

China Deep Space Exploration

——Achievements and Prospects

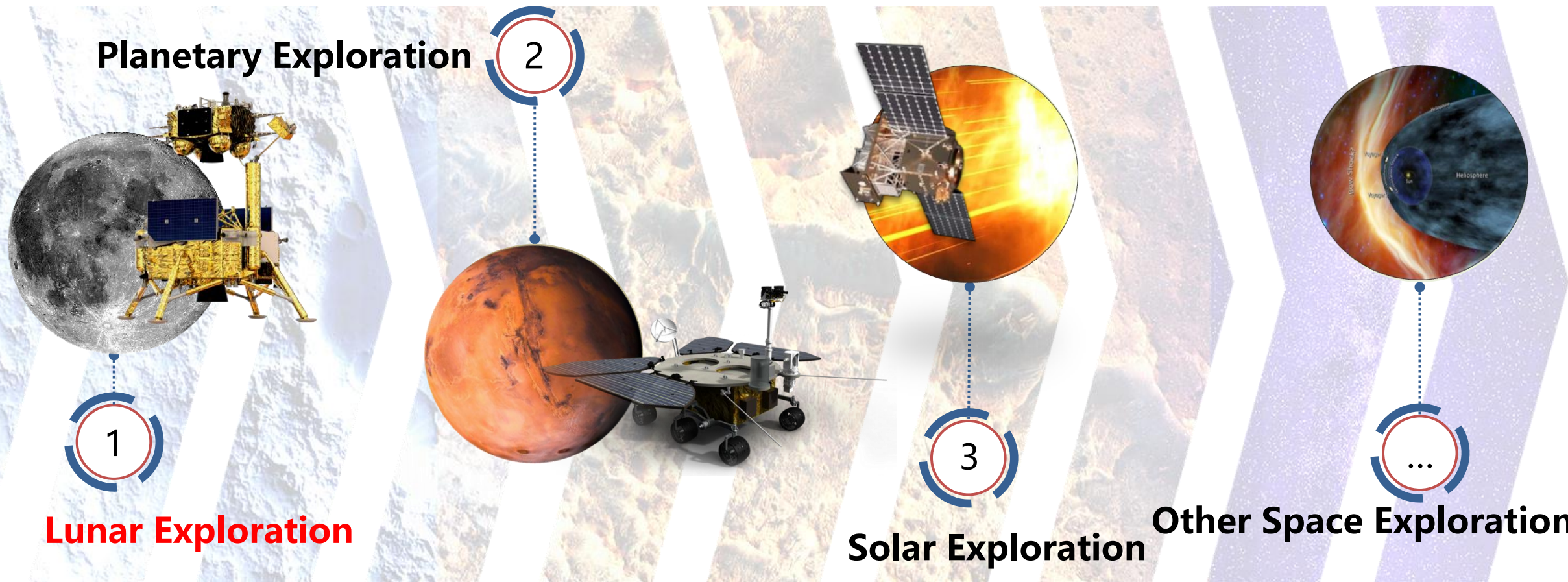
Dengyun YU

Chief Designer(4th Phase of CLEP)、Academician

November 21th, 2022

Preface

Deep space exploration is an activity of exploring **the Moon and the beyond** by launching space vehicle and important approach to conduct **scientific research**, **technical innovation** and **SERU**.



1

China Lunar and Planetary Exploration

2

Prospect of China Deep Space Exploration



—、China Lunar and Planetary Exploration



(一) Three Steps of China Lunar Exploration Program

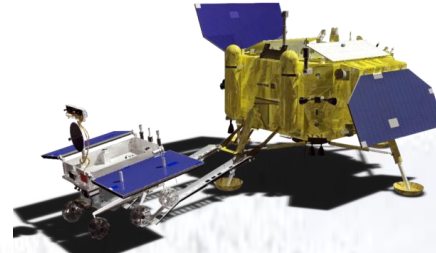
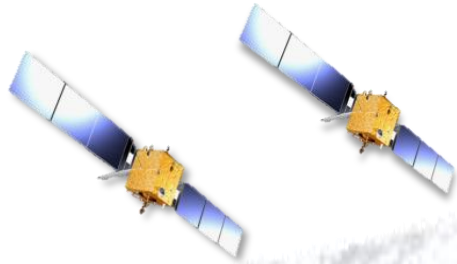
Chang'E-1
2007.10

Chang'E-2
2010.10

Chang'E-3
2013.12

Chang'E-4
2018.12

Chang'E-5
2020



Orbiting

Landing

Sample Return

—、China Lunar and Planetary Exploration



■ Chang'E-1



Launch Successfully

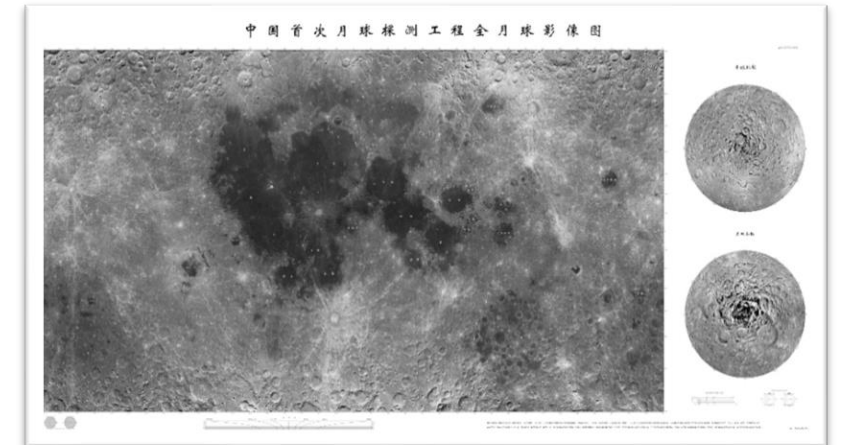
October 24th, 2007
XSLC

Controlled Impact

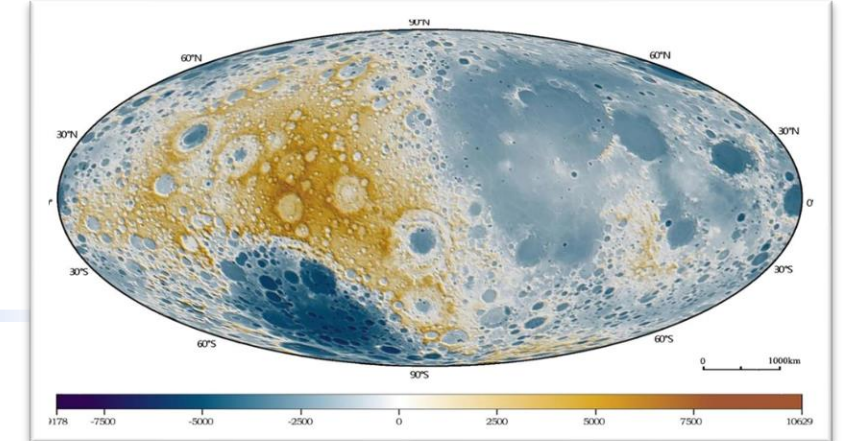
March 1st, 2009
Mission completed, 494
days in orbit

Comprehensive RS

Images acquired, as 3D full lunar map with a 120-meter resolution, lunar elements distribution map, etc.



3D Full Lunar Map with a 120m Resolution



Full Lunar Elevation

Realizing a thousand-year dream
of lunar exploration by Chinese

—、China Lunar and Planetary Exploration

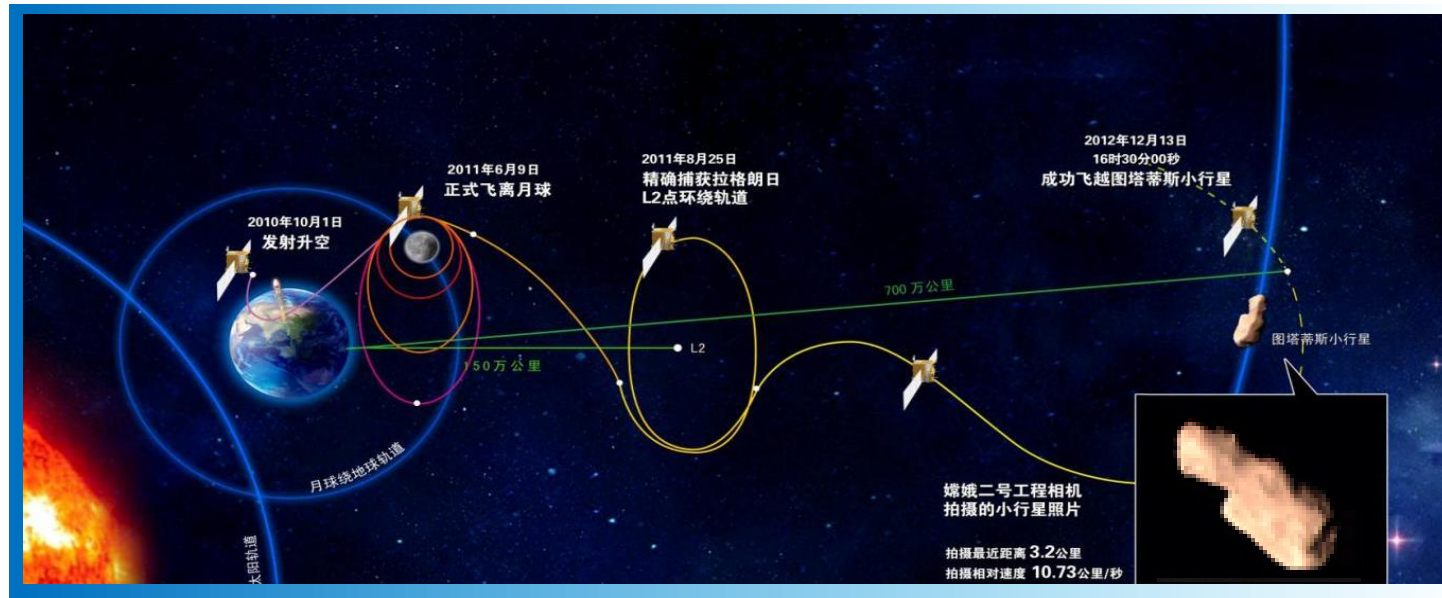


■ Chang'E-2

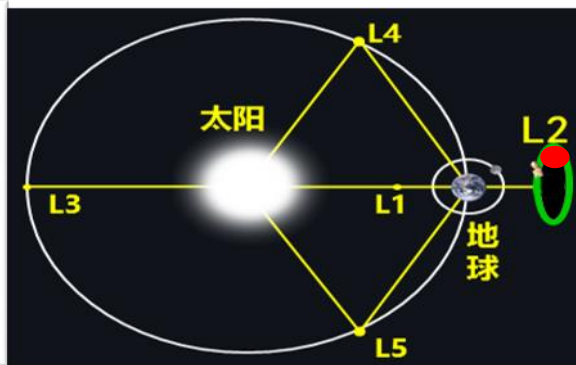
Launch Successfully

October 1st, 2010

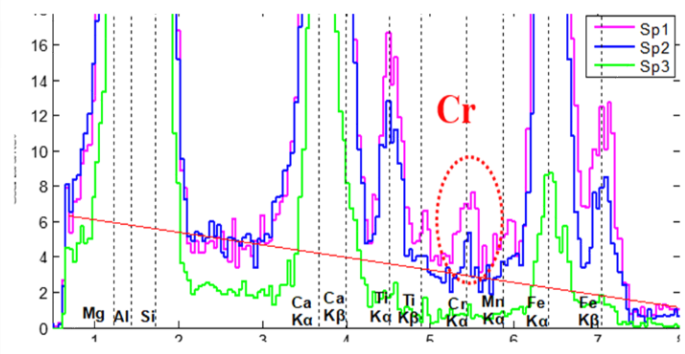
- Acquiring Moon Map with a 7m resolution (Full) , 1.5m(Regional)
- Finding Chromium in the lunar surface, Micro magnetic layer, Solar wind speed-up & speed-down
- High-precision detection on L2 (Sun-Earth) 、No.4179 asteroid.



