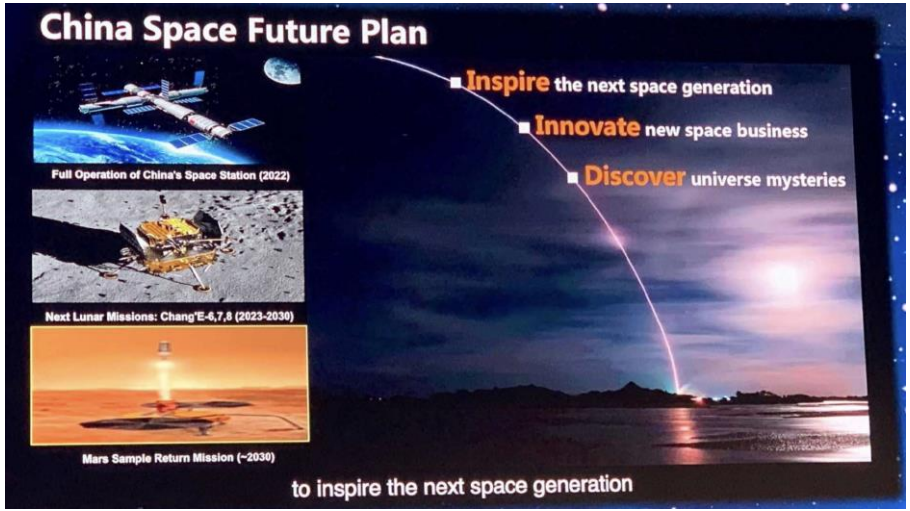
China Deep Space Exploration Activities

Human Spaceflight, Lunar Exploration and beyond…



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August 29, 2022

PART 01

Introduction of Space Development in China

Basic Information about Chinese space programs

1. Introduction of Space Development in China

Dr. Lu

Dr. Prandtl, Dr. Qian, Dr. Von Karman

1. Introduction of Space Development in China

1. Introduction of Space Development in China

China is one of the few countries to combine responsibilities in all space activities and has developed several programs covering large value chains：

1. Launchers
2. Telecommunication
3. Navigation
4. Earth Observation
5. Space Sciences
6. Human Spaceflight
7. Lunar and Mars Exploration
8. Launch and TT&C operation

PART 02

China Deep Space Activities

Learn more about Chinese deep space programs

Road Map of Human Space Program in China

01

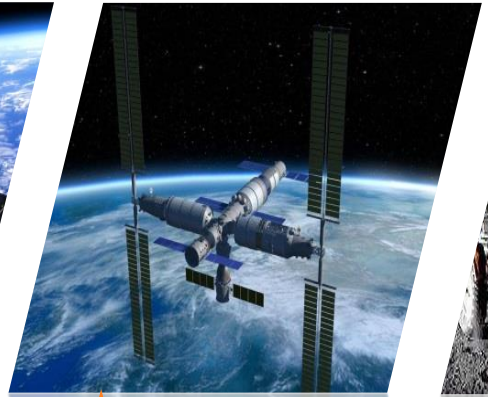
Manned Spaceship

- 1992-2005

02

EVA, RDV and Docking, Spacelab

- 2005-2018



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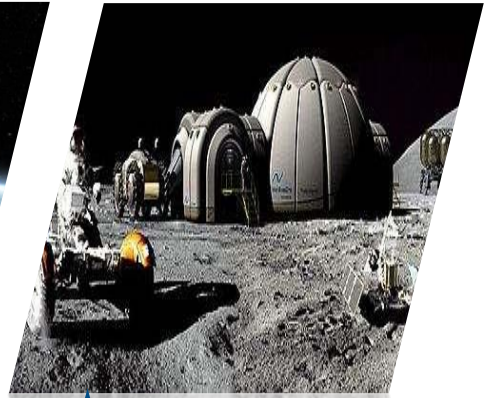
Space Station

- 2010-2035



04

Human Lunar Exploration…

- to be Continued

Phase 1

Objective is to launch a manned spacecraft, set up primarily integrated experimental manned spacecraft engineering, and carry out space application experiments with 6 flights.

