Progress and Prospects of Unmanned Deep Space Exploration in China

Ming LI
China Academy of Space Technology
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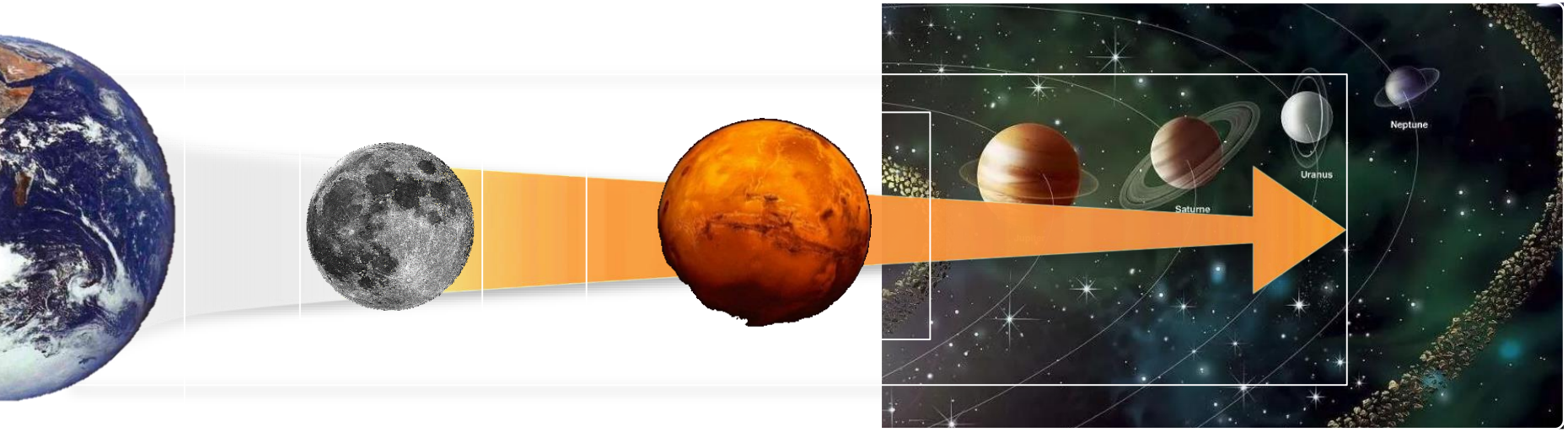
Contents

1 Overview

Overview

Two Areas： Development in parallel.



CLEP

China Lunar Exploration Program

CE-1,2,3,4 5,6,7,8

Planetary Mission

Exploration beyond Moon

Mars, Asteriod, Jupiter

2 Mission Completed & in Development

- Mission Completed and in Operational
- Mission under Development

Mission Completed & in Development

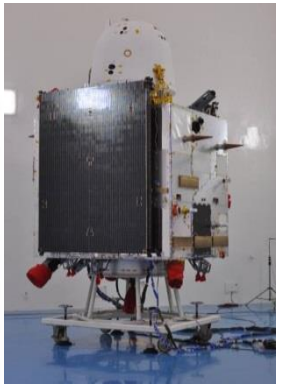
CLEP Robotic Exploration

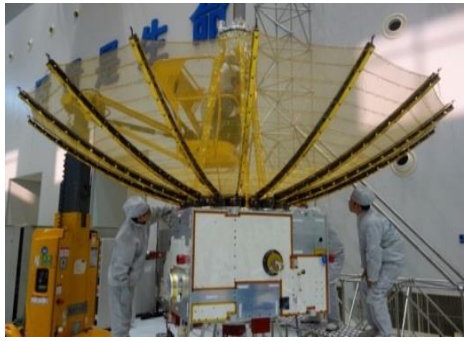
Orbiting » **Landing** » **Sample Return**

- Chang'E-1 2007.10
- Chang'E-2 2010.10
- Chang'E-3 2013.12
- Chang'E-4 2018.12
- T1 Reentry Test 2014.10
- Chang'E-5 Around 2020

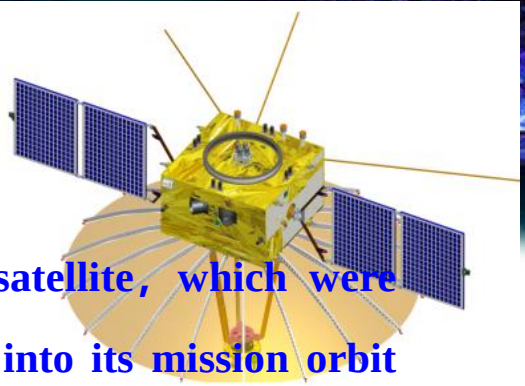
Missions Completed and in Operational

- 2007: Chang'e-1 achieved global remote sensing of the Moon
- 2010: Chang'e-2 achieved technology validations and multi-task multi-Objective exploration
- 2013: Chang'e-3 achieved soft-landing and rover survey on the Moon
- 2014: Chang'e-5 Flight Test Vehicle achieved high-speed reentry test validation
- 2020: Chang'e-4 achieved soft-landing and patrol survey exploration on the far side of the Moon

