The Envision of Earth-Moon and Deep Space Communication-Navigation-Remote Sensing Integrated Constellation System

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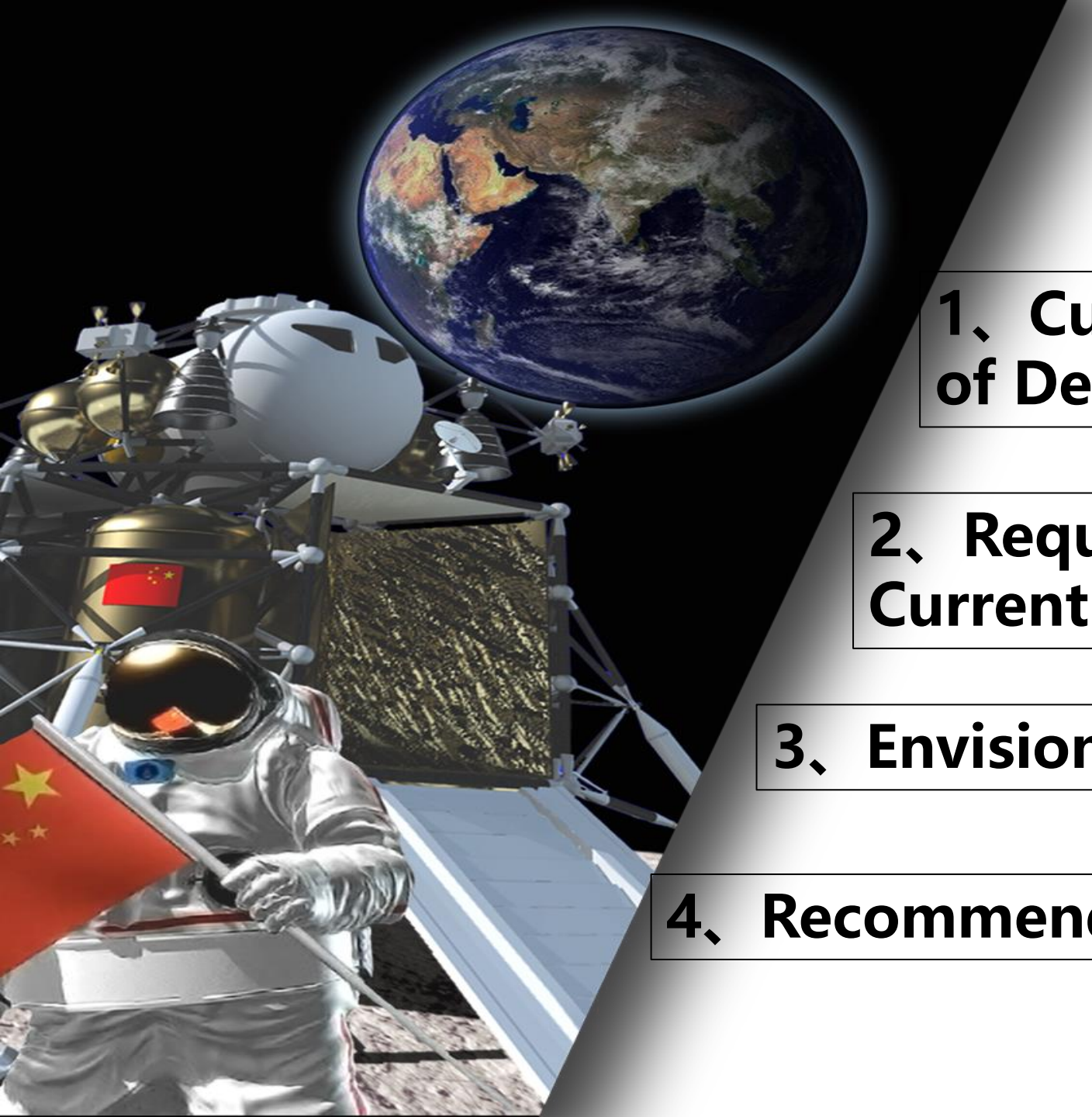

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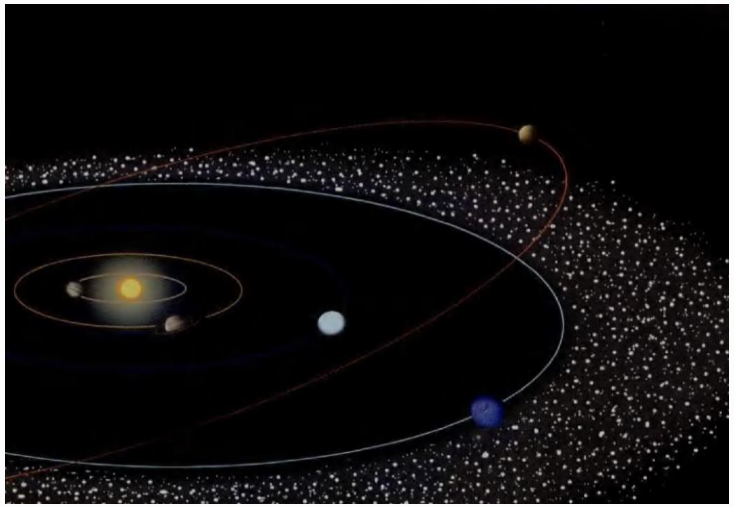
1、Current Situation and Envision of Deep Space Exploration in China

Current Situation and Envision of Deep Space Exploration in China

- In deep space exploration, "CE-4" has landed on the far side of the moon, "CE-5" returned to the earth with soil of the moon. Three steps of China's Lunar exploration project "surrounding, landing and returning " have been completed successfully. "CE-6" returned with soil from the far side of the moon with support of "QueQiao-2". "TW-1" visited Mars, accomplished "surrounding, landing and touring " with one mission. Space Exploration of China has been accomplished from Earth-Moon scope to interplanetary scope.