- ✓ Four unmanned missions:
  - *Shenzhou-1* *1999.11.20*
  - *Shenzhou-2* *2001.01.10*
  - *Shenzhou-3* *2002.03.25*
  - *Shenzhou-4* *2002.12.30*
- ✓ Two Manned missions:
  - *Shenzhou-5 (1 astronaut, 1-day flight) on 2003.10.15*
  - *Shenzhou-6 (2 astronauts, 3-day flight on 2005.10.12*

Long March 2F

Phase 2: EVA, RDV and Spacelab

Objective is to make technology breakthroughs in extravehicular activities (EVA) as well as space rendezvous and docking of manned spaceships and spacecrafts, launch a space lab, and provide a solution for space application of a certain scale with man-tending on a short-term basis with 8 flights.

1. EVA mission: SZ-7 (3 astronauts, 7-day flight)
2. RDV mission: Tiangong (TG)-1 with SZ-8, SZ-9 and SZ-10
3. Spacelab mission:
   Tiangong-2 Spacelab
   LM-7 maiden flight with Tianzhou(TZ)-1;
   SZ-11

Phase 3

The phase 3 is to deploy a space station and provide a solution for space application of larger scale with human-tending on a long-term basis by the end of 2022.

- **Cargo transportation**
  - Pressurized, semi-pressurized, unpressurized
  - Transport airtight cargo, large extravehicular payloads, experiment platform
  - To be launched by CZ-7
  - At China Wenchang Space Launch Site

- **Crew transportation**
  - Shenzhou (SZ) Spaceship
  - CZ-2F launch vehicle
  - Crew members: 3
  - Crew rotation: up to 6 months
  - Launch site: Jiuquan

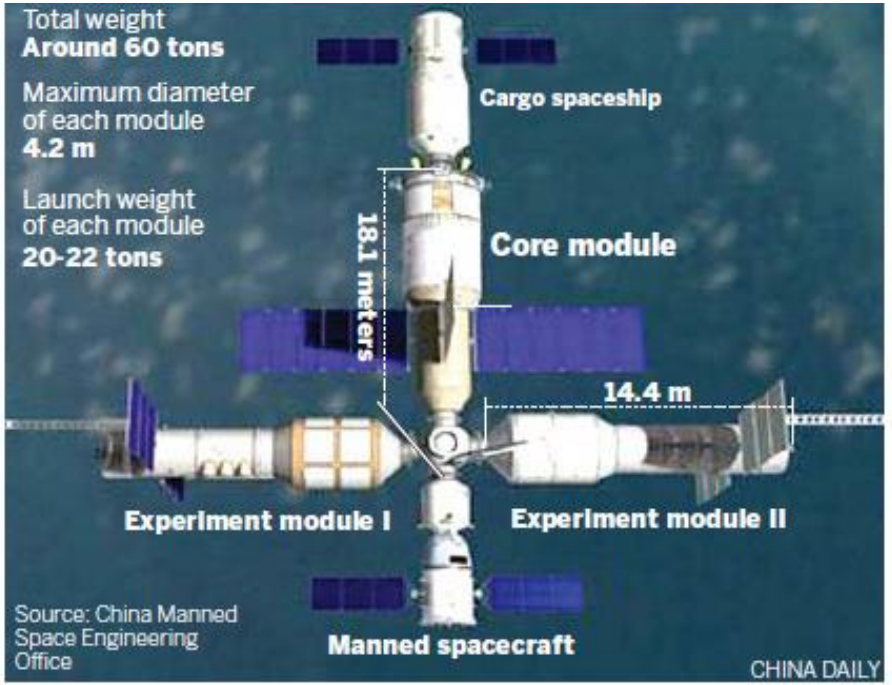
- **Station modules**
  - To be launched by the CZ-5B
  - At China Wenchang Space Launch Site.
  - Complete construction in 2022

China Space Station (CSS)

CSS Configuration:

The basic configuration
- Core Module (CM)
- Experiment Module I (EM I)
- Experiment Module II (EM II)