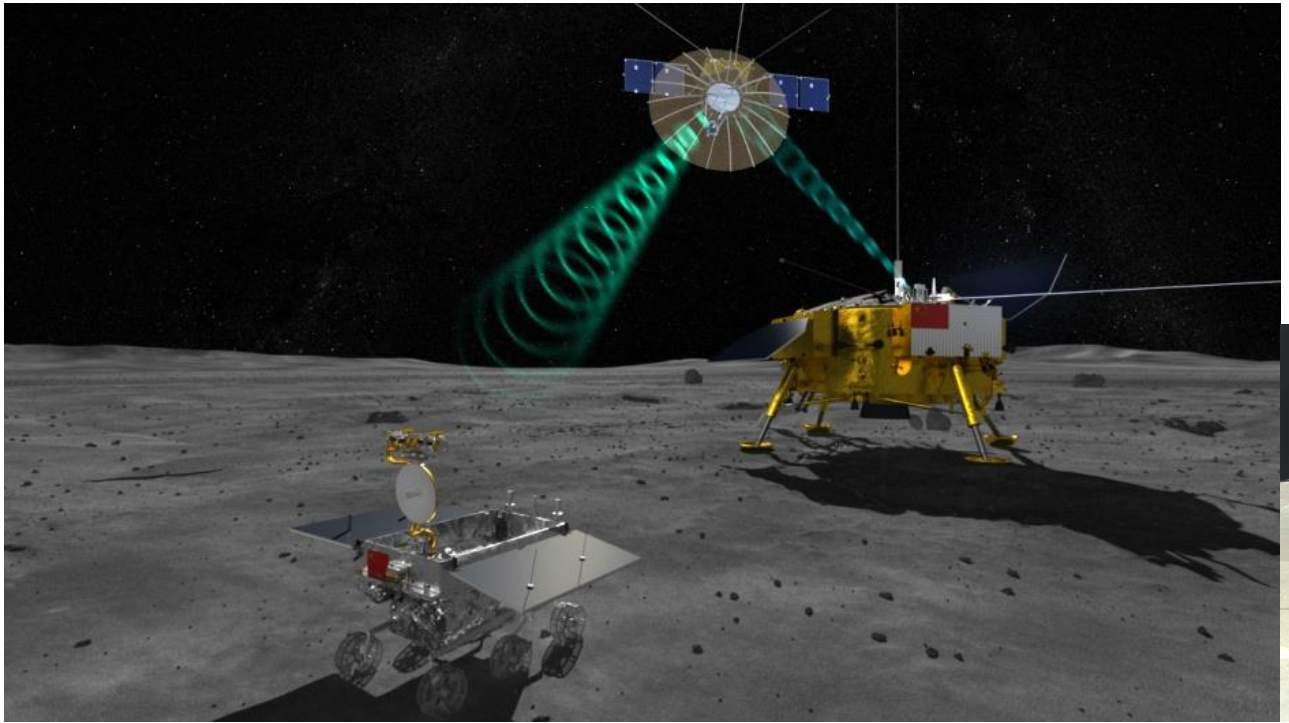



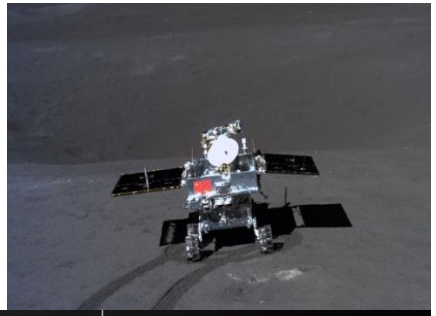


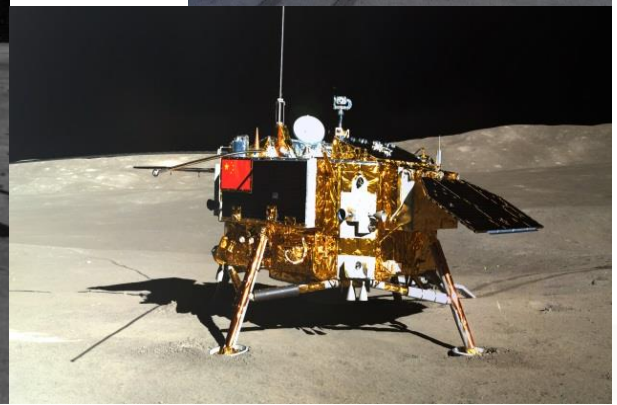
Mission in Operational-CE-4



CE-4 flight system consists of a lander, a rover and a relay satellite, which were launched separately. First, the relay satellite was launched and flew into its mission orbit about the Earth-Moon Lagrange point L2; Secondly, the lander and rover were launched together, flew to the Moon, and landed on the far side of the Moon, later the lander and rover were separated from one another, and started in-situ exploration and patrol survey respectively, with the relay link support from the relay satellite.





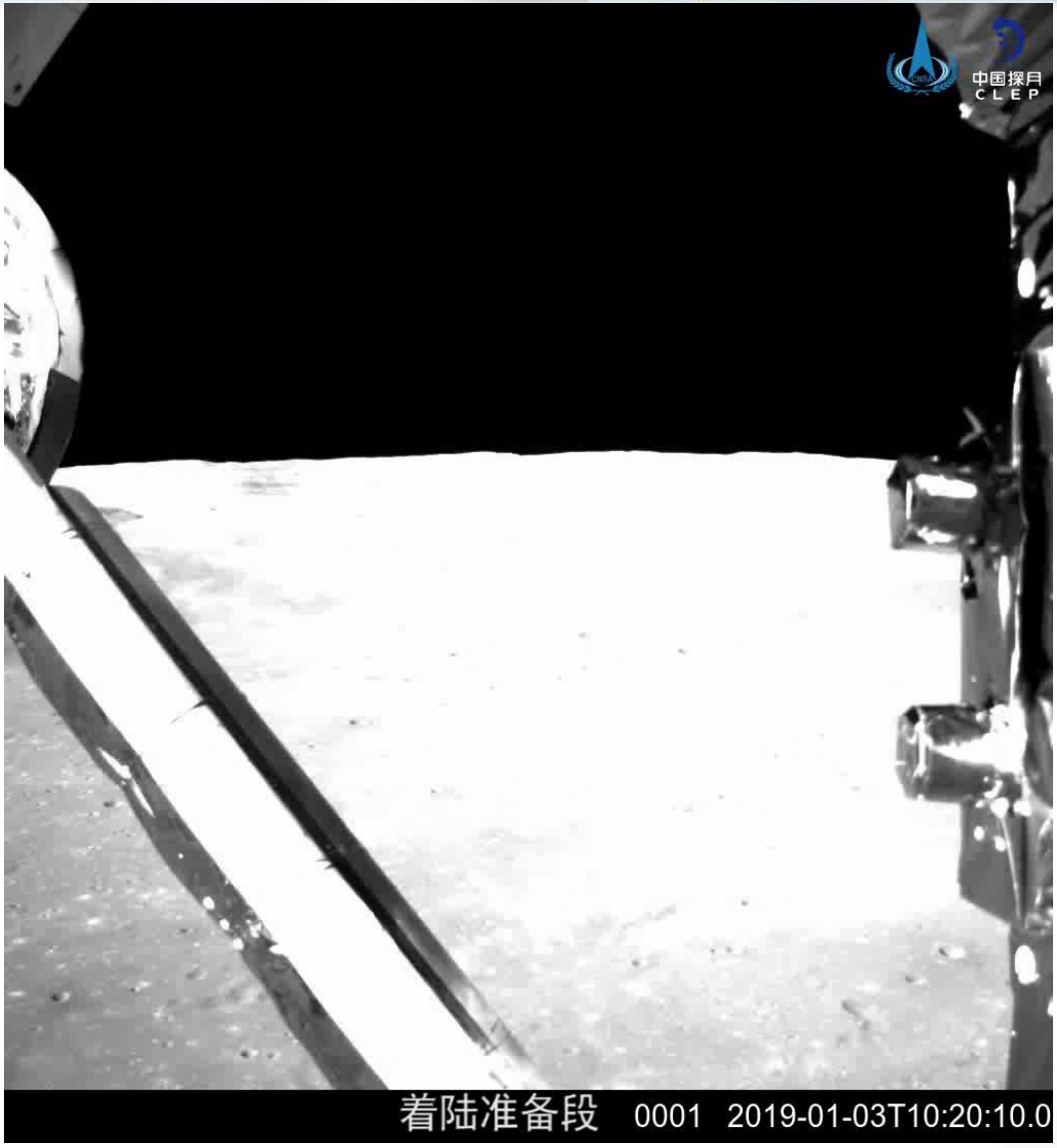


Mission in Operational-CE-4

Powered Descent

Powered descent was initiated at Jan 3, 2019, 10:14:35.