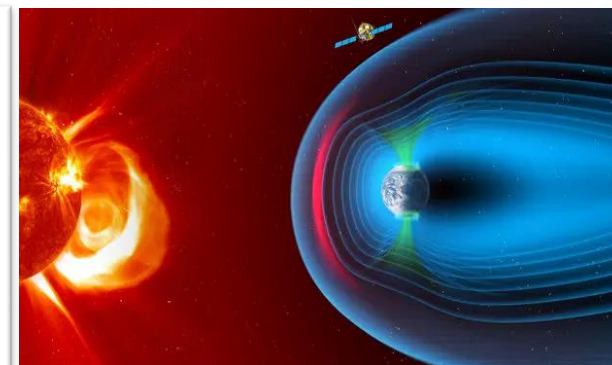
Full Moon Map with a 7m resolution



L2 (Sun-Earth)



Chromium in the lunar surface



Micro magnetic layer & Solar wind speed-up & speed-down

“Three detections by one spacecraft”
Man-made planet orbiting the Sun

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■ Chang'E-3

Launching

December 12th, 2013
XSLC

Landing

December 14th, 2013
land on targeted area
in Sinus Iridium

Operating

Conduct **in-situ detection** after soft
landing in Sinus Iridium

Rovering

Touring exploration after
separation from the
Lander



The Lander has operated for more than **nearly 10 years**,
which makes a record of **longest lunar surface exploration**.

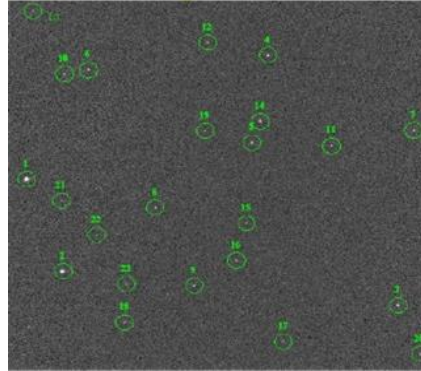
—、China Lunar and Planetary Exploration



■ Chang'E-3 Three No.1 & “Moon Measuring、Sky Patrolling、Earth Observing” Scientific Exploration

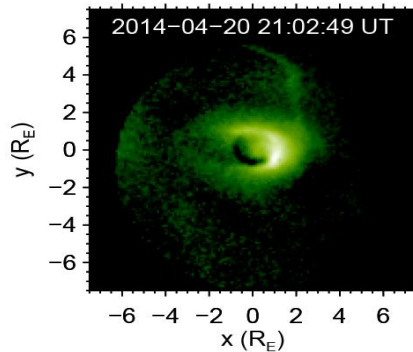
1

For the **first** time, the luminance changes of various celestial sources in the near-ultraviolet band were continuously monitored and **astronomical images** were collected on the lunar surface. **23 stars** were observed.



A lunar - based astronomical survey of the stars

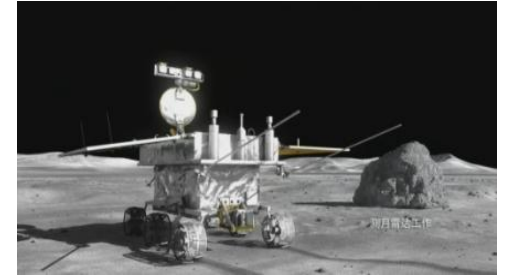
Imaging the plasma layer around the Earth



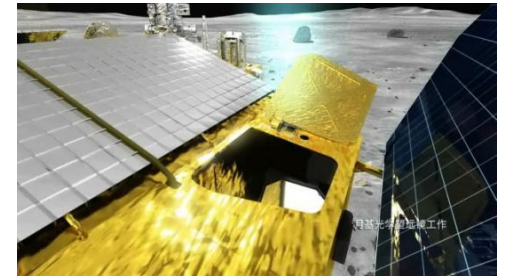
For the **first** time, the plasma layer around the Earth has been observed from the Moon with a field of view of 15 times Earth radius.

2

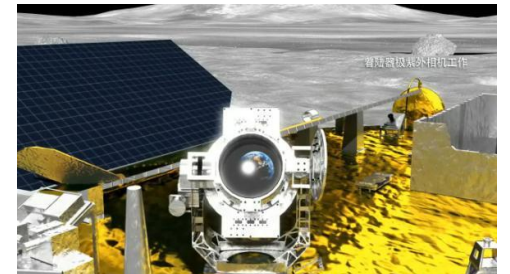
Moon Measuring



Sky Patrolling

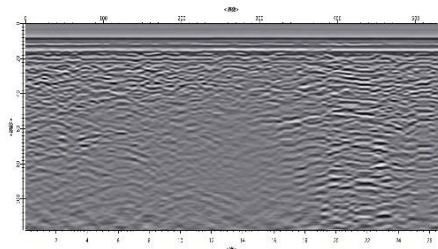


Earth Observing



3

For the **first** time, the shallow **geological profile** of the frontal lunar crust was obtained.

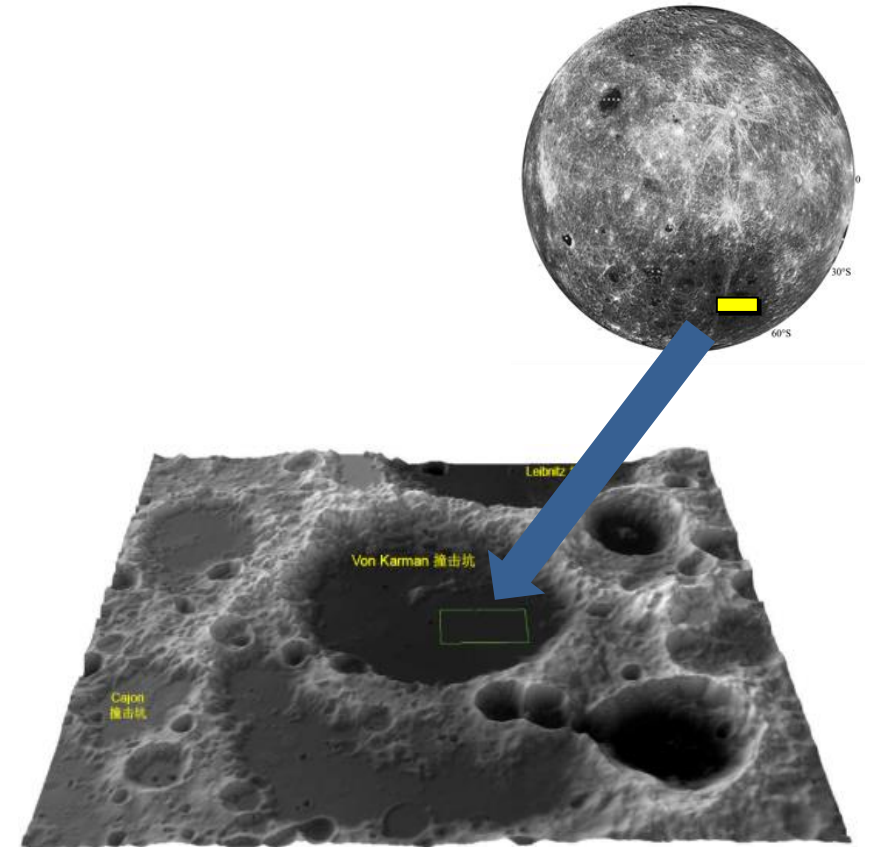
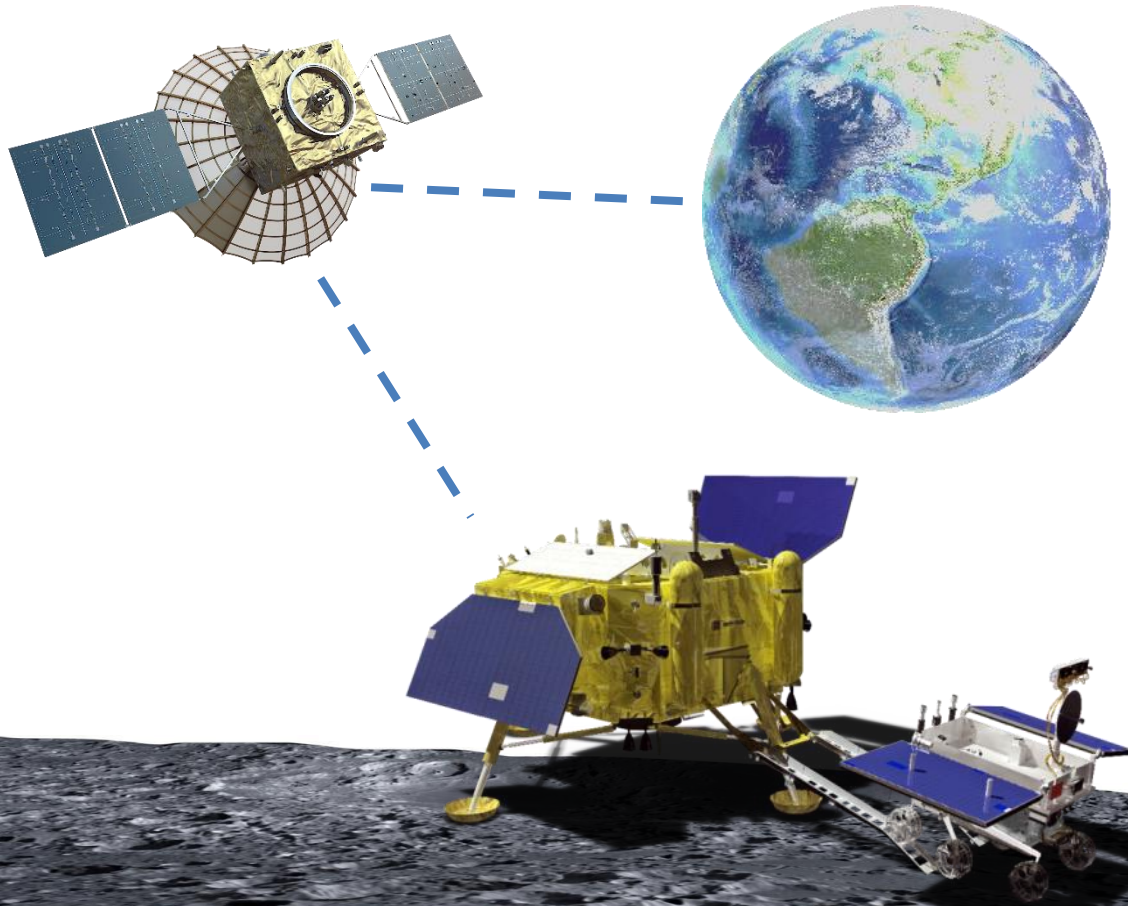


Shallow geological section of lunar crust (10m)

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■ Chang'E-4



Landing area——South Pole-Aitken Basin

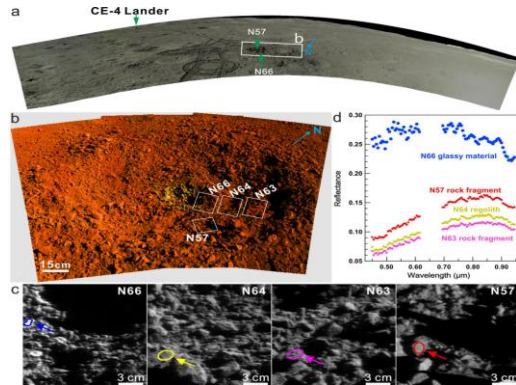
Establishing **new milestone** of international lunar exploration

— China Lunar and Planetary Exploration

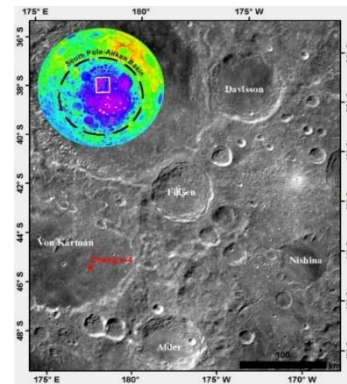


■ Chang'E-4

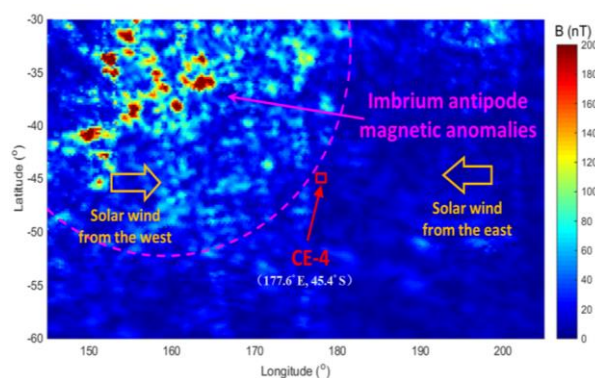
Comprehensive exploration of **surface topography, material composition and space environment** on the dark side of the Moon, yielding fruitful achievements.