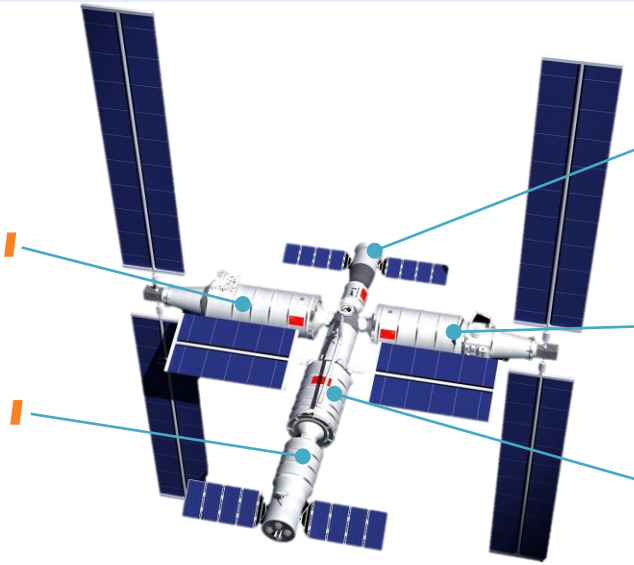
Inclination: 41° ~ 43°
Altitude: 340~450 km
Lifetime: >=10 years
Crew members: 3 for daily work
6 for rotation



Expansion Capability:

Upon future requirements for utilization and international cooperation, newly built modules could be added to the Station.

CSS Facts and Figures

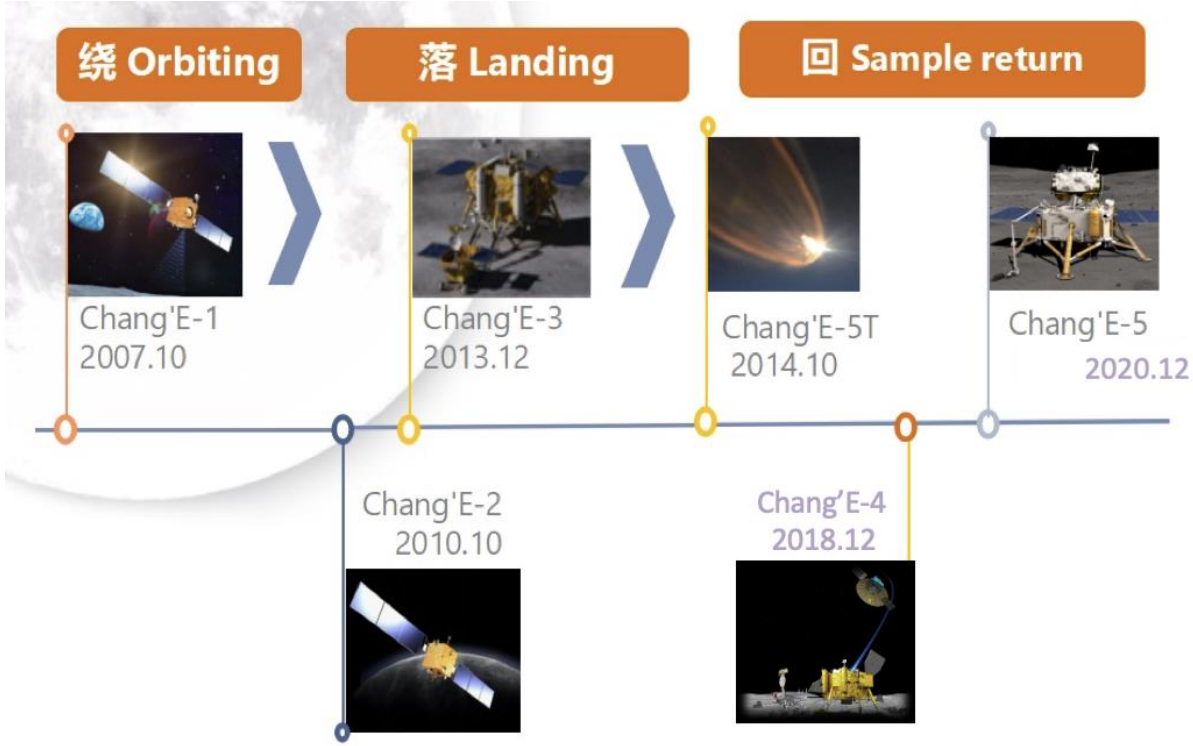


Altitude	**350-450km**
Lifetime	>10 years
Microgravity	10^{-3} - 10^{-5} g
Payloads support	17 tons , 12kW
Crew on board	3
Cargo ship	6 t to orbit