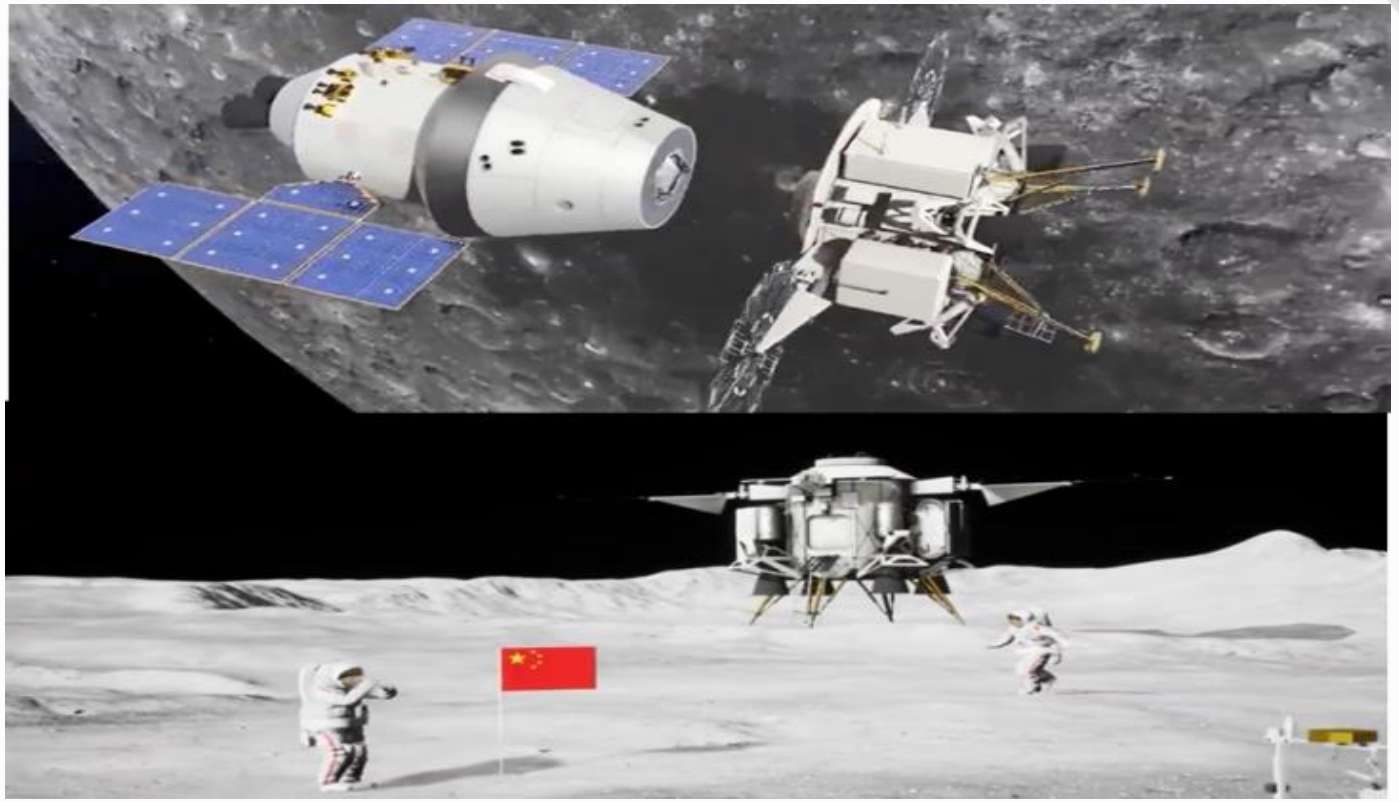
Current Situation and Envision of Deep Space Exploration in China

- In the coming year, China will continue to carry out Lunar exploration project, such as high-precision Lunar polar region landing ,and carry out the construction of International Lunar Research Station(ILRS).
- China will continue to carry out planetary exploration project, complete missions like sampling and returning from Mars, exploring the Jupiter scope, sampling from near-Earth asteroids, exploring the comets belt, and demonstrate plans for exploring the margin of solar system.



Current Situation and Envision of Deep Space Exploration in China

- **Before 2030, China will achieve a manned landing on the moon, and in the long term, it will further promote the development of new industries such as the utilization of in-situ lunar resources.**



2、Requirement and Analysis of Current Ability

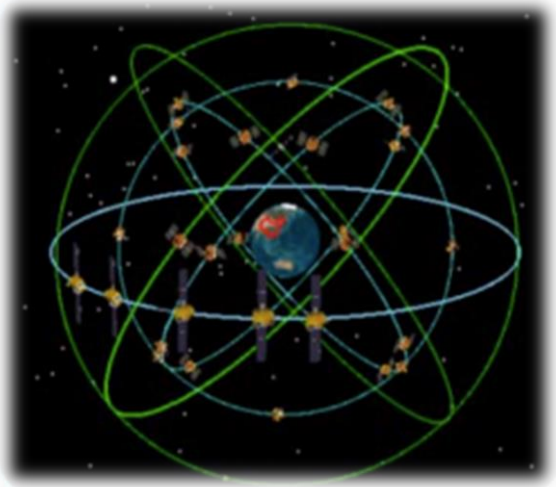
2.1 Communication-Navigation-Remote Sensing Requirements for Deep Space Exploration

- **Efficient network communication**: to increase high-speed laser/ microwave relay in Earth-Moon space and even interplanetary space to support multiple frequency bands and more users.
- **Precise PNT**: support large-scale lunar movement navigation, lunar surface ascent and descent navigation, planetary probe positioning, timing, etc.
- **Efficient space awareness:** support space environment monitoring, etc.
- **On-demand information services:** support scientific payload information processing, on-demand distribution, etc.