At 10:26:02, the touch down sensor was triggered, signaling the safe landing of the lander on the Moon.



Mission in Operational-CE-4

Piggyback 4 international payloads

DLR

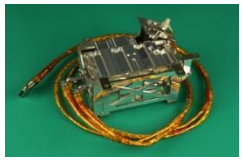
月球中子及剂量探测仪
（着陆器）

Germany

SRON
Netherlands Institute for Space Research

低频射电探测仪
（中继星）

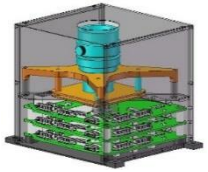
Netherlands



RYMDSTYRELSEN

中性原子探测仪
（巡视器）

Sweden



月球轨道光学成像仪
(KACST)

International cooperation according to principle of "free piggyback, data sharing”.

Mission in Operational-CE-4

Some scentific studies on the lunar far-side:

(1) Lunar based low-frequency radio astronomical observation

The low-frequency radio astronomical observation was carried out for the first time on the far side of the Moon.

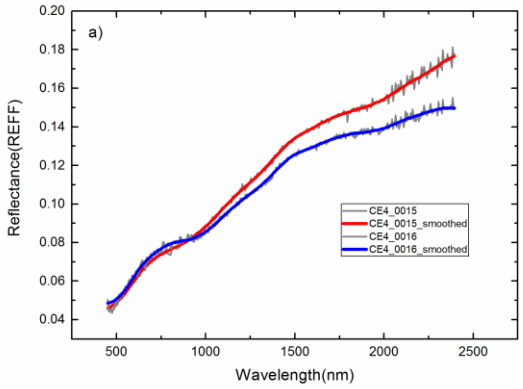
(2) Detection and study of the morphology and mineral composition of the far side of the Moon.

(3) Detection and study of the shallow structure on the far side of the Moon

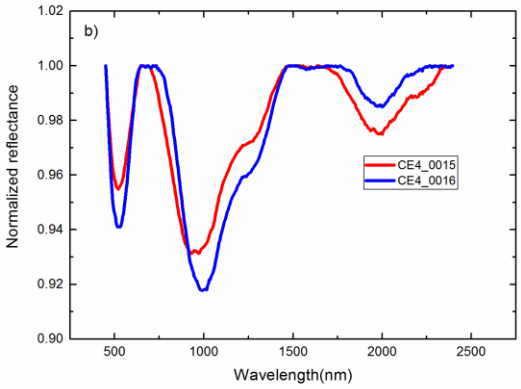
(4) Detection of Cislunar Space Environment

Detector has worked on the lunar surface of radiation dose data, neutron and charged particle energy spectrum data were obtained.

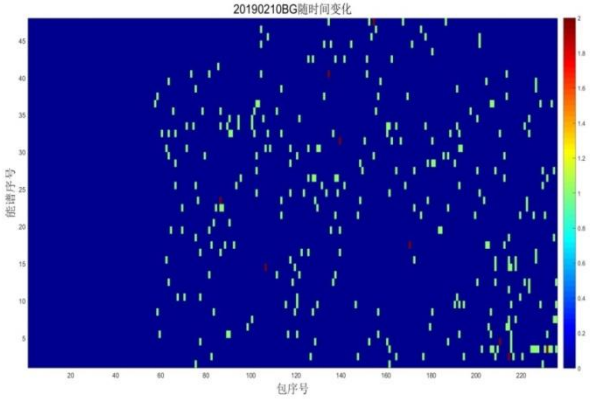
(5)Autonomous measurement of Lunar Soil Temperature at Lunar Night with RTG Power Supply



Two spectral curves from the detection during 1st day on the Moon



The spectral curves after filtering



Time variation of background particles in neutral atom detector on February 10, 2019

Mission under Development

Chang'E-5

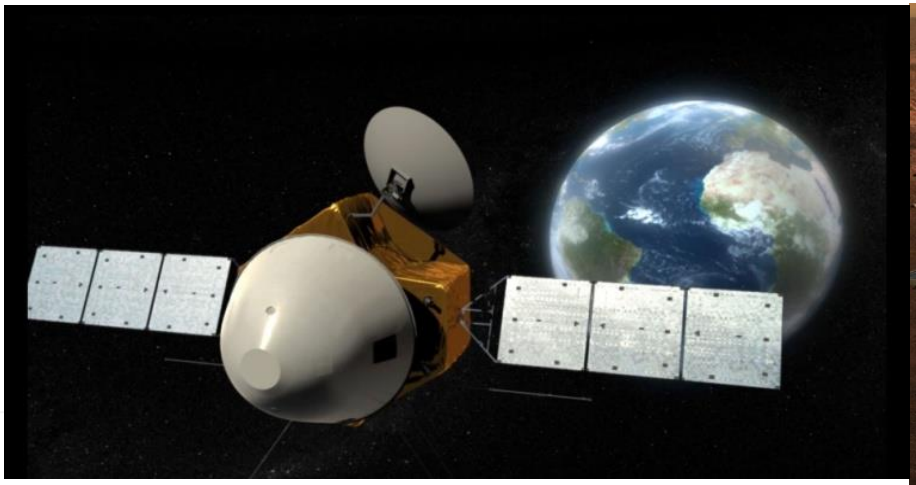
- Will be finished around 2020, automatic sampling and return of lunar sample.
- The first three phases of CLEP "Orbiting, Landing and Sample return" will be finished.