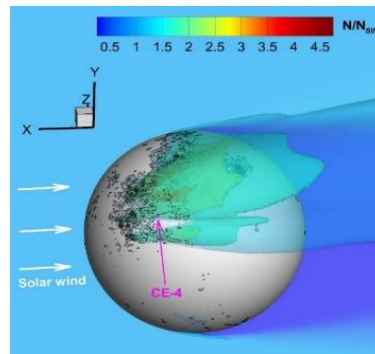
Discovery of impact residue



Dating the Fensong Crater



First lunar surface energy neutral atom in-situ detection



First Observation on micromagnetosphere of the Moon



World Space Award(IAF)

一、China Lunar and Planetary Exploration



■ Chang'E-5

Launch Successfully

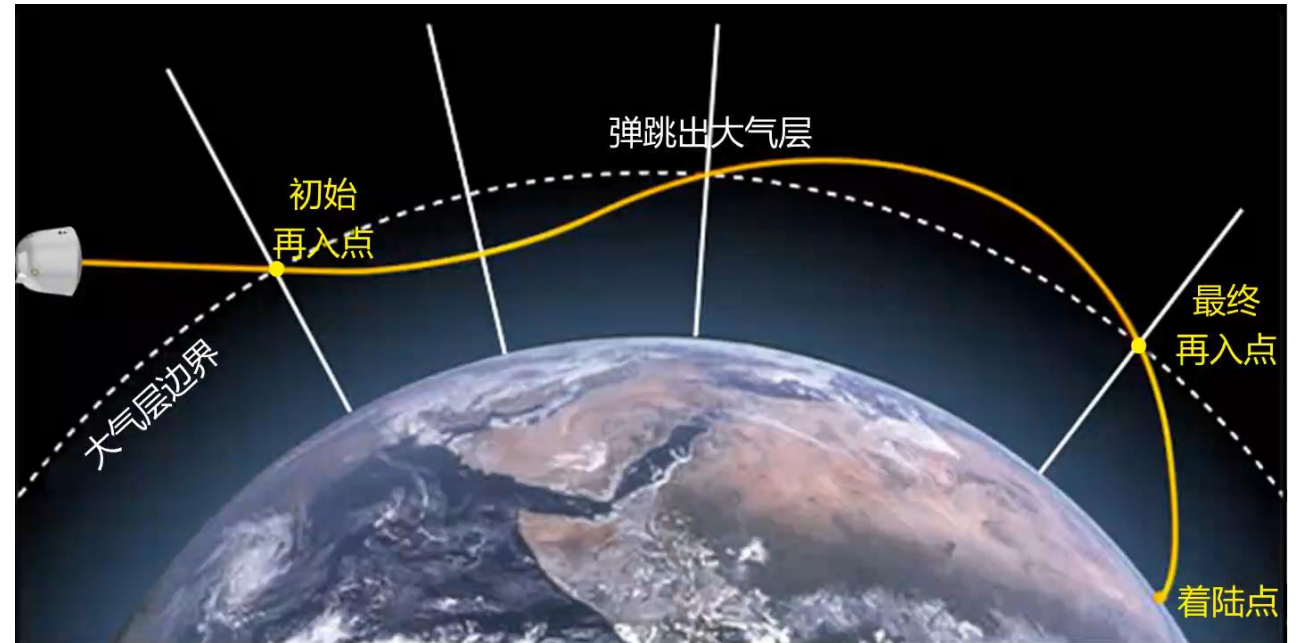
November 24th, 2020
WSLS

Semi-ballistic Trajectory



← Sample

Return →



One of three countries that **returning lunar samples** in the world

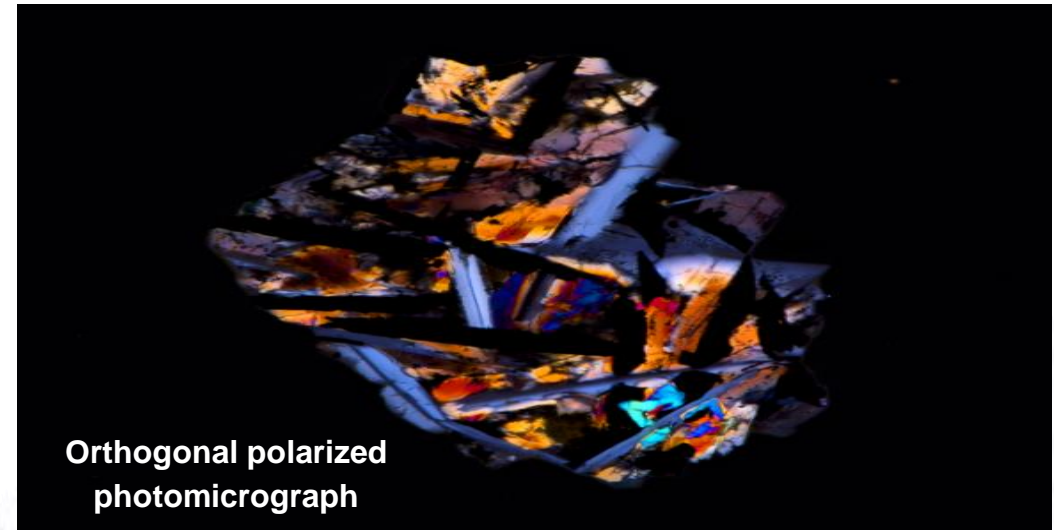
—、China Lunar and Planetary Exploration



■ Chang'E-5

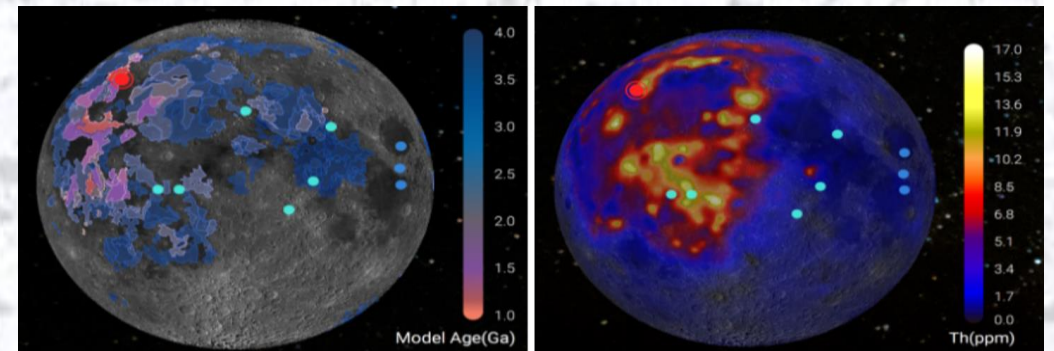
Revealing mystery of the most youngest volcano on the Moon

Lunar Sample Permanent collection
of National Museum



Orthogonal polarized
photomicrograph

Basalt particles in the lunar soil



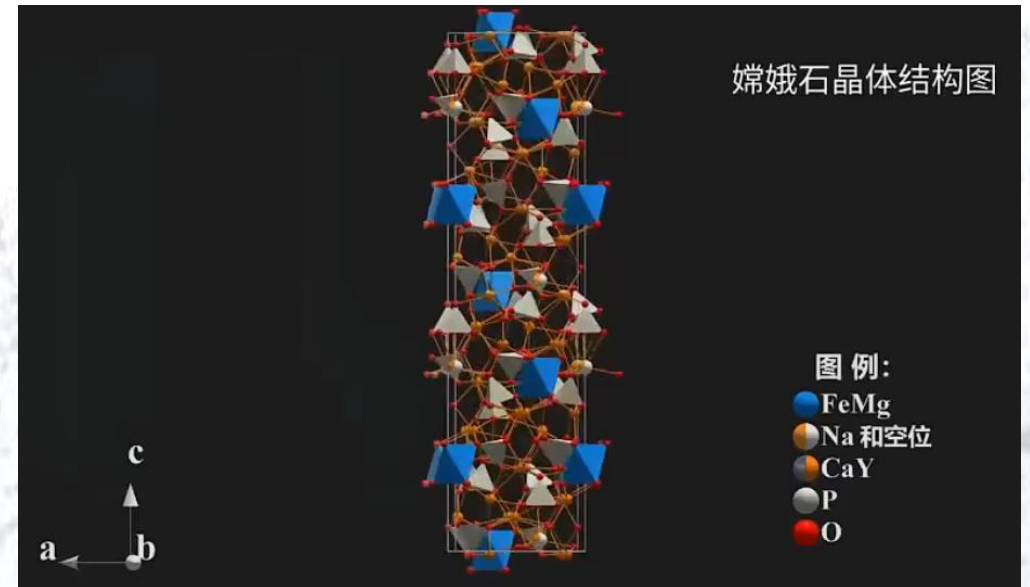
Content distribution map of basalt and thorium in the
lunar large basin

一、China Lunar and Planetary Exploration



■ Chang'E-5

- IMA names a new mineral **“Chang'E Stone”** which is one kind of **colorless, transparent** and **glassy phosphate** founded in the lunar samples.
- The sixth kind of lunar mineral founded by human being (US find 4 kinds、Russia finds Natural Cerium) .



Chang'E Stone New lunar mineral

一、China Lunar and Planetary Exploration



(二) First Mars Exploration Mission

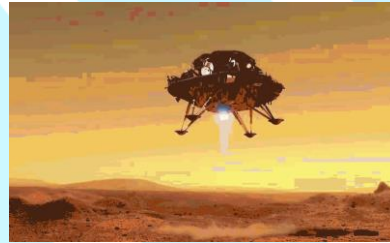
Launch
Successfully

July 23th, 2020
WLS



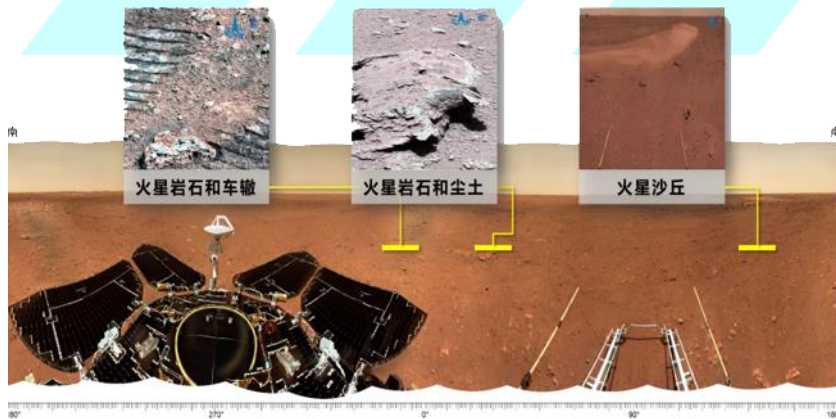
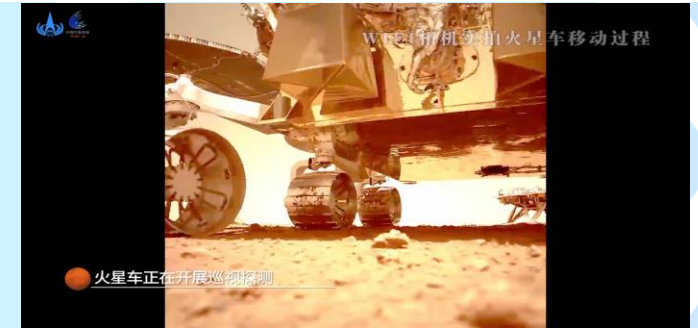
Land
Successfully

May 15th, 2021
Combination lands



Milestone

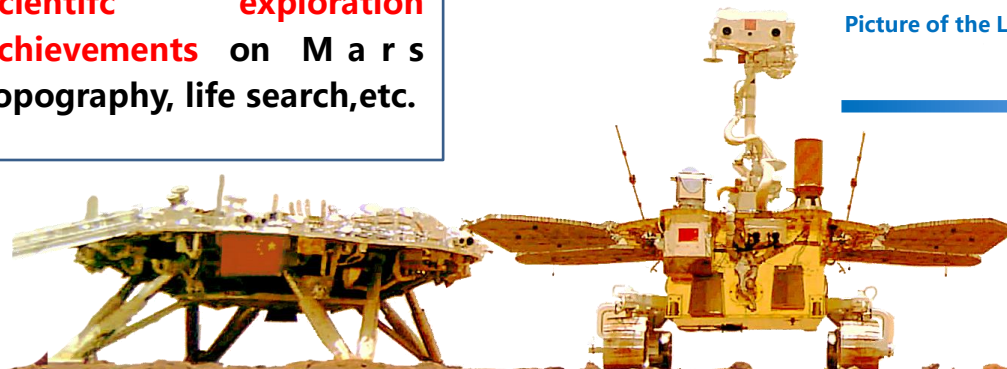
Start China's journey of
planetary exploration



- It drives **1921m**
- **Scientific achievements** on **Mars** exploration
topography, life search, etc.

Picture of the Lander & Rover

Zhurong Rover Imaging



—、China Lunar and Planetary Exploration



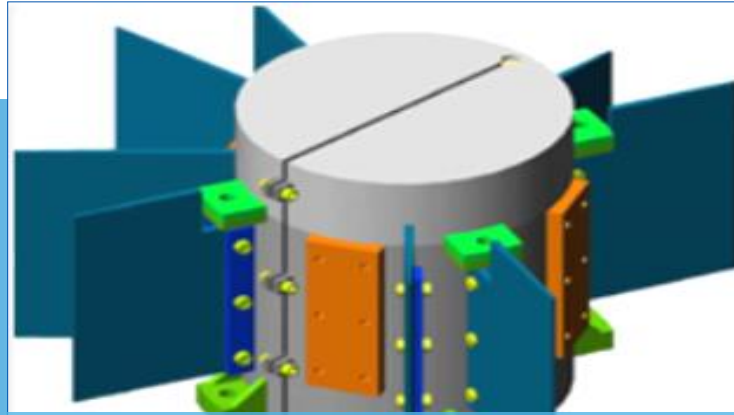
Achievements of China Deep Space Exploration

1. Leap of space technical capability

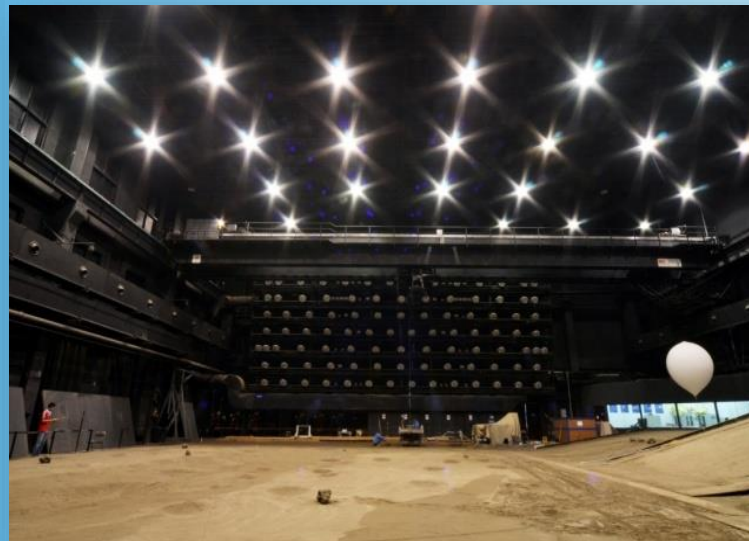
Support for organization and implementation of major engineering program and scientific research program in the field of deep space exploration.



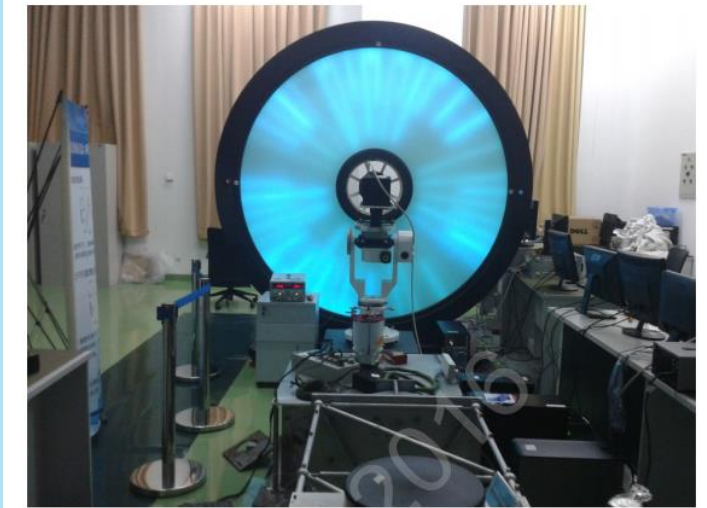
Reusable Spacecraft Landing
Compound Test Range



New Material Energy



Lunar and Deep Space Exploration
Remote Operation Mission Test Field



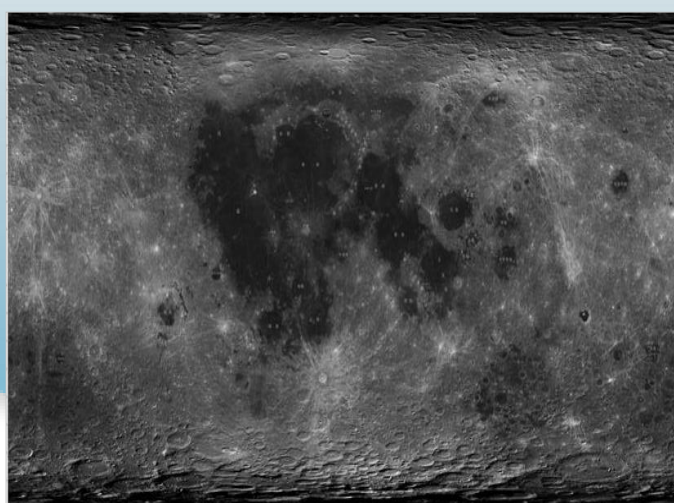
Deep Space Auto Navigation
Control Simulation Test Bench

— China Lunar and Planetary Exploration

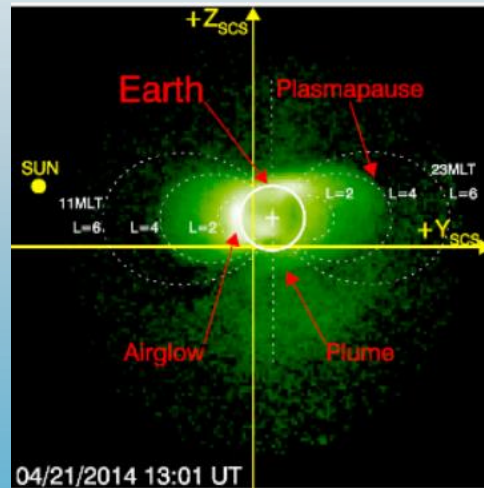


(三) Achievements of China Deep Space Exploration

2. Space Science Exploration: “First” Achievements



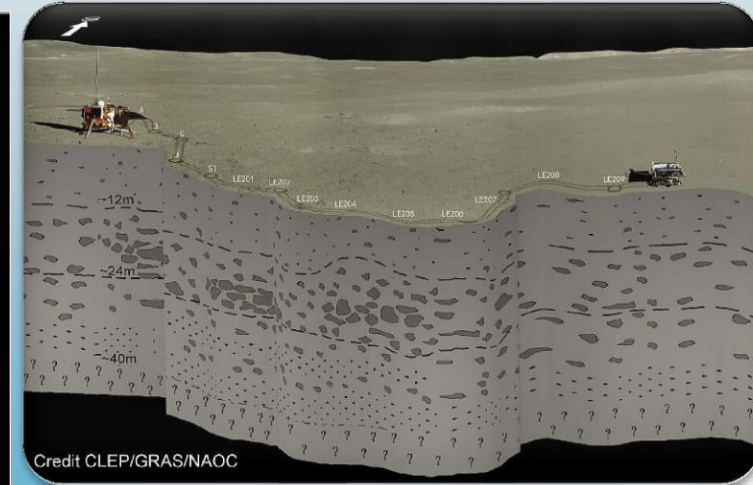
Full Moon Map
with a 7m resolution



Sun-Earth-Moon
Environment



Tutatis
Asteroid



Shallow geological stratification
of the lunar crust

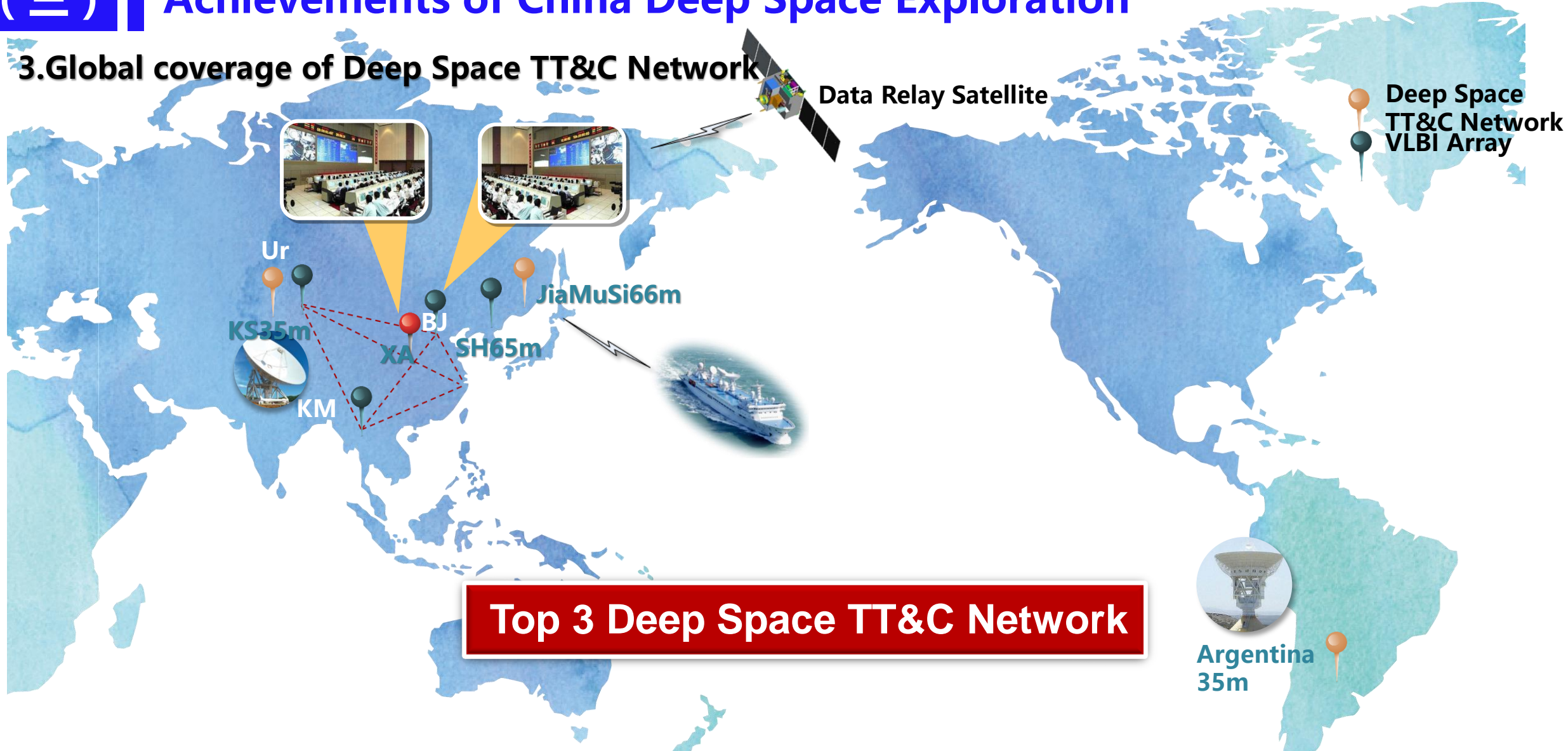
China ranks **top level** of planet science research

—、China Lunar and Planetary Exploration



(三) Achievements of China Deep Space Exploration

3.Global coverage of Deep Space TT&C Network



Top 3 Deep Space TT&C Network



Argentina
35m

一、China Lunar and Planetary Exploration



(三)

Achievements of China Deep Space Exploration

4. Prioritization of overall layout of launching site



WSLS

It's the only center that is located in the costal side where is at low latitude, and main launching base for deep space exploration missions. WSLS has completed missions as:

- Lowest latitude
- Big Launching angle
- Safe scattering zone
- waterway transportation

- Chang'E-5 Mission
- Tianwen-1 Mission
- China Space Station (Tianhe, Mengtian) Mission
- Tianzhou Mission...

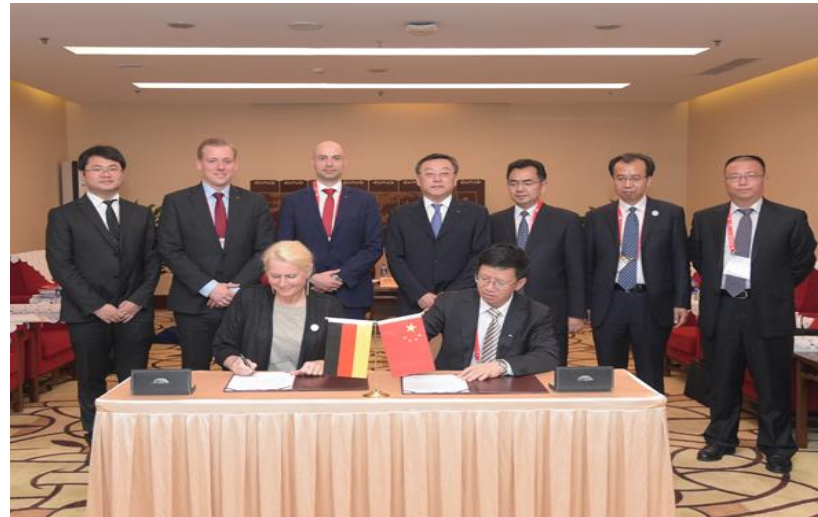


一、China Lunar and Planetary Exploration



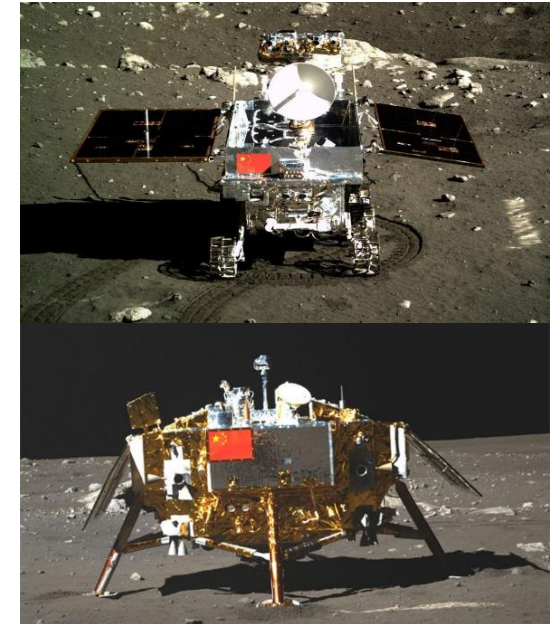
(三) Achievements of China Deep Space Exploration

5. Formation of Spirit of Lunar Exploration



Spirit of Lunar Exploration

- Catching Dream
- Exploring Bravely
- Coordination & Researching
- Cooperation & Win-Win



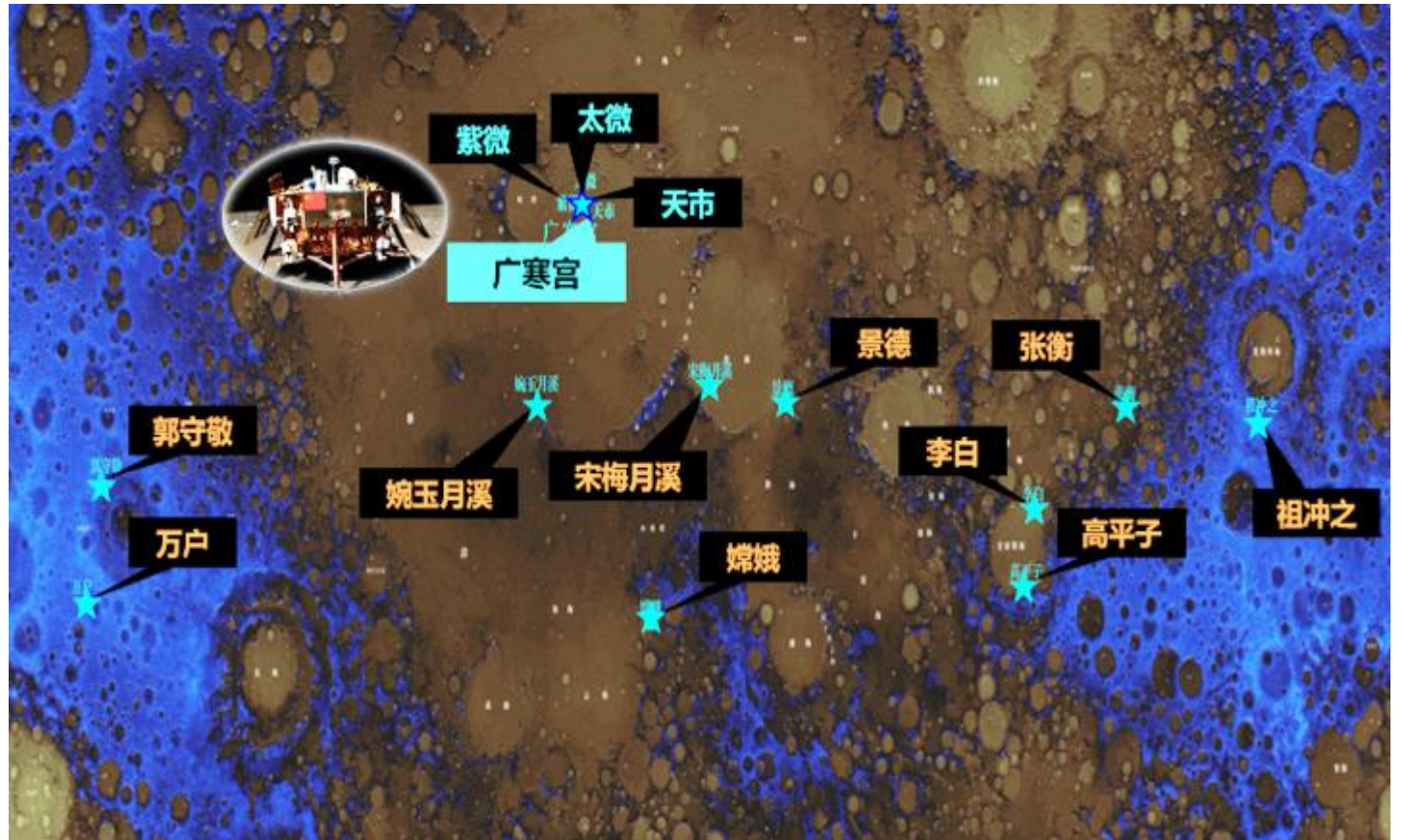
一、China Lunar and Planetary Exploration



(四) Naming of Lunar Geography Entities

Numbers of Chinese scientists and cultural elements are **named permanently** on the Moon.

CE-1	毕昇、蔡伦、张钰哲
CE-3	广寒宫、紫微、天市、太微
CE-4	天河基地、泰山、织女、河鼓、天津
CE-5	天船基地、华山、衡山、裴秀、沈括、刘徽、宋应星、徐光启



1

China Lunar and Planetary Exploration

2

Prospect of China Deep Space Exploration



二、Prospect of China Deep Space Exploration

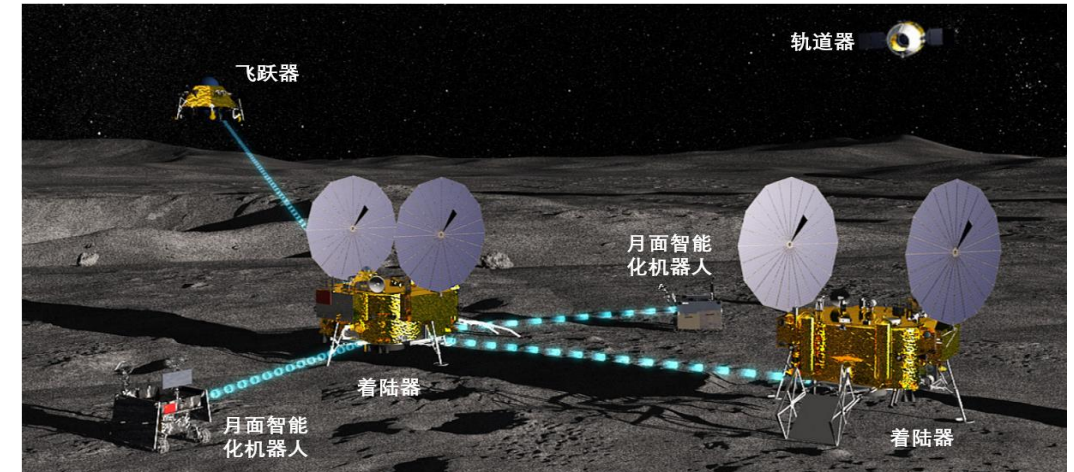


(一)

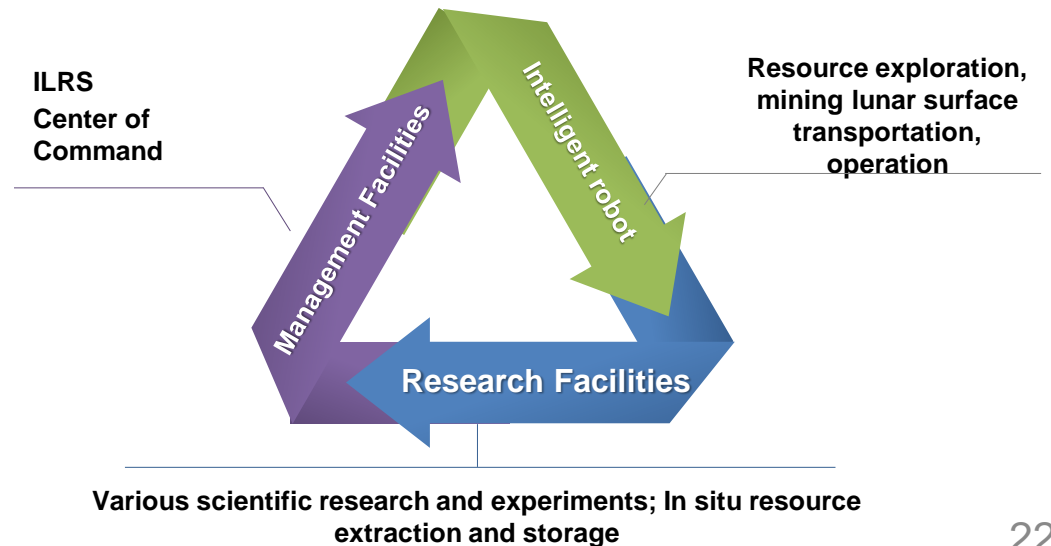
Lunar Exploration——1. The 4th Phse of CLEP

ILRS (basic type)

Through the **Chang'E-6/7/8** missions, it will build a **basic unmanned lunar research station** at the **South Pole** of the Moon, consisting of lunar orbiters and lunar probes. It will have functions such as integrated control, information communication, intelligent operation and scientific exploration, and will initially be able to **exploitation and utilize lunar resources**. This will lay the foundation for the subsequent construction of a lunar research station with long-term unmanned operation and short-term manned care.



Operation of ILRS (basic type)



二、Prospect of China Deep Space Exploration

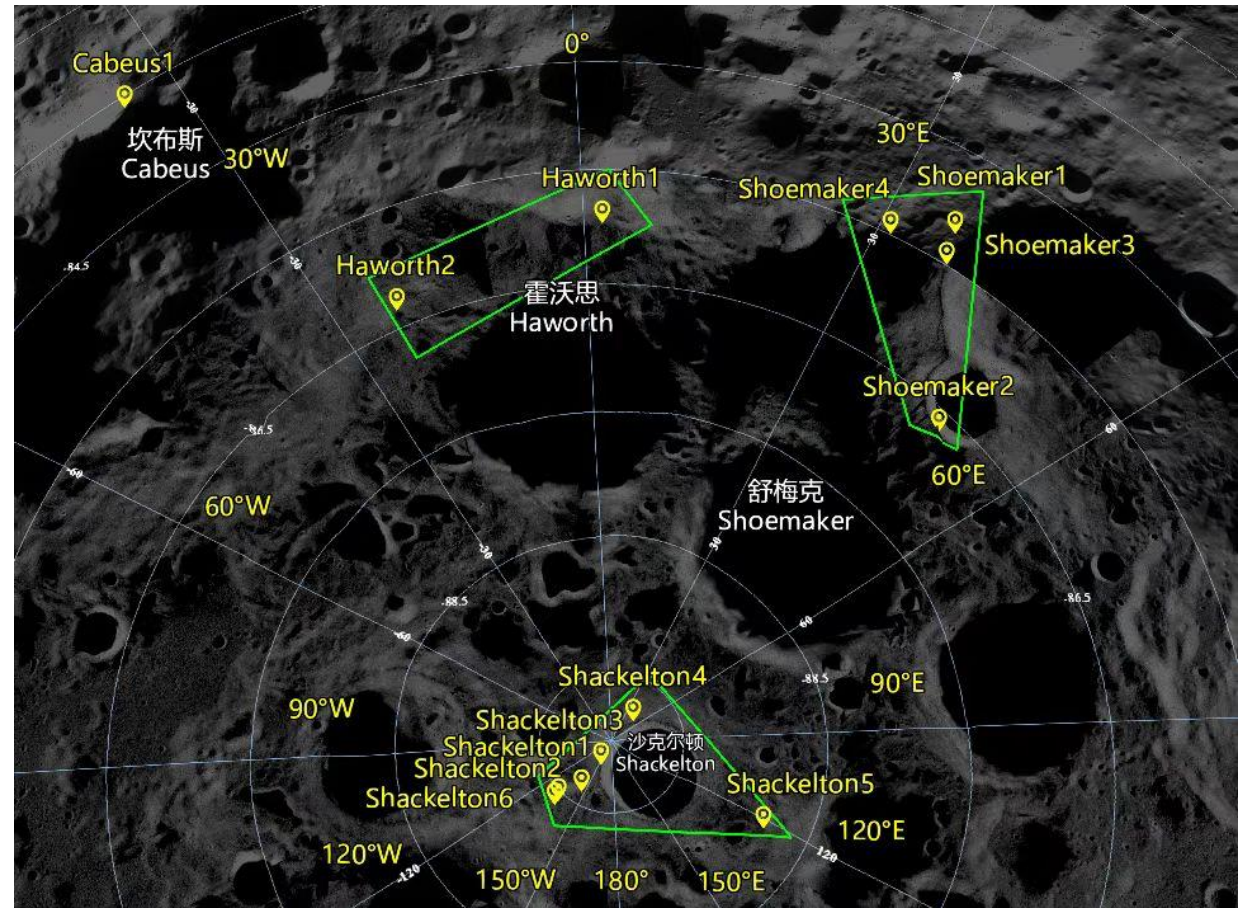


(一)

Lunar Exploration——1. The 4th Phse of CLEP

Chang'E-7 Optional Landing Area

Chang'E-7 consists of orbiter, lander, rover, fly-byer and relay satellite. It plans to be launched by CZ-5 launching vehicle in the WSLC, and conduct surveys of **resources and environment in the lunar South Pole**, landing, touring and fly-by exploration. The optional landing area is **South Pole-Aitken Basin** whose part is above 85° south latitude.



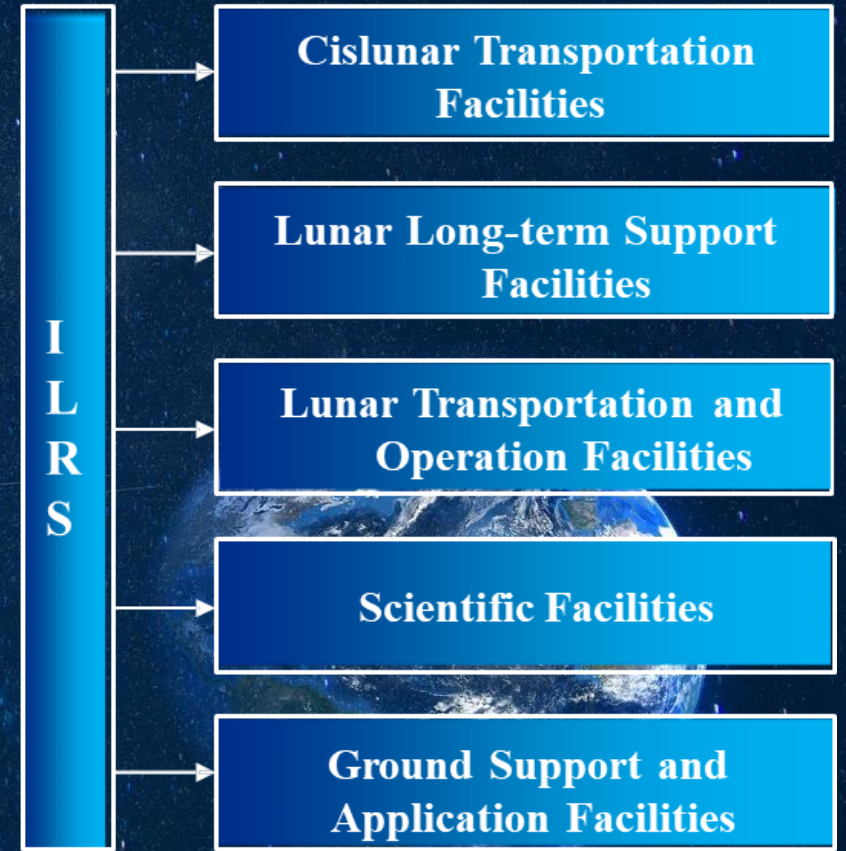
二、Prospect of China Deep Space Exploration



(一) Lunar Exploration——2. ILRS

Advising International Partners to Construct ILRS Together

Based on the idea of Mode, it consists of modes of experiment bench、TT&C station on the lunar surface, mobile exploration & fly-by exploration、orbiting the Moon、relaying 和 energy-supplying. It standardize interfaces, which is free to add functions and takes on ideas of co-negotiation, co-constrution and co-sharing.



二、Prospect of China Deep Space Exploration

(一) Lunar Exploration——2. ILRS

Three Steps: **Reconnaissance**, **Construction**,
Utilization



二、Prospect of China Deep Space Exploration



(一) Lunar Exploration——2. ILRS

Completed Missions of ILRS

Mission	Scientific Objectives
ILRS-1	focus on detailed investigation of geology and multi-source particle detection, in-situ analysis and sample collection
ILRS-2	conduct VLBI astronomy, in-situ analysis and sample collection
ILRS-3	conduct subsurface geological investigation by ground-penetration radars
ILRS-4	implement Sun-Earth-moon space physical observation, moon-based biological science experiments
ILRS-5	implement lunar-based astronomical observation, Sun-Earth space environmental investigation, and other experiments

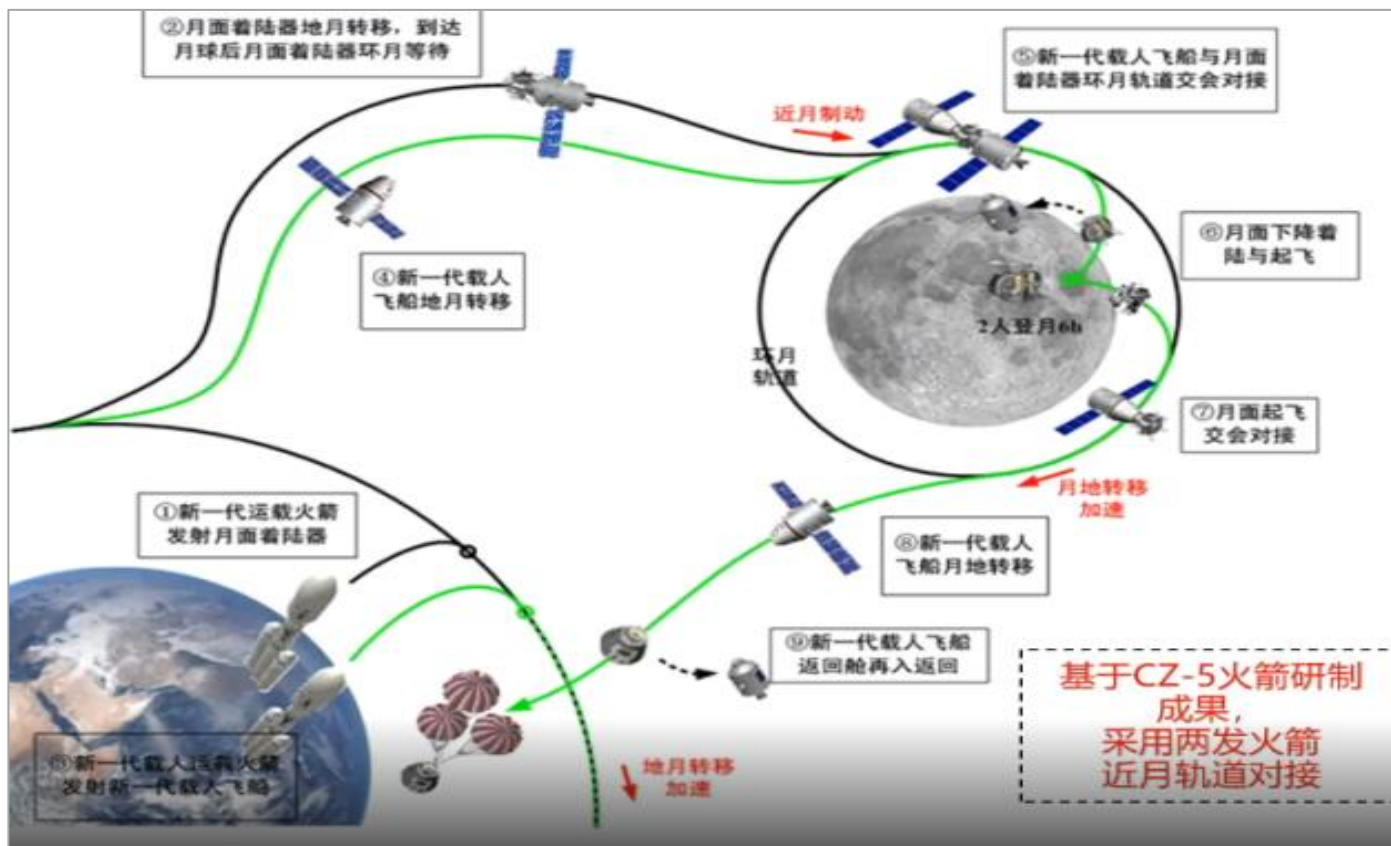
二、Prospect of China Deep Space Exploration



(一) Lunar Exploration——3. Manned Lunar Landing

Preliminary Scheme

The preliminary scheme is to conduct **manned lunar landing** successfully around the year of 2030. After that, it will conduct system-level, sequential demonstration of technical tests of lunar exploration.



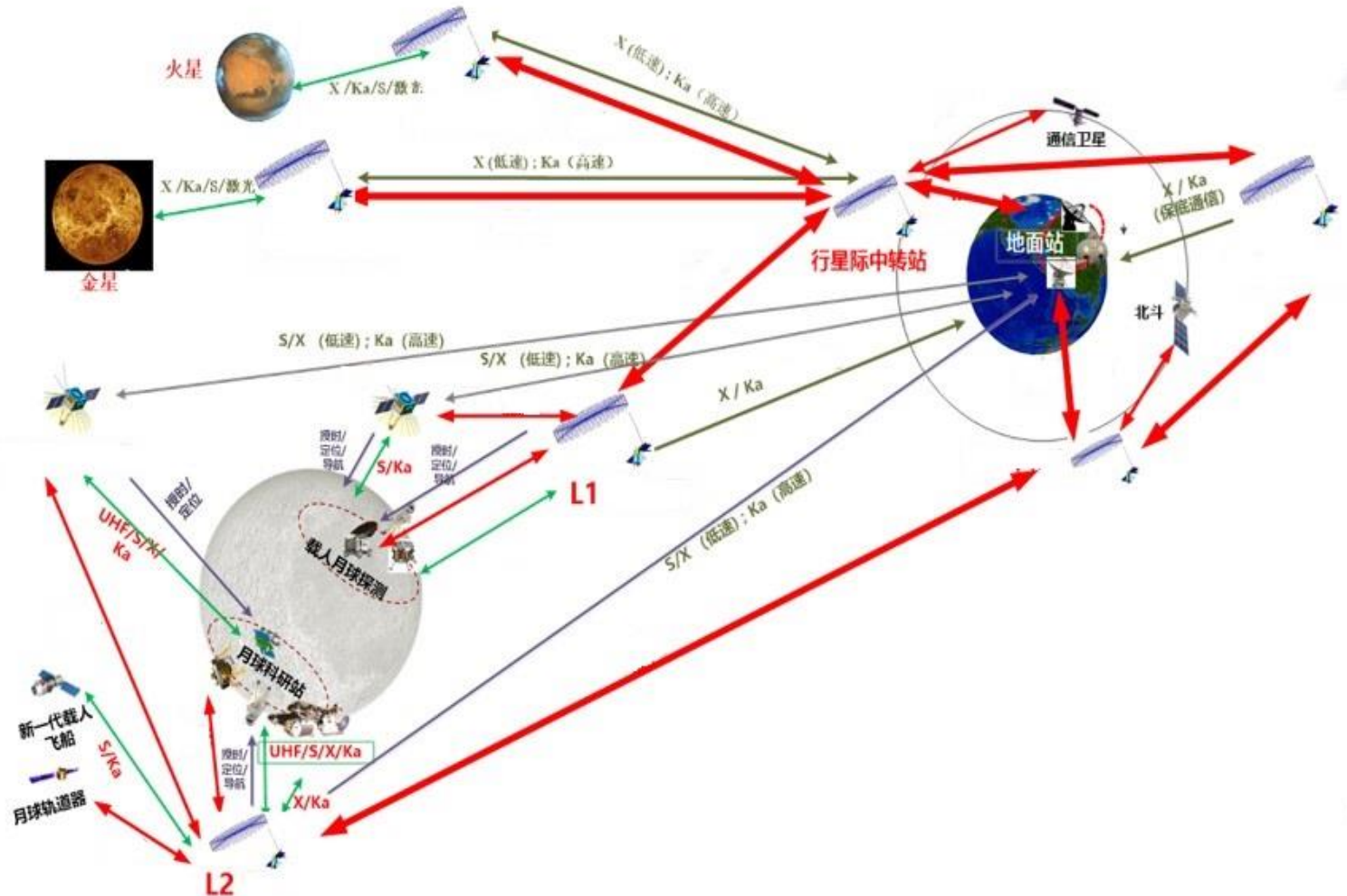
二、Prospect of China Deep Space Exploration



(一) Lunar Exploration — 4. Lunar Communication & Navigation System

Overview of Mission

- The integrated **system of planetary communication and navigation** consists of orbiter that orbiting the Moon、Spacecraft that is at Earth-moon translation point、planetary relay station、planetary orbiter. It embraces capabilities of **communication、navigation、GPS、computing and storing in orbit information service 、scientific exploration**, etc.
- Providing service for spacecrafts on the orbit of Earth-to-Moon、Lunar orbit、Lunar surface and deep space.
- Expanding support for **inter-planetary** scientific test.



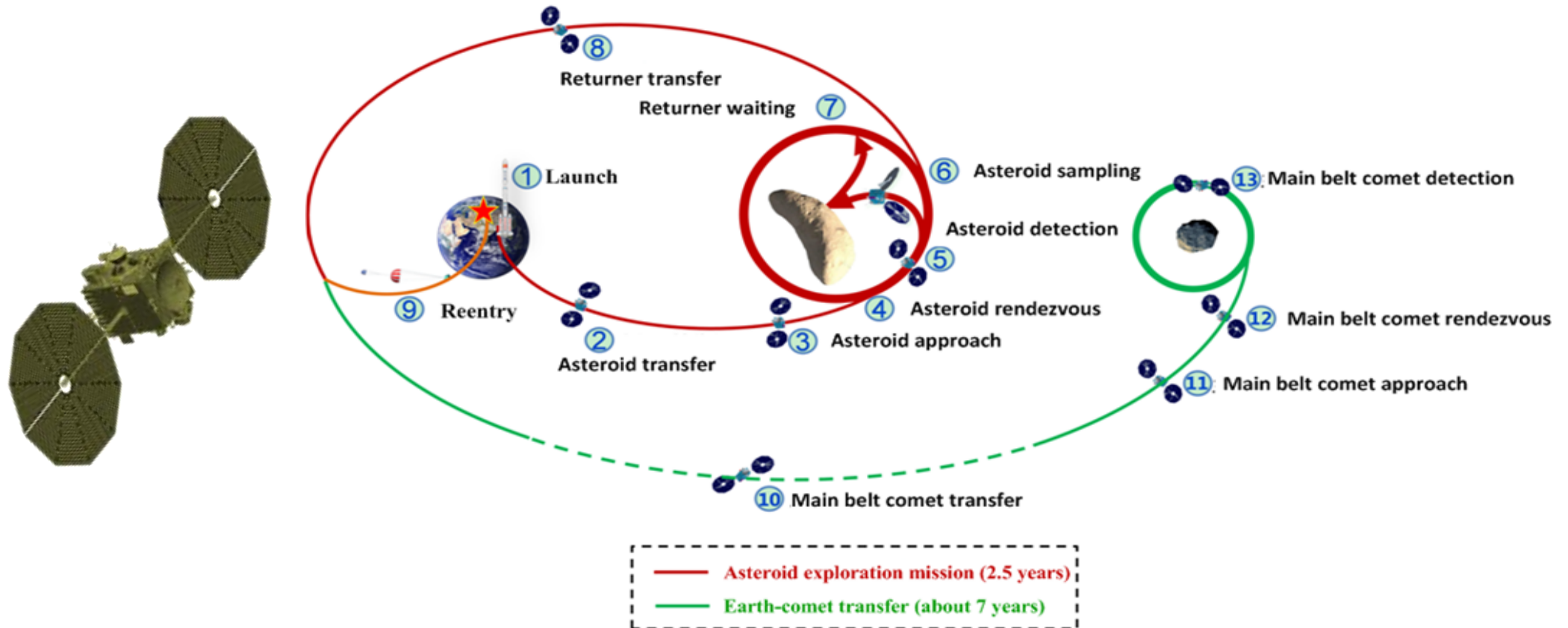
二、Prospect of China Deep Space Exploration



(二) Asteroid Exploration——1. Asteroid Sample Return

Overview of Mission

The mission of **near-Earth asteroid sample returning** would be carried out around the year of 2025, which will provide data of scientific exploration and true samples of origin and evolution of asteroids.



二、Prospect of China Deep Space Exploration



(二)

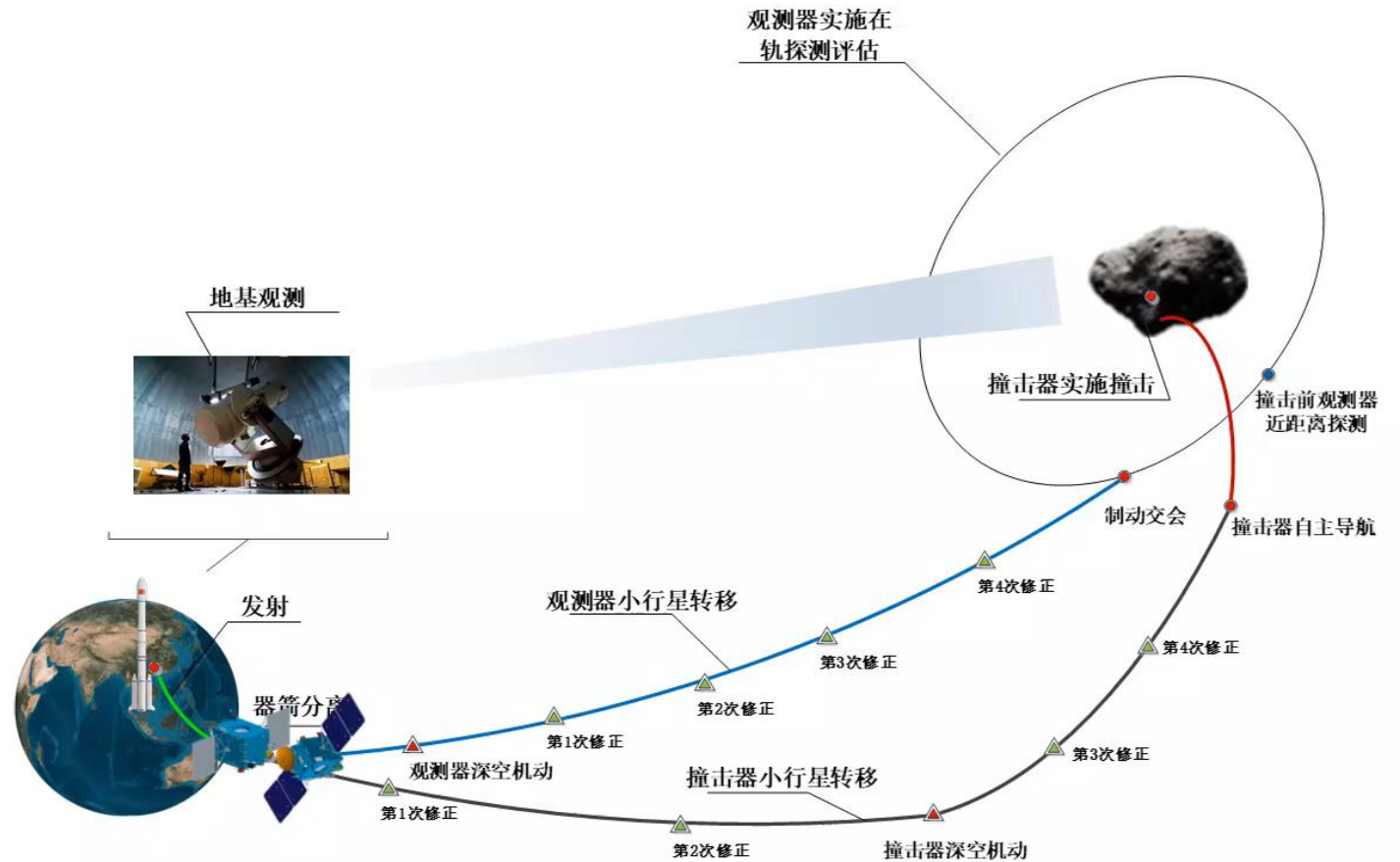
Asteroid Exploration——2. First Asteroid Defense Mission

Engineering Objective

- Conduct super high speed impact on 50m-level asteroid
- In-orbit direct estimation of effect of kinetic impact

Science Objective

- To conduct near detection on targeted asteroid, enrich asteroid sample.
- To recognize effect and mechanism of terrestrial change caused by the impact and sputtering distribution and to enrich understanding of evolution of asteroid.



Impact accurately, Push properly, Mesuring out, Speak clearly

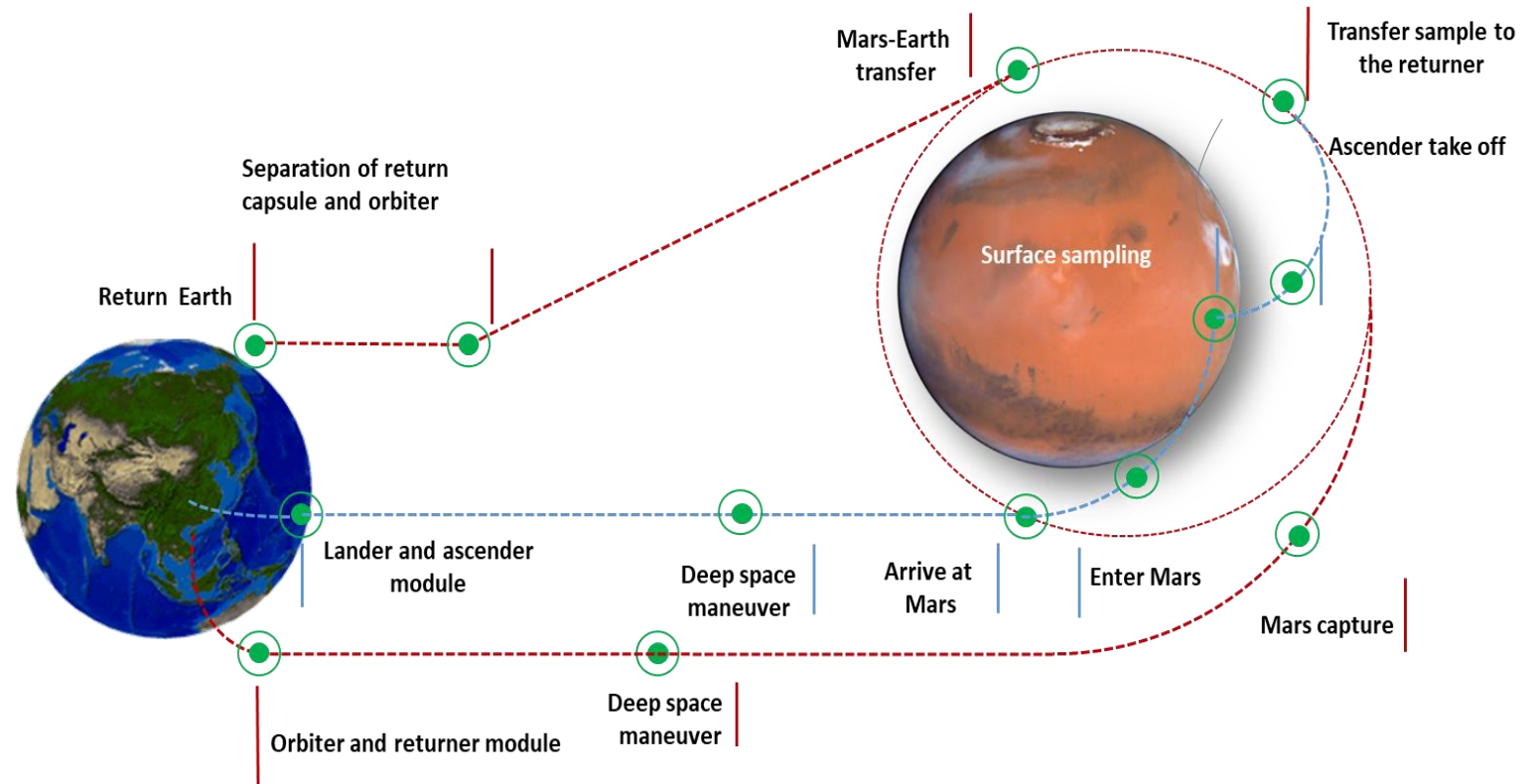
二、Prospect of China Deep Space Exploration



(三) Planetary Exploration——1. Mars Sample Return Mission

Overview of Mission

- To implement a mission of Mars Sample Return around the year of 2028.
- To conduct exploration of morphology 、 elements of materials in the landing area and acquire background data of landing area and sampling place.



Deepen understanding of origin and evolution of Mars, conduct research on **comparative planet science**.

二、Prospect of China Deep Space Exploration

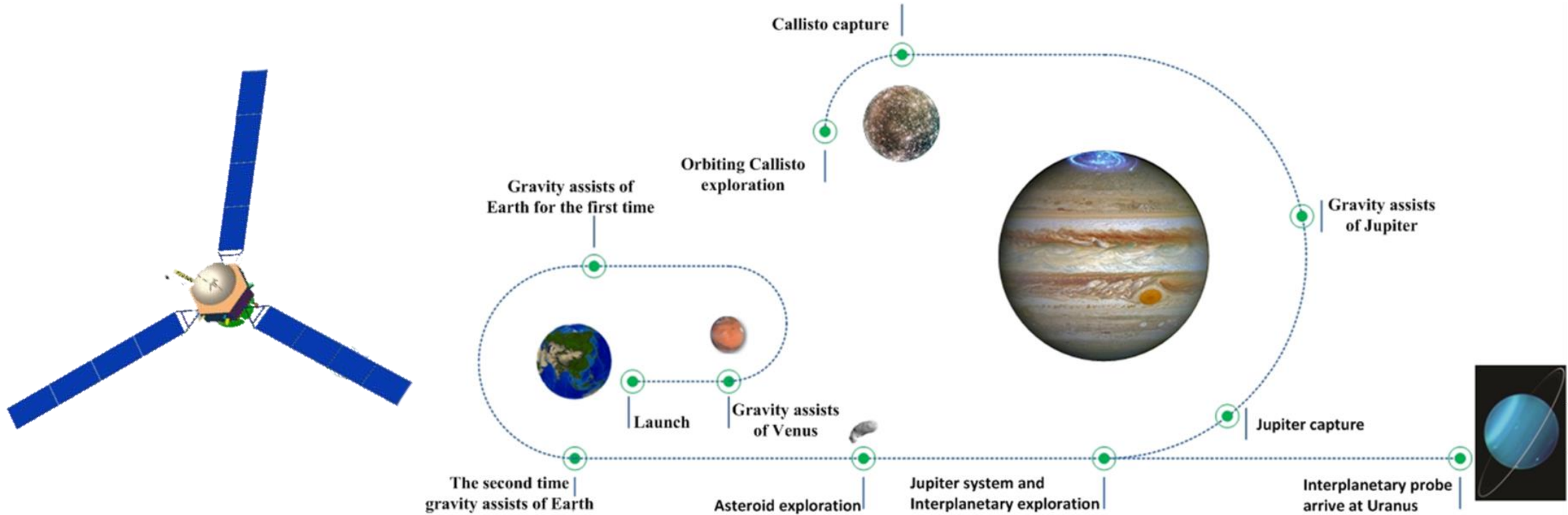


(三)

Planetary Exploration——2. Jupiter system & Transversing inter-planetary exploration

Overview of Mission

To make breakthroughs in key technologies such as **adapting to and protecting the space environment of the Jupiter system** and efficient photoelectric conversion under low light conditions, and be capable of orbiting the Jupiter system and reaching Uranus around the year of 2030.



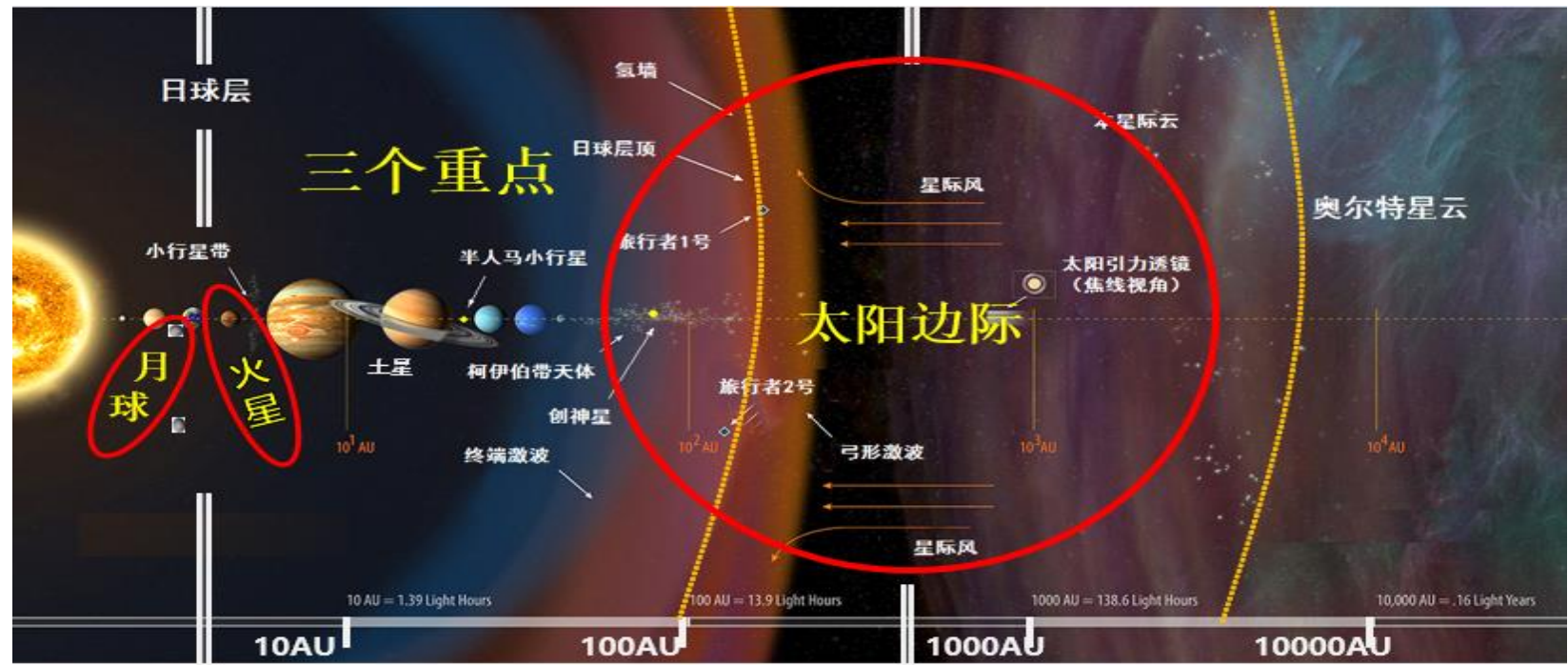
Deepen **scientific understanding** of Jupiter system & Inter-planetary space

二、Prospect of China Deep Space Exploration

(三) Planet Exploration——3. Exploration of Solar system boundaries

Overview of Mission

To form capabilities of exploration of near-sun (**0.05AU**) detection, access to any type of celestial body in **20AU**, access to all space in **60-100AU**, exploring inter-planetary space in **100AU and beyond**.



To make China's contribution to recognize scientific characteristics of boundaries of solar system and its inner planet science and **search for alien life**.

二、Prospect of China Deep Space Exploration



(四) Heavy-lift launch vehicle

Overview of Mission

- LTO 50t、LEO150t, Lift Mass > 4000t
- Breakthrough in 15 crucial technologies, like overall design、high thrust engine.
- Around 2035, to carry out flight test of one-time formation.

Parameters of CZ-9

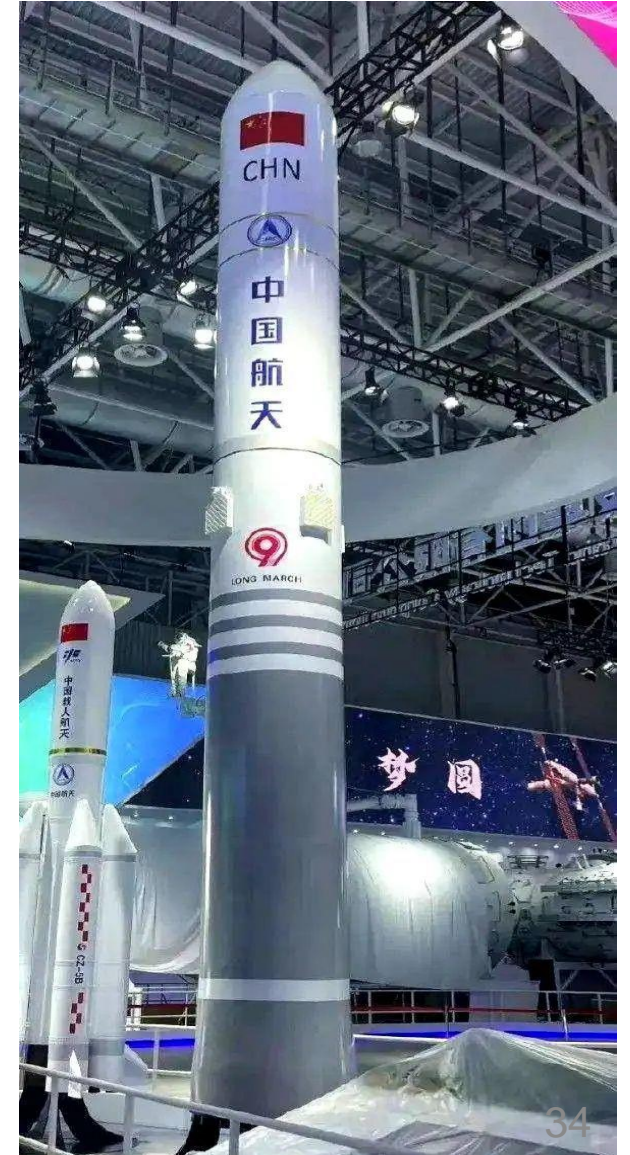
Length : 108 m

lift Mass: 4180 t

Body diameter: 10.0m (First Stage) , 10.0m(Second Stage),
10.0m(Third Stage)

Capability: LEO 150 t

LTO 50 t





DEEP SPACE EXPLORATION LAB
深空探测实验室



Deep Space Exploration Lab are co-founded by **China National Space Administration**、**Anhui government** and **University of China Science and Technology**. It gathers domestic and international strengths to support the implementation of **several major deep space exploration projects**, plans development of deep space exploration in the future, carries out **strategic, forward-looking** and **basic research** in the field of deep space exploration, achieves integrated innovation in **science, technology** and **engineering**, and strive to build a global center for talent center and highland of inovation.



There is no end to scientific exploration, and there is a long way to go in the deep space. We sincerely hope to work with our international partners to build close partnerships on space exploration and innovation. In the march of exploring mysteries of the universe, we should work together to overcome new challenges, create new opportunities, and build a community of shared future for mankind in space.

Thanks!