2.2 Analysis of existing GNSS and Lunar Communication capabilities

(1) Support capability of BD for SSV

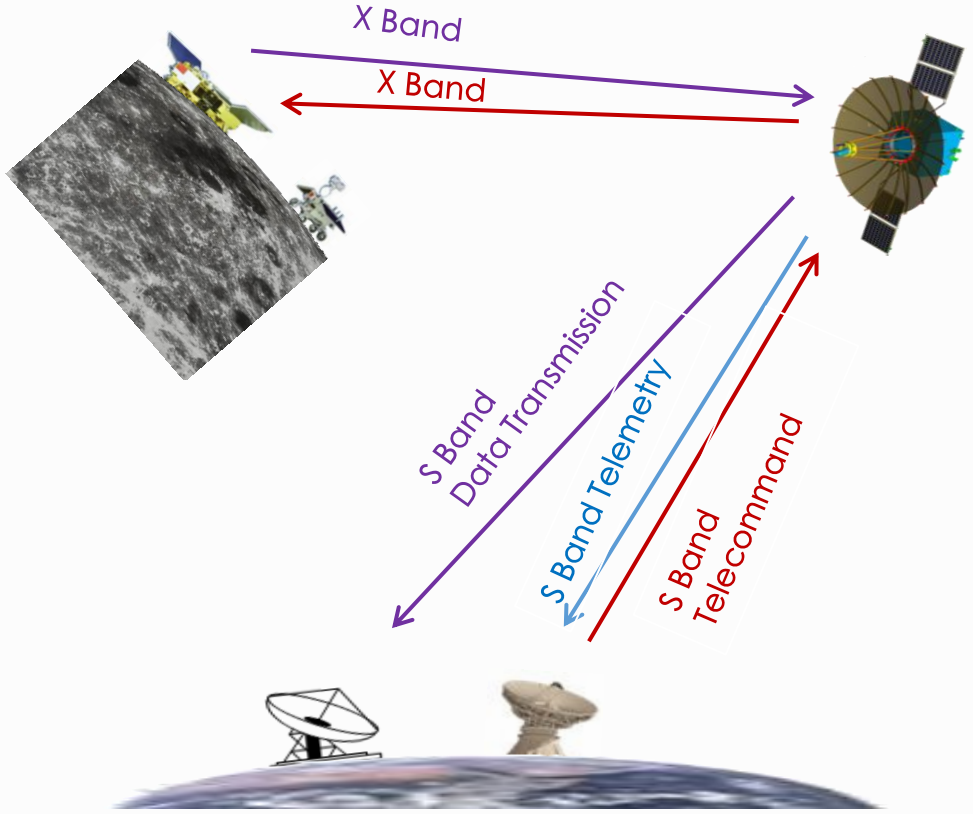
- The interoperability of navigation signals and message information with other GNSS systems is designed in the navigation signal of the Beidou system, which lays the foundation for the interoperability with other GNSS systems to realize SSV.
- At present, technical tests on receiving Beidou navigation signals in the Earth-Moon transfer orbit have also been carried out in China's lunar probes.



2.2 Analysis of existing GNSS and Lunar Communication capabilities

(2) Capability of Lunar relay communication

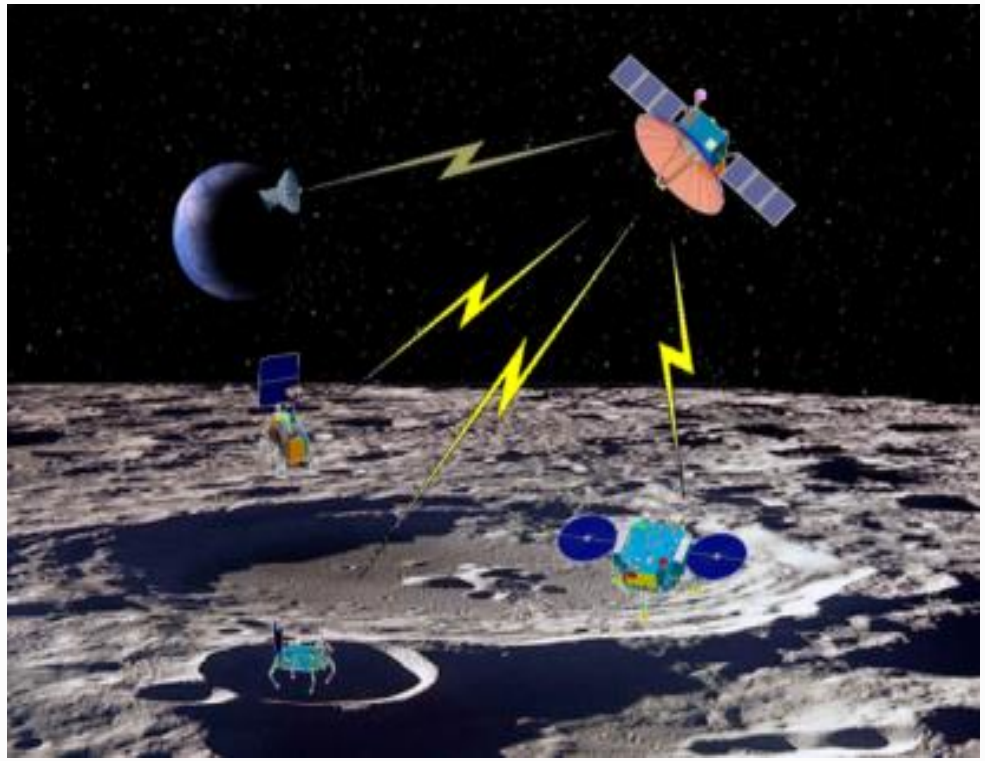
- The QueQiao-1 satellite developed by China was launched into halo orbit at L2 point, which is **the first relay satellite providing communication** on the far side of the Moon.



2.2 Analysis of existing GNSS and Lunar Communication capabilities

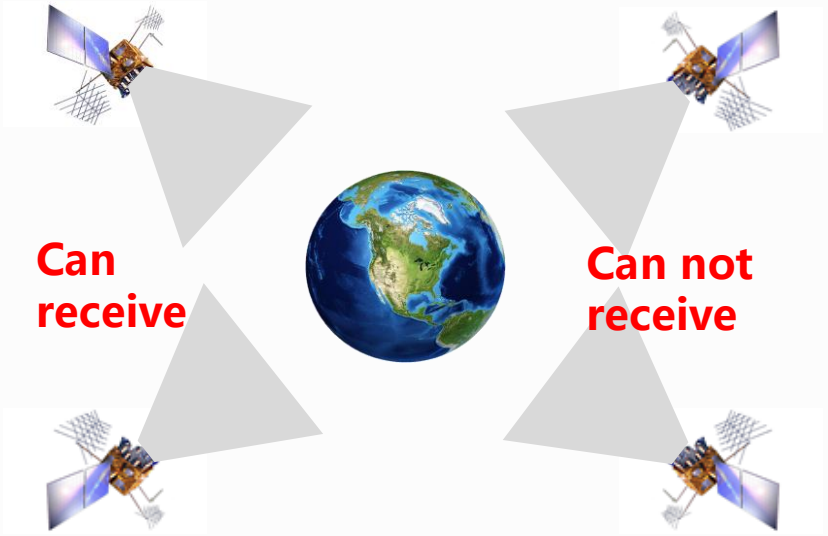
(2) Capability of Lunar relay communication

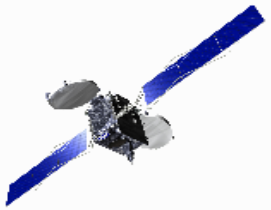
- In March 2024, China launched a new lunar relay satellite, QueQiao-2 which operates in the lunar elliptical frozen orbit and supported Chang'e-6 , will also support follow-up missions and carry out a serial of experiments.



2.3 Shortage of Earth-Moon scope GNSS and relay communication

- **GNSS satellites mainly serve the ground or near-Earth space, which limits the number of navigation satellite that can be received by the probe in the Earth-Moon space.**
- **When the probe is on the far side of the moon, all GNSS satellites are not visible.**
- **The orbit determination accuracy of Earth-Moon space probe using GNSS navigation is limited.**

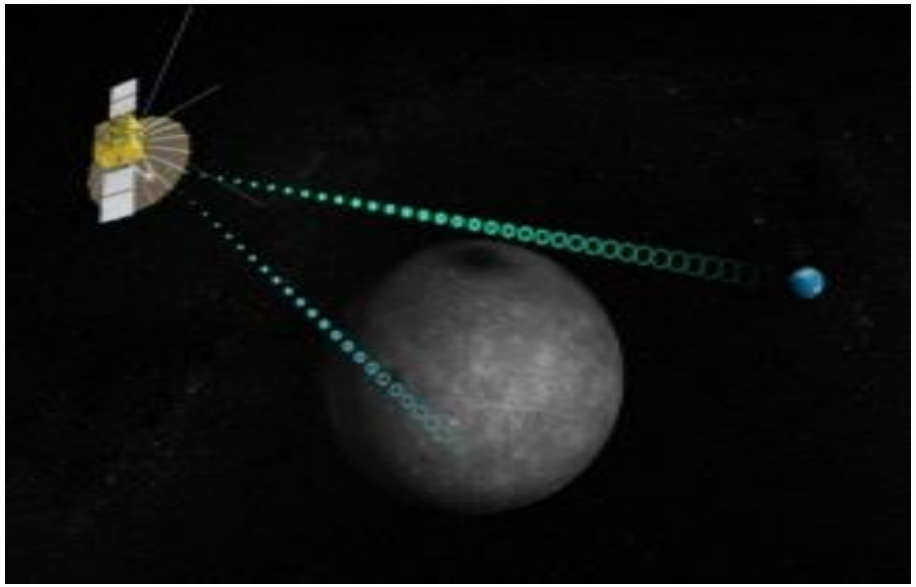




A probe in the Earth-Moon transition segment

2.3 Shortage of Earth-Moon scope GNSS and relay communication

- At present, Queqiao-1 and Queqiao-2 are difficult to support the relay communication needs of missions such as Earth-Moon space round-trip missions and follow-up ILRS in lunar south polar.
- The relay communication frequency band only has the X-band, which cannot support S, Ka and other links.
- It does not have the ability to navigate, provide information services, etc.



3、Envision of Prospective Scheme

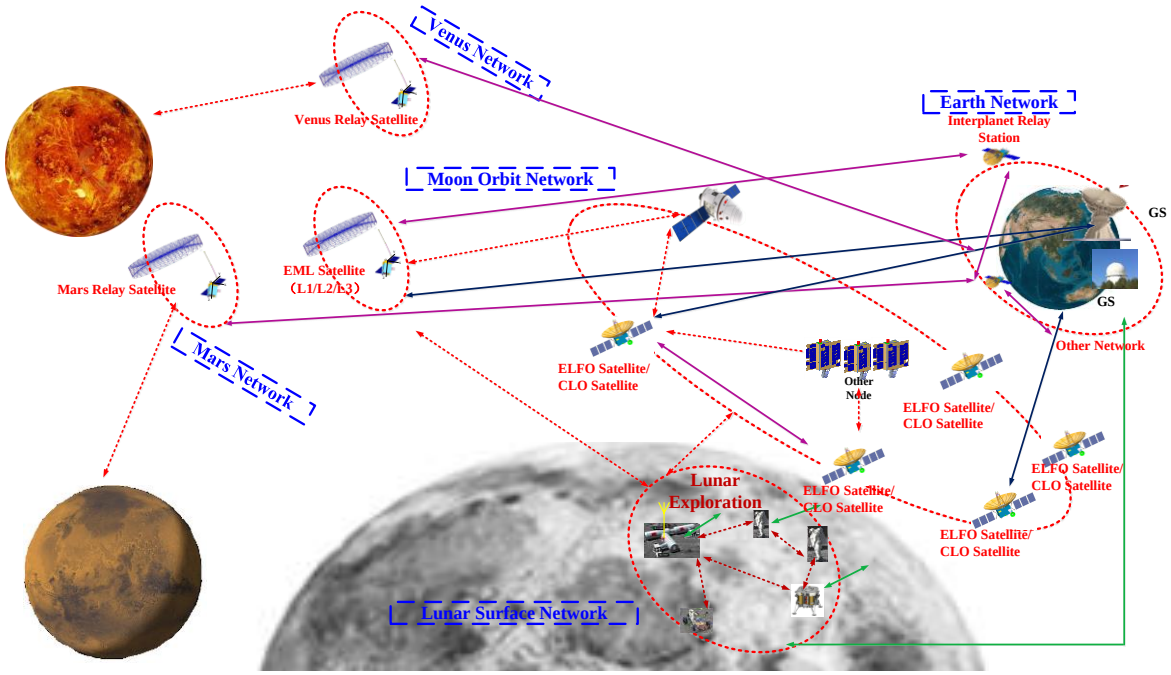
3.1 Concept and Intension

Various countries have put forward plans for the lunar communication and navigation system, and we have also put forward a preliminary idea for the Earth-Moon and Deep Space Communication-Navigation-Remote Sensing Integrated Constellation System according to the needs of lunar and deep space exploration.

□Role: Information Facility of Deep Space Communication-Navigation-Remote Sensing

□Function: Provide Efficient Network Communication, Precise PNT, Efficient Space awareness , On-demand Information Services to Deep Space Exploration and Resource Utilization

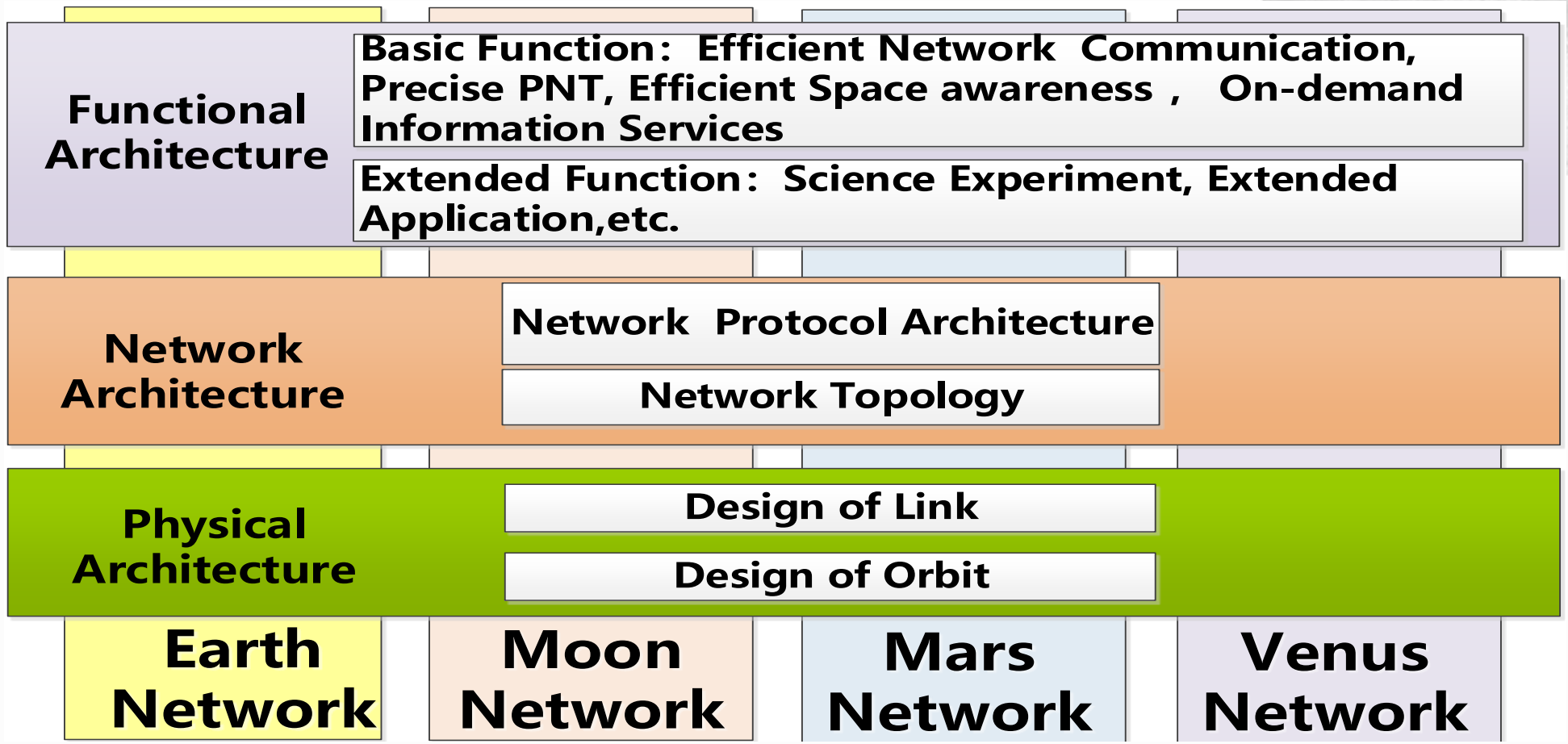
□Service Scope: Earth-Moon Space, Interplanetary Space , etc.



Earth-Moon and Deep Space Communication-Navigation-Remote Sensing Integrated Constellation System

3.2 Envision of Prospective Scheme

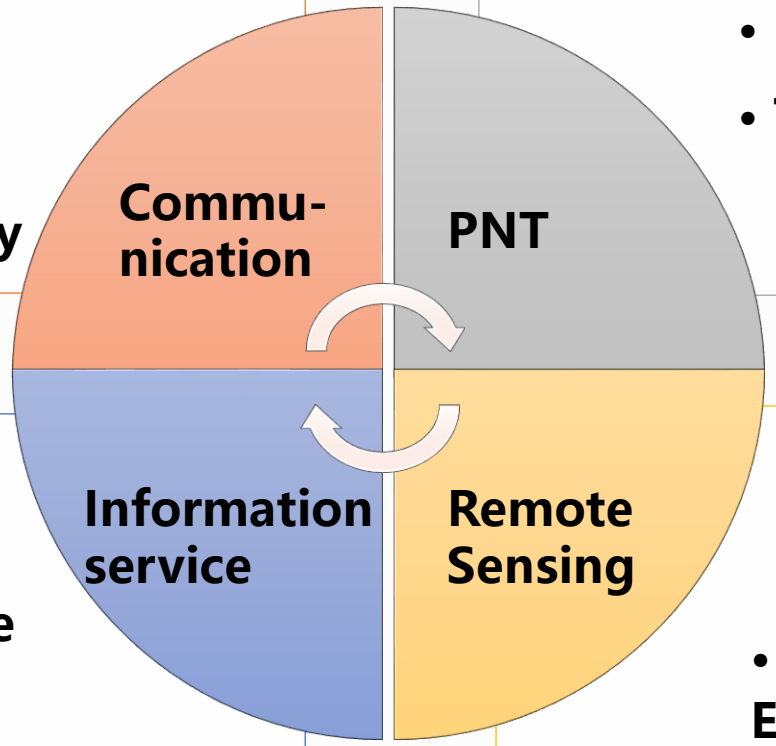
Construct the Earth Network, Moon Network, Mars Network, Venus Network as an Interplanetary Network through the design of Function Architecture, Network Architecture and Physical Architecture.



3.2 Envision of Prospective Scheme

1、Functional Architecture

- Moon Relay Communication
- Earth-Moon Roundtrip Communication
- Deep Space Relay



- Positioning
- Navigation
- Timing

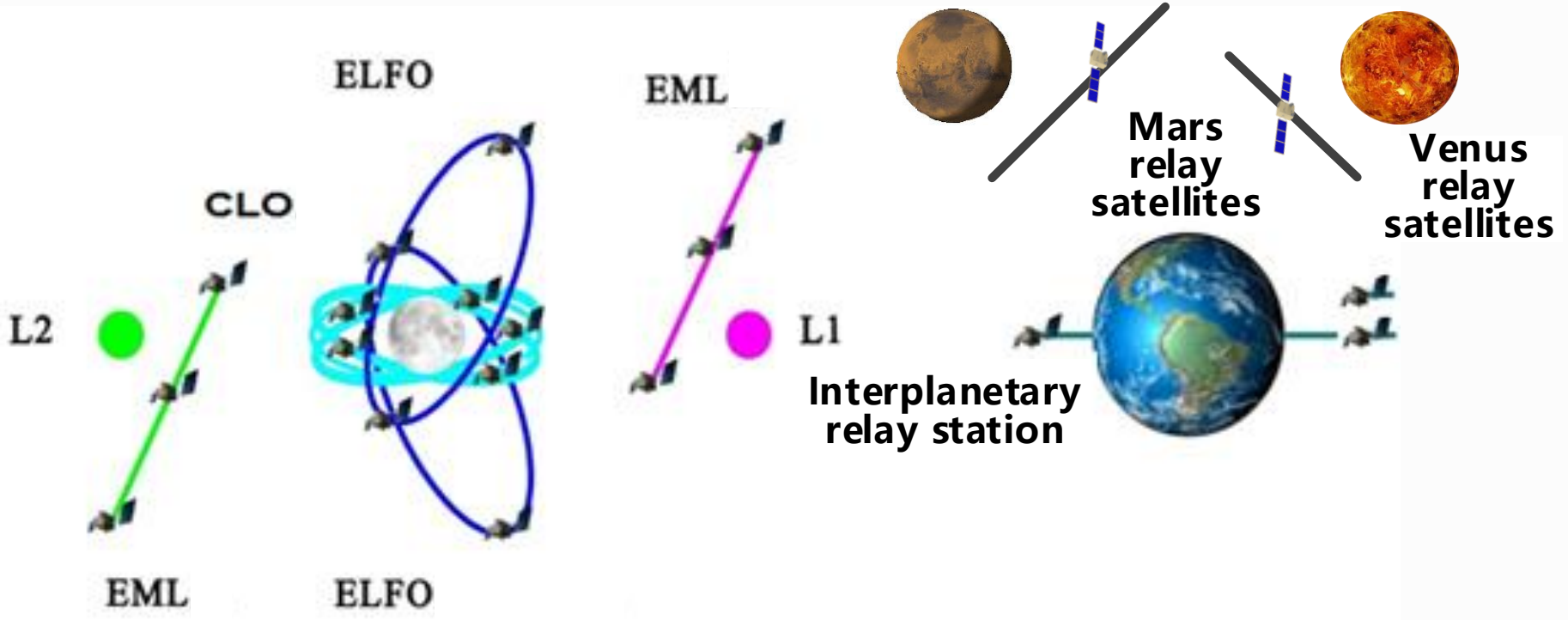
- Onboard Computing
- Onboard Storage
- Information Subscribe/Pub

- Space Environment Detection

3.2 Envision of Prospective Scheme

2、 Physical Architecture

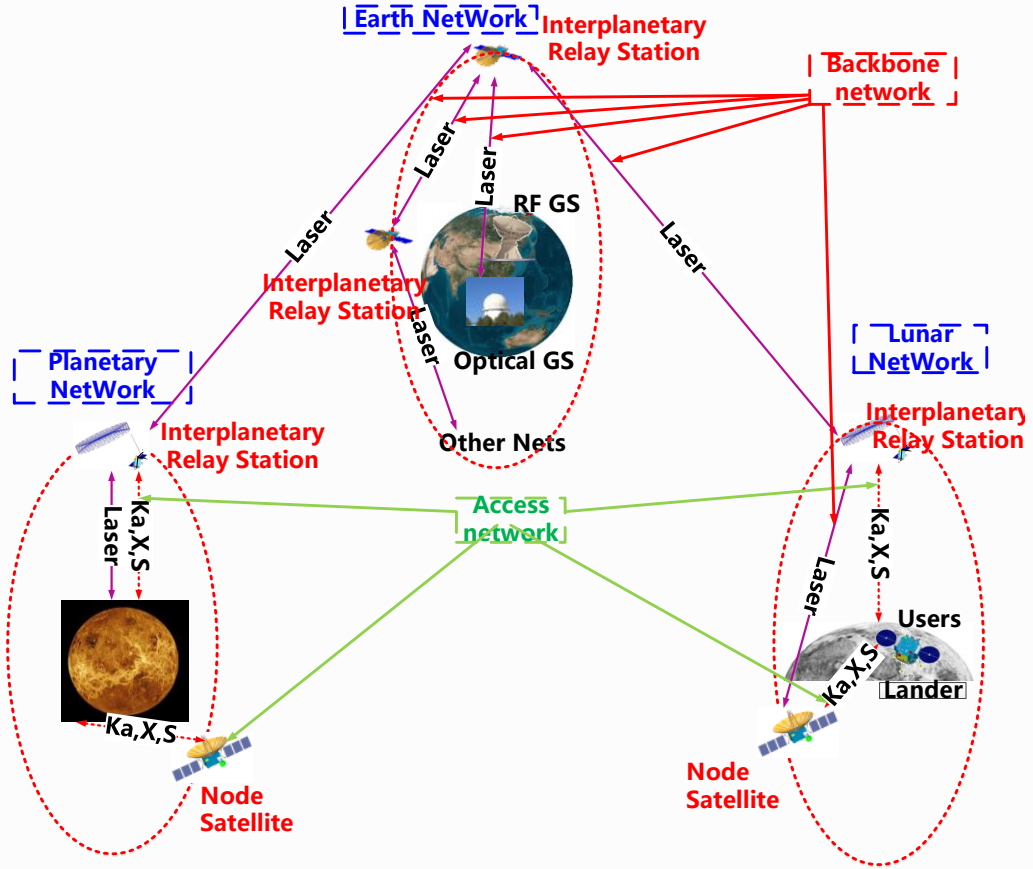
- Support users on the lunar surface and orbit through **ELFO** and **CLO** satellites.
- Build backbone link between Earth and Moon through **Interplanetary Relay Station** and EML satellites.
- Build backbone link between Earth and Mars/Venus through **Interplanetary Relay Station** and Mars/Venus relay satellites.



3.2 Envision of Prospective Scheme

3、Network Architecture

The future system is divided into Earth Network, Moon Network and Planetary Network, and each network can be interconnected through Interplanetary Relay Stations.



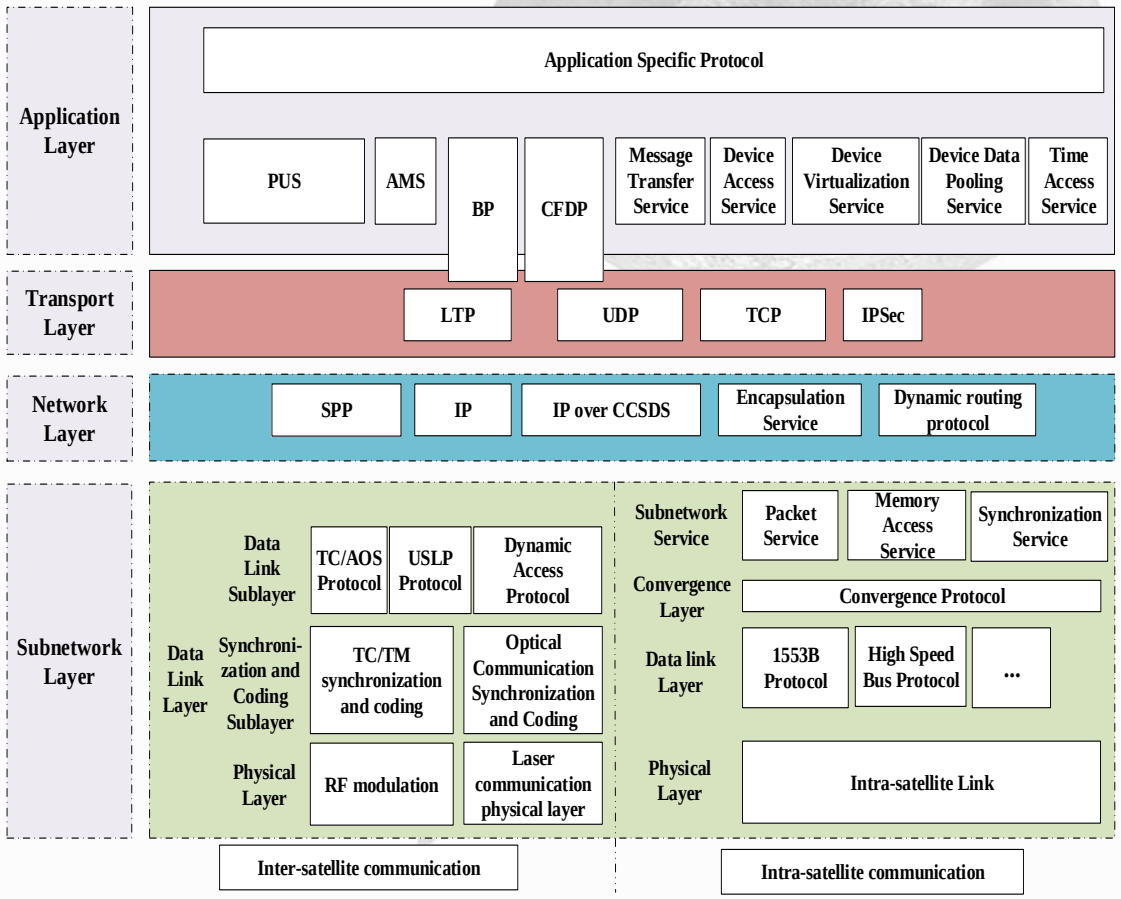
Primary Network Topology

4、Recommendations

4.1 Recommendations on network protocol specifications

At present, CCSDS and other related standardization organizations have proposed moon-related space network communication protocols, onboard communication network protocols and other architectures, but they have not yet been fully unified.

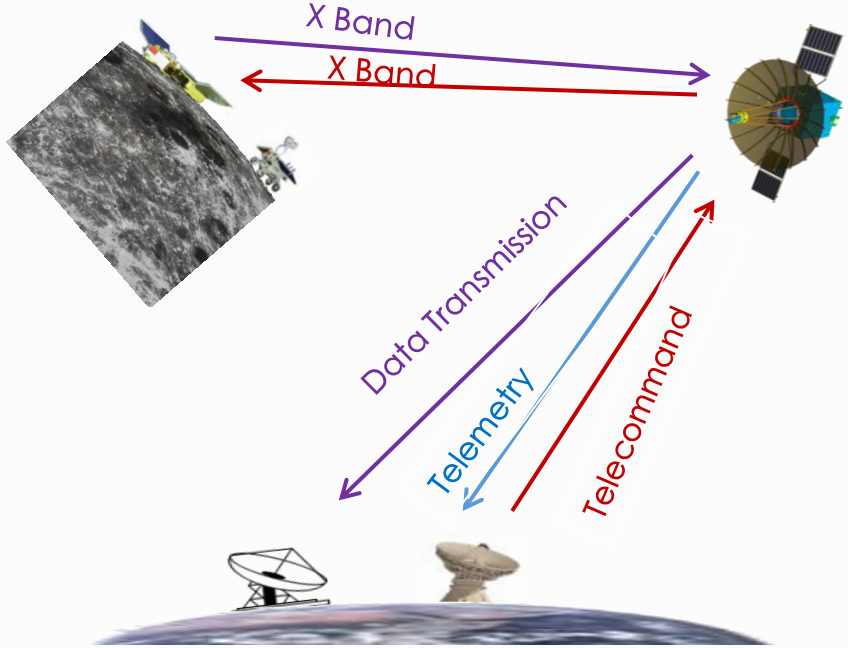
We have proposed an integrated network protocol architecture that integrates space communication and onboard communication to facilitate interoperability in the future.



Primary Network Protocol Architecture

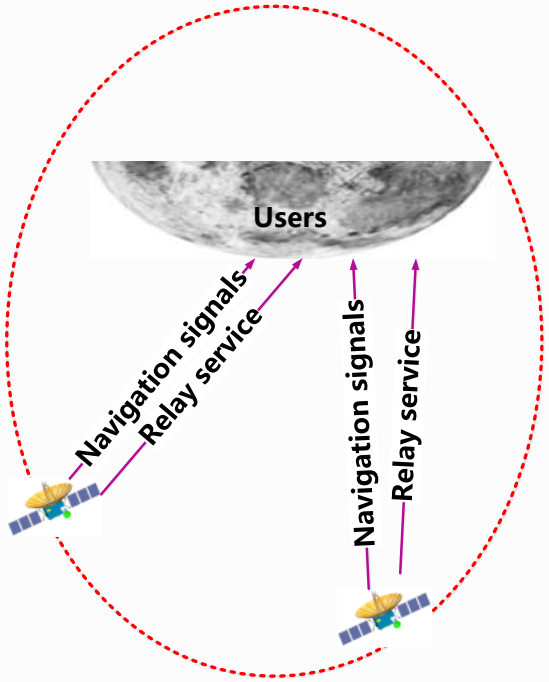
4.2 Recommendations on relay frequency

Considering that the X-band is also one of the frequencies currently used by lunar probes, it is suggested that the X-band can be used as one of the lunar relay communication frequencies in the future system. It is suggested that X/S/Ka/laser relay services can be provided in the future system at the same time, which can take into account the communication between the earth and the moon to reduce the weight of the user.



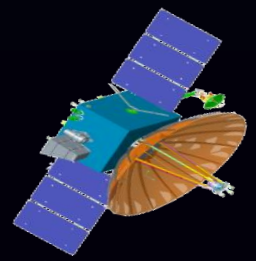
4.3 Recommendations on international cooperation

We are also planning to carry out technical tests such as communication and navigation for the lunar south polar in the future, and provide communication, information and other services.
It is suggested that in the future, all parties jointly negotiate interfaces and protocol specifications, jointly build and conduct technical tests, and jointly share various services provided by the system.



The Ending

- The establishment of the Integrated Constellation System, as the Earth-Moon and deep space information infrastructure, will provide communication ,navigation and remote sensing services for international lunar exploration, deep space exploration, etc.
- It is a powerful guarantee to boost the development of the Earth-Moon space economy and aerospace industry, and an important support for efficient utilization and cognition of space.



Thanks!