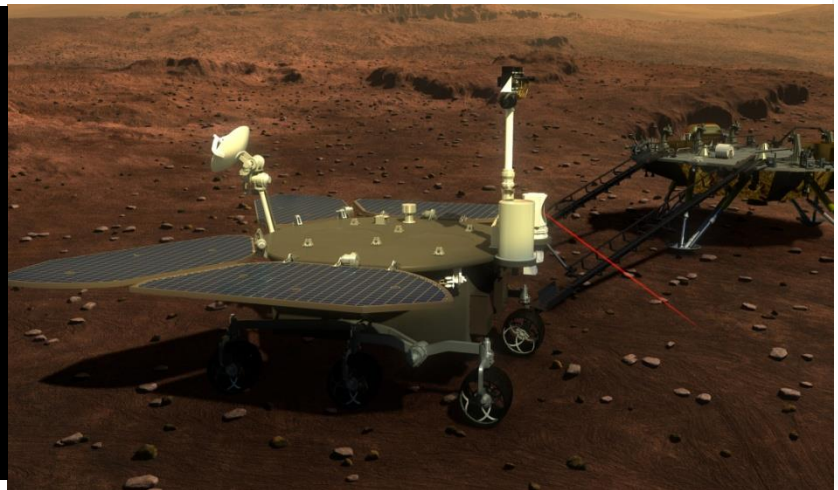
Mission under Development

The 1st Mars Exploration Mission

- **Objective :** orbiting and roving exploration of the Mars. To be launched in 2020.

- **Scientific Goal**
  - Global and comprehensive exploration of the Mars through orbiting exploration
  - High accuracy and high resolution refined exploration of the key areas of Martian surface through roving exploration

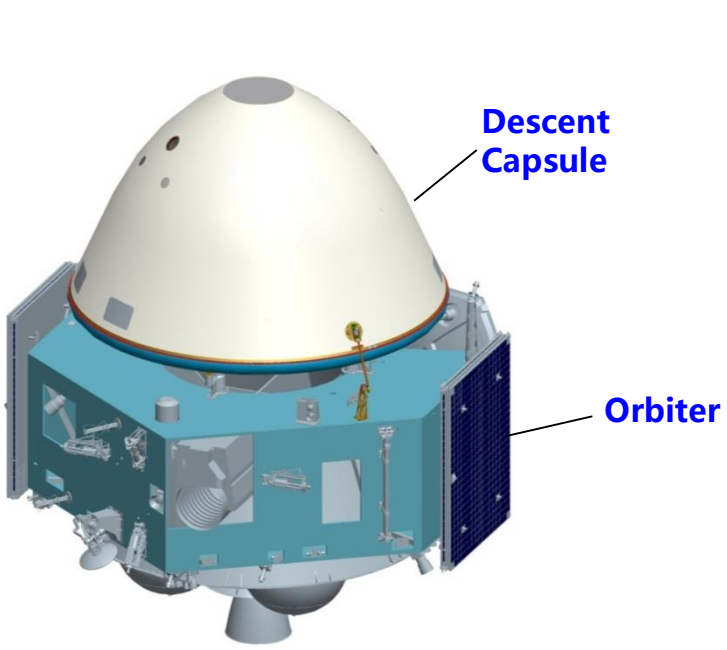


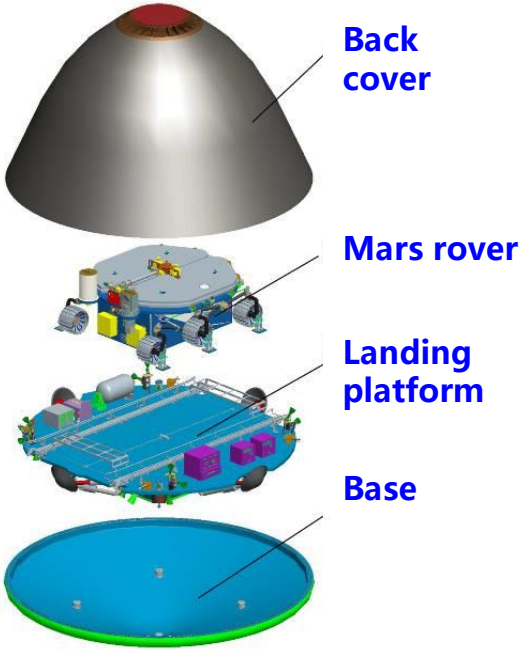


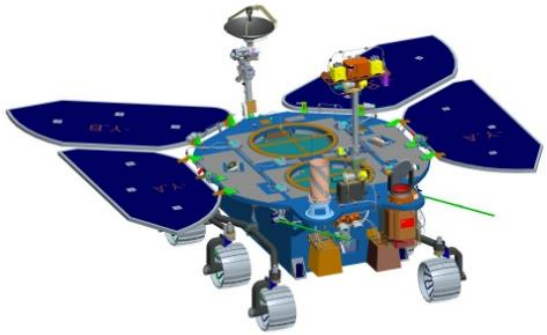
Mission under Development

The 1st Mars Exploration Mission

Probe= Orbiter + Decent Capsule（Landing platform、Mars rover)

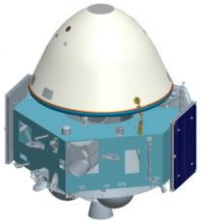




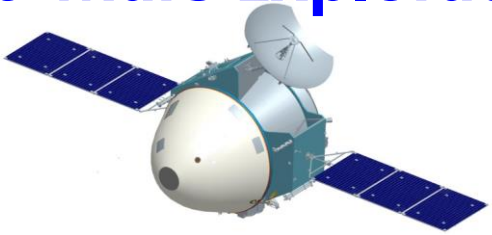


Mission under Development

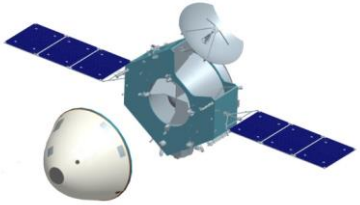
The 1st Mars Exploration Mission



Launch



Earth-Mars transfer and in parking orbit



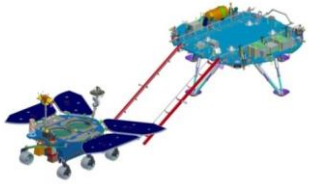
Separation between the orbiter and the entry capsule

Deploy the trim wing

Open the parachute

Deploy the landing system

After landing



Mars rover drives away

Mission under Development

Payloads on Orbiter

The 1st Mars Exploration Mission

Orbiter payload	Scientific target
Medium-resolution camera	Exploration of geological conditions and their changes
High-resolution camera	Exploration of geological conditions and their changes
Subsurface exploration radar	Exploration of geological conditions and their changes Exploration of surface and underground water-ice Exploration of soil type distribution and structure Analysis of atmospheric ionized layer and exploration of extraterrestrial environment
Mars mineral spectrometer	Exploration of soil type distribution and structure Surface material composition investigation and analysis
Mars magnetometer	Analysis of atmospheric ionized layer and exploration of extraterrestrial environment
Mars ions and neutral particle analyzer	Analysis of atmospheric ionized layer and exploration of extraterrestrial environment
Mars energetic particles analyzer	Analysis of atmospheric ionized layer and exploration of extraterrestrial environment

Mission under Development

Payloads on Mars Rover

The 1st Mars Exploration Mission

Payloads on Mars rover	Scientific target
Mars Surface Composition detector	Exploration of surface elements, minerals and rock type in the roving area
Multispectral Camera	
Topography Camera (Navigation camera)	Exploration of landform and geologic structure in the roving area
Subsurface exploration radar	Exploration of soil structure (section plane) and water-ice in the roving area
Mars magnetic field detector	Exploration of atmospheric physics features and surface environment in the roving area
Mars climate detector	

3 Mission Planned

- CLEP follow-on Mission
- Planetary Exploration

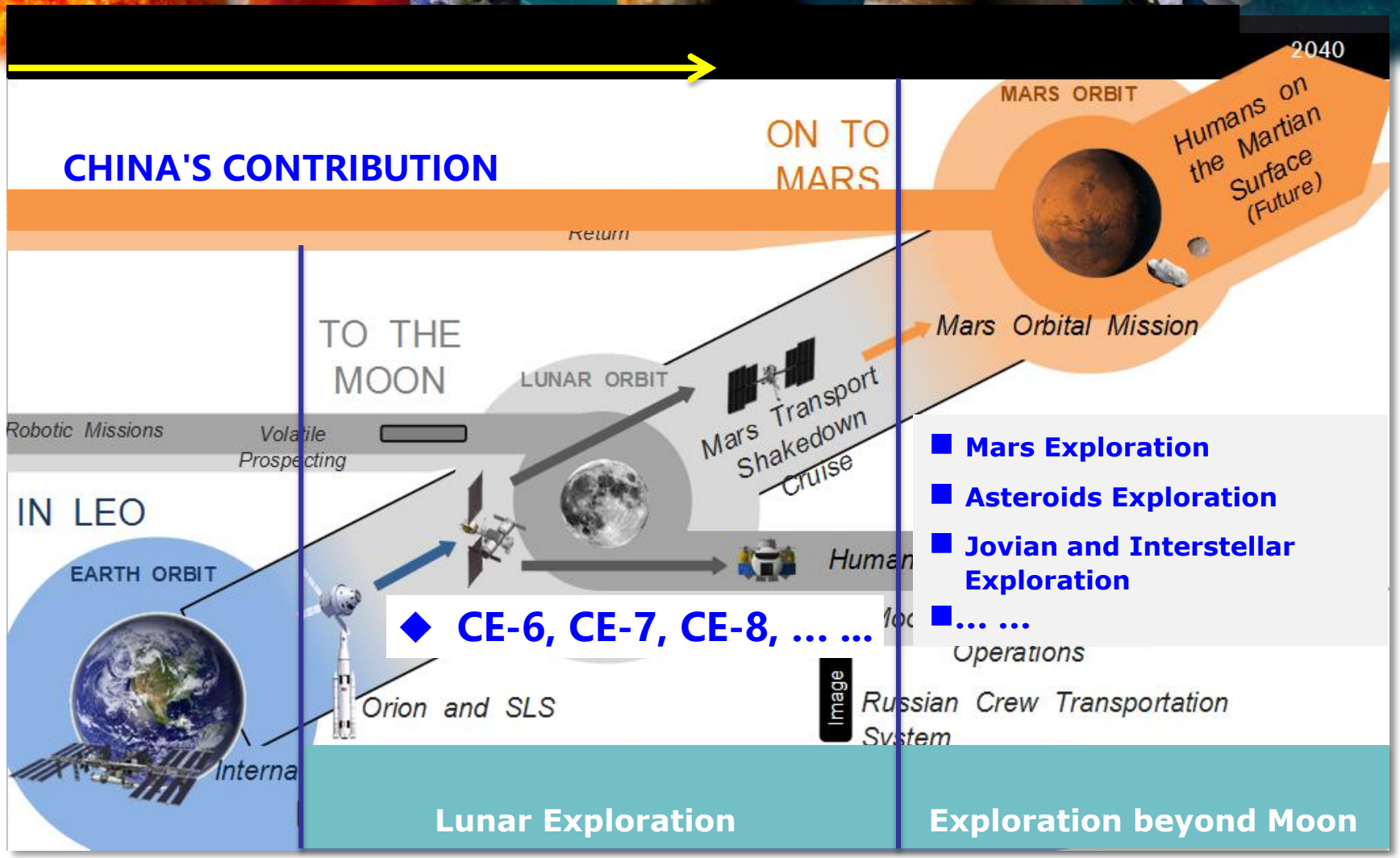
Three Transitions in China’ s Deep Space Exploration

Development modes: From independence exploration to cooperation.

Exploration destinations: From earth-moon system to planetary space.

Exploration purposes: **From mastering space technology to developing space technology, space science and space application.**

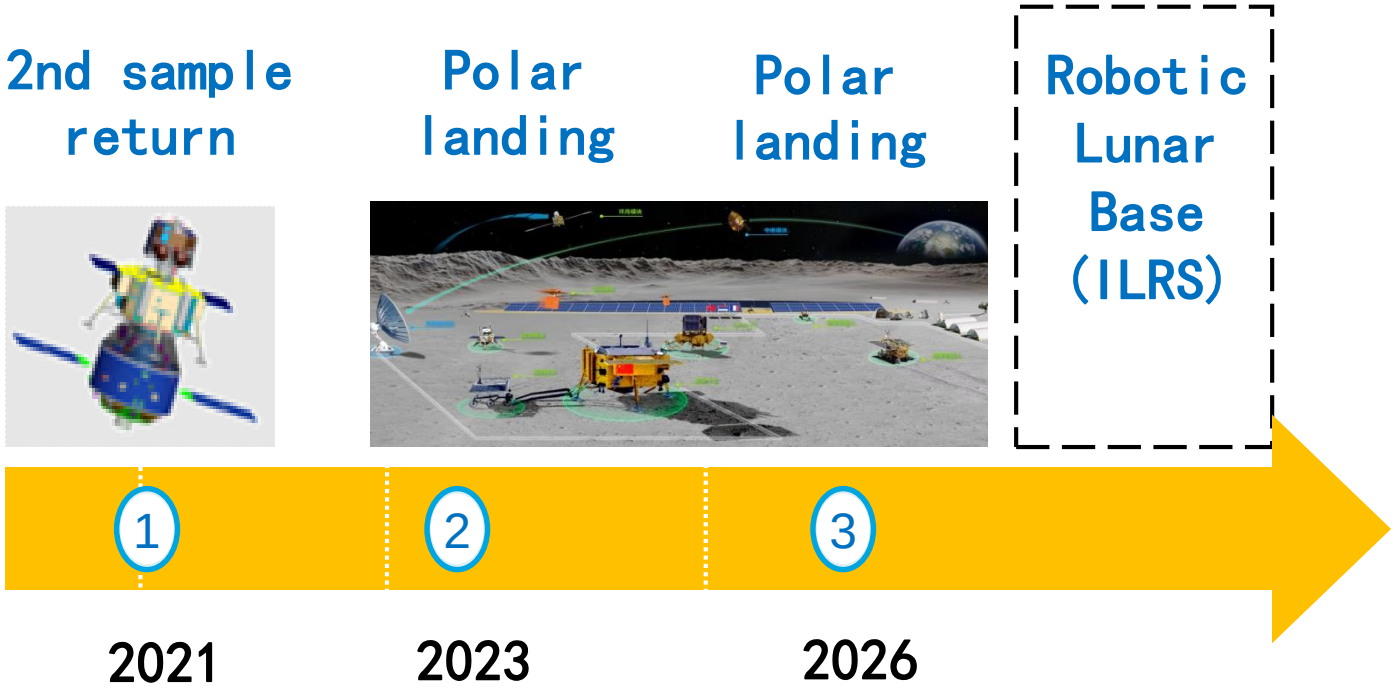
Mission Planned



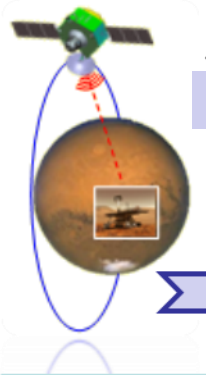
China's contribution to ISECG road map (2018.2)

CLEP follow-on Mission

There are three missions have already been planned after CE-5. In January 2019, Wu Yanhua, deputy director of CNSA said: Chang'e-6 plans to do sample return from the lunar Antarctic; Chang'e 7 will carry out a comprehensive exploration mission on the lunar landform, material composition and space environment; Chang'e 8 will also carry out a comprehensive exploration mission, and execute some key technical demostartion on lunar suface.



Planetary Exploration Before 2030



火星首次探测任务

First Mars exploration

火星取样返回任务

Mars sample and return

取样返回

2020 2022 2024 2028 2029 2030 2031 2036 2046

Further robotic deep space exploration

取样返回

小行星探测

Asteroid exploration

Arrive MBC

到达主带彗星

木星系和行星际探测

到达木星

Arrive Jupiter in 2036

到达天王星

Arrive Uranus in 2036

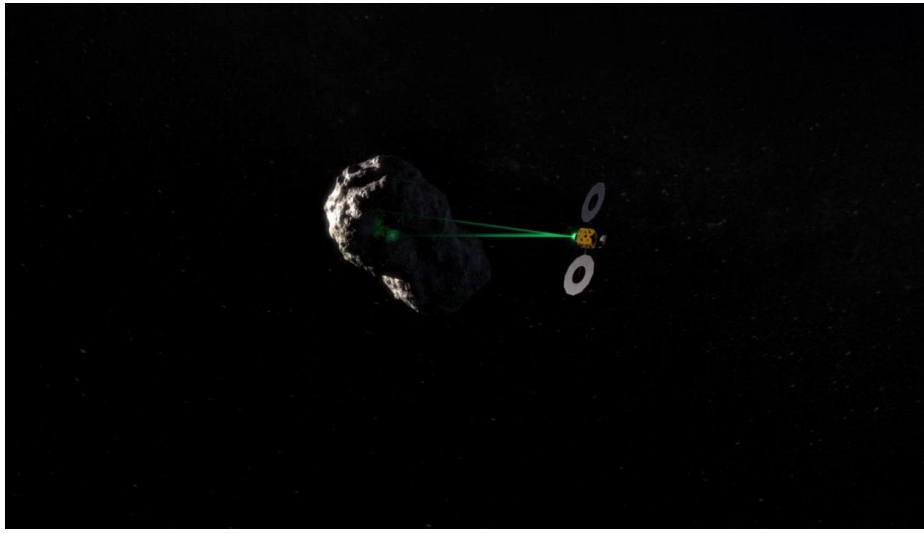
Jovian system exploration

Asteroid Exploration

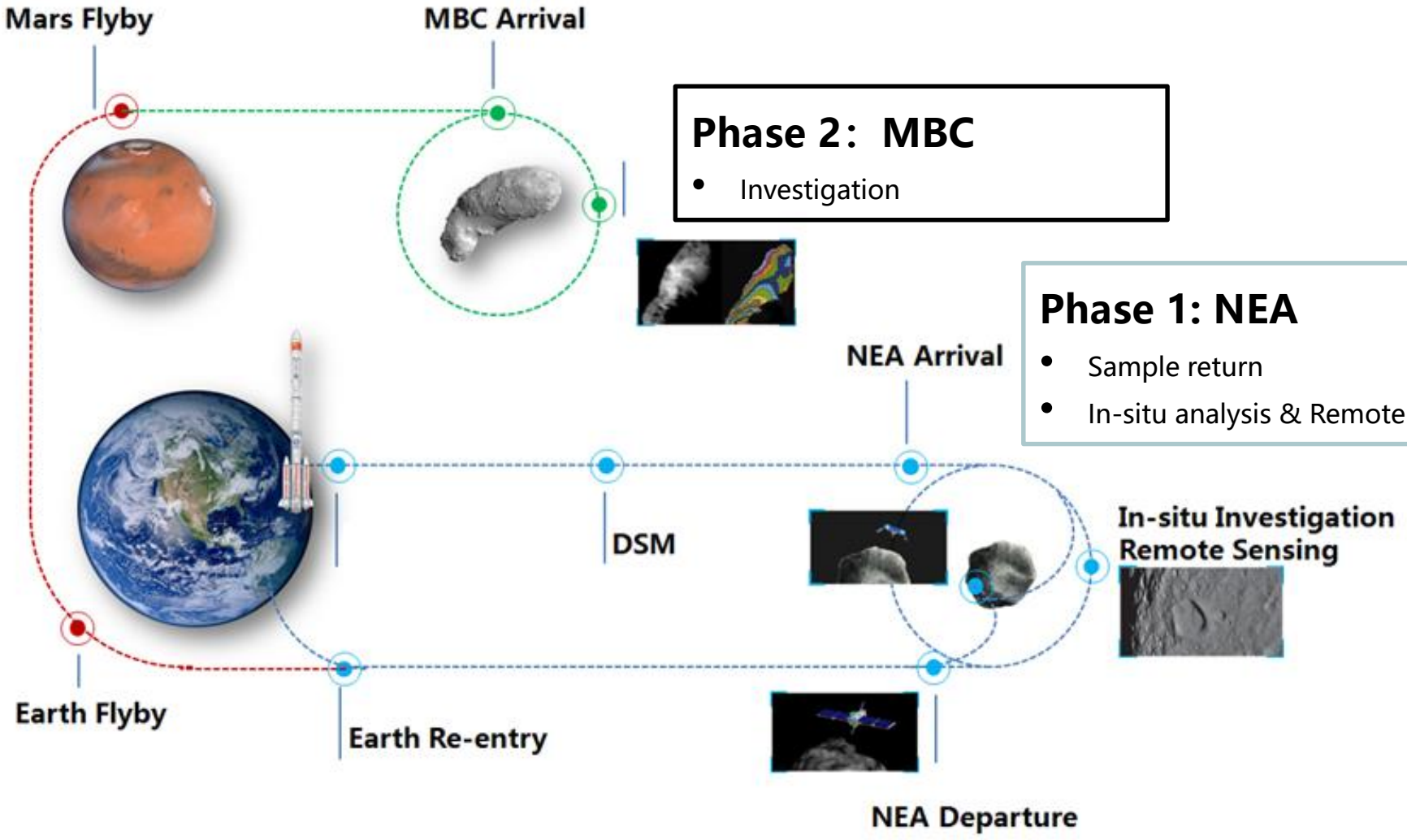
Mission concept of CAST

- Target selection: Constellation of heterogeneous wide-field NEO surveyors
- **Exploration: Sample return and main-belt comet investigation**

- Phase 1: NEA，quick outcome
- Phase 2: MBC，high value (long distance)
- Multi-task、multi-target、multi-function
- Validation of new technology
- International cooperation



Asteroid Exploration



Phase 2: MBC

- Investigation

Phase 1: NEA

- Sample return
- In-situ analysis & Remote sensing

Asteroid Exploration

Science Target

formation and evolution of the Solar System

the role of NEA and MBO impacts in the origin of life

the solar system small bodies dynamics formation

origin of the earth quasi-satellite

earth co-orbital objects dynamics

Connection between asteroids and meteroids

Activity mechanism

Direct detect the Water

NEA **MBC**

Remote sensing (Document the sampling site)

γ -ray&NS — Elements

W/NAC — Morphology Geology

V/NIR — mineralogy

W/NAC — Volume

RS — Gravity field

TES — thermal properties

LFR — Internal structure

Connections,Clues &evidences

Global surface characteristic

Global physical properties

Subsurface constrain

Sample site Special materials

- Water
- Volatile
- Organic
- Dust grain

In-situ measurement

Sampler — Original Bulk Sample

MS — D/H ratio of water

MS — Volatile Organics

GIA&DA — Dust grain

Thermal measurement Micro imaging...

Asteroid Exploration

Payloads

Name	Function
Wide/Narrow angle camera	Perform global and local characterization of the target
Visible/Near-Infrared imaging spectrometer	Perform global and local characterization and distribution of the mineralogy (including water-altered minerals) and organics
Thermal emission spectrometer	Provide key information on the nature of the surface and near subsurface (the thermal inertia) and composition
Radar	Provide a detailed understanding of the internal structure at a variety of scales
Dust analyzer	To detect the physical and dynamic characteristics and the distribution of the dust on the asteroid belt and main-belt Comet.
Charged and neutral particle analyzer	To measure the neutral gas composition and its isotopes and the cold plasma ions and their isotopes near the main comet, in combination of the measurement to the dust particle environment Through measure the plasma environment of the main-belt Comet and the asteroid, in combination of the measurement of the spatial magnetic field

Other Missions

Mars sample and return:
Under concept studies.

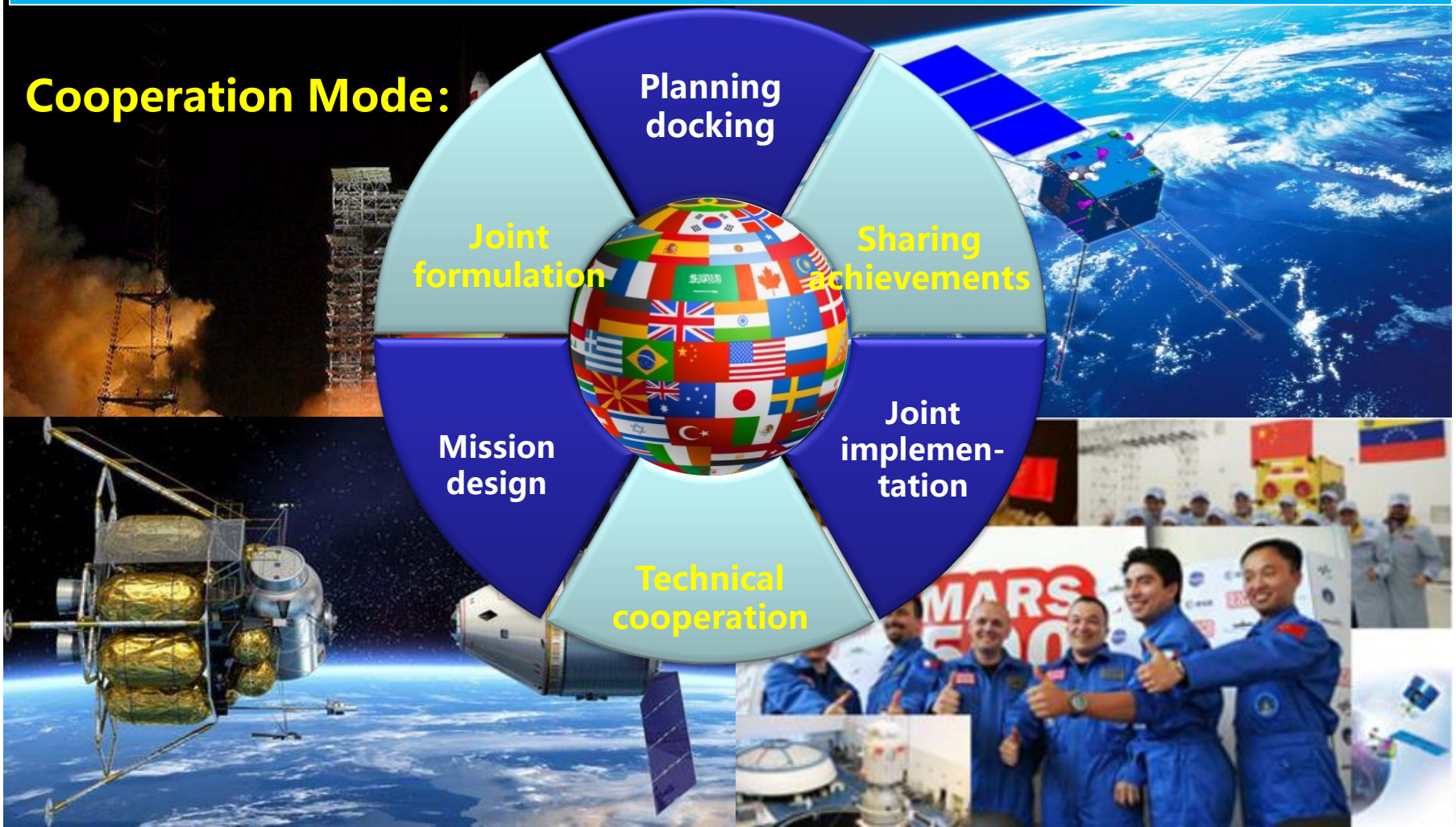
Jovian system exploration:
Under concept studies.

4 Cooperation Opportunities

Cooperative Ways:

- **Different levels:** Task level, system level, data/sample type.
- **At mission stages:** Pre-study, project demonstration, task design, development and construction, implementation and operation, data research.
- **Contributions:** Physical, non-physical.

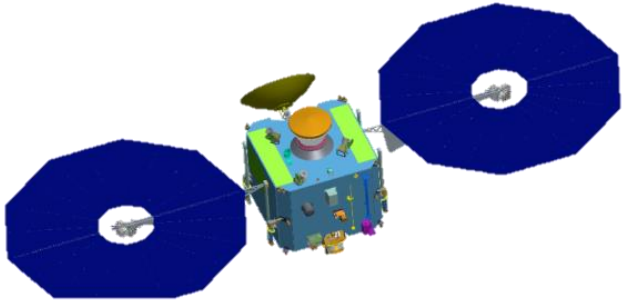
Cooperation Mode:



Opportunities for Two Exploration Missions

Asteroids Exploration Mission

- Near-earth asteroid 2016HO3 exploration
- Main-belt comet 133P exploration



- Call for 8 types of payloads with total mass of 200 kg
- Encourage to jointly develop the payload with Chinese academy, like CAST.
- Call for onboard project schemes

Chang' E-6 Exploration Mission

- Return lunar samples

Call for 20kg payloads

For more information:

www.cnsa.gov.cn

www.clep.org.cn

Opportunities for Mars and Other Cooperations

Cooperation in mission level :

Each side carries out relevant exploration missions independently, and in-orbit Probes coordinate with each other for exploration activities to obtain the scientific data unobtainable in an individual mission or improve the mission's efficiency.

Cooperation in system level :

Both or several parties define the responsibility in the mission and are responsible for developing respective functional modules; the Chinese side is responsible for integration; for example, one party provides the launch vehicle, or carries scientific payloads or a small-scale Probe with independent functions.

Call for papers

Call for papers
Journal of Deep Space of Exploration
Special Issue on Planetary Science 2061

The special issue will include contributions in this emerging field including but not limited to:

- major scientific questions on planetary systems;
- the different types of space missions
- the key technologies which need to be mastered to make these missions flyable;
- the ground-based and space-based infrastructures needed in support to these missions.

Manuscript Submission Information

Manuscripts should be submitted online at *http://jdse.bit.edu.cn/sktcxben/ch/index.aspx*, Manuscripts can be submitted until the deadline. All papers will be peer-reviewed. Accepted papers will be published continuously in the journal (as soon as accepted) and will be listed together on the special issue website. Research articles, review articles are invited. Only the english language will be accepted.

Dates:

Submission deadline: 01-Nov-2019
Final Manuscripts: 30-April-2020

Guest Editors:

Michel Blanc(lead guest editor), Planetary scientist, Space plasmas physicist,Astronomer, Institut de Recherche en Astrophysique et Planetologie (IRAP), Observatoire Midi-Pyrénées (OMP), Université Toulouse III – Paul Sabatier, Toulouse, France; Academic affiliate, Climate and Space Department, University of Michigan, Ann Arbor, USA; Visiting Professor, State Key Laboratory of Space Weather, NSSC, Chinese Academy of Sciences, Beijing, China.
Email: michel.blanc@irap.omp.eu

GUO Linli, professor, Vice Chief Engineer, Science and Technology Satellite System Engineering Department, DFH Satellite CO., Ltd, China Academy of space technology (CAST). More than 50 articles in China are refereed journals and publications (approximate number). Officially published 3 academic monograph, and 2 academic treatises are being signed.
Email：guolinlidfh@spacechina.com

Yang Xiaoyan, the editor of *JDSE* office, is responsible for the editing and publishing for the special issue of the journal.
Email：jdse@bit.edu.cn

深空探测学报
JOURNAL OF DEEP SPACE EXPLORATION

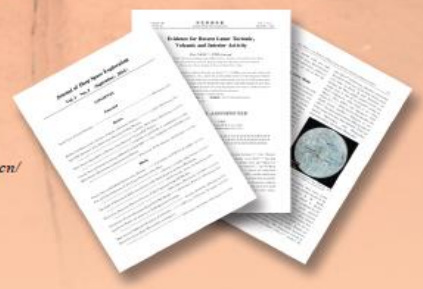
The *Journal of Deep Space of Exploration*(*JDSE*), has been officially supervised by the Ministry of Industry and Information Technology(MIIT) of People's Republic of China, which is a ministry attached to the State Council and in charge of industry and information management. *JDSE* is co-hosted by the Beijing Institute of Technology(BIT) and the Committee of Deep Space Exploration Technology(CDSET), which is a branch of Chinese Society of Astronautics(CSA). The journal is authoritative scholarly journal in the field of deep space exploration in China, seeking to promote research development of deep space exploration.

There are 60 editorial members from core technologies of spaceflight. Wu Weiren who is architect for Chinese Lunar Exploration Program and was elected academician of the Chinese Academy of Engineering in 2015 as well as Academician of IAA, is the in chief editor of the *JDSE*.

We have published plenty of topics about science and technology in the deep space exploration, such as

- The issue of lunar dynamics
- Lunar farside exploration
- Science payloads
- Chang'E-4 lunar relay communication satellite
- Deep space TT&C technology
- Planetary protection and microbial control and so on.

Please download the related papers at *http://jdse.bit.edu.cn/sktcxben/ch/index.aspx*



5 Summary

Summary

- Exploration of the unknown world is the eternal power to promote the development of mankind.
- Exploration of the vast universe is the inevitable course in expanding living space of human being.
- CAST will, and is willing to make contribution to the deep space exploration, with her partners.

LET'S WORK TOGETHER
CREATING A BETTER FUTURE

Thanks!

www.cast.cn/en

Some pictures are from the source of CNSA.