
GLONASS	Roscosmos	Global	19,130	24
Galileo	GSA and ESA	Global	23,222	26
BeiDou	CNSA	Global	21,528 (MEO satellites) 35,786 (GEO and IGSO satellites)	48
QZSS	JAXA	Regional	32,000 (perigee) 40,000 (apogee)	4
IRNSS/NavIC	ISRO	Regional	36,000	8

BeiDou Navigation Satellite System (BDS)

- In Chinese, the Big Dipper Constellation is known as BeiDou.
- BDS provides geolocation and time information to BDS receivers anywhere on or near the Earth.
- “GPS capabilities are now significantly surpassed by China's BeiDou system.”-U.S. 27th PNT Advisory Board Meeting.



Conclusion

Conclusions

Advantages

- Global coverage.
- Independent of physical infrastructure.

Limitations

- Signal delay (latency).
- Atmospheric interference.
- Impossible to repair and maintain
- Cost of launching satellites.

Thank You