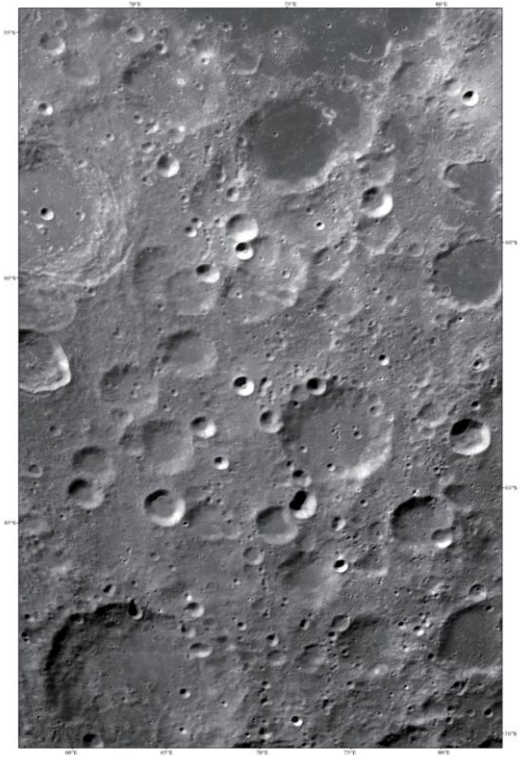
Experiment Rack	**26, placed in pressurized cabin**
Payload adaptor	67, placed on exposed platform
In-orbit storage capacity	1000 Tbits
In-orbit Computing rate	10 Tflops

2.1 Overview of Chinese Past Lunar Missions

Initiated in 2004 with three steps: Orbiting, landing and sample returning



Lunar Probe – Chang'e-1



First lunar surface image of
China's first lunar exploration program

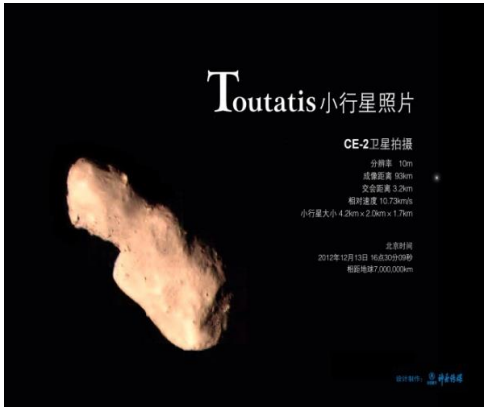
Chang'e-1 lunar probe:

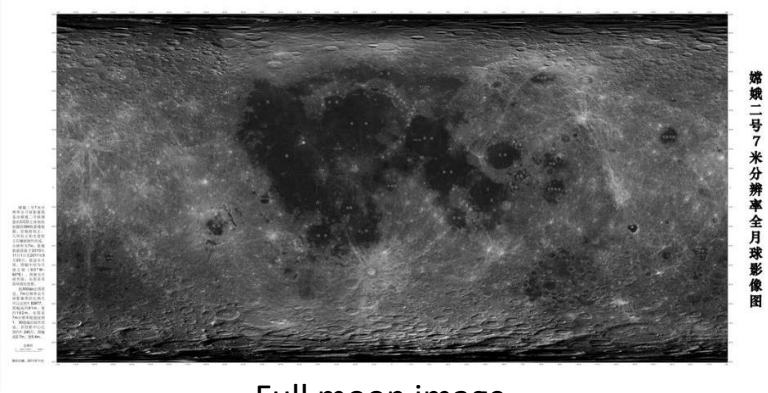
- ✓ Launched on Oct. 24, 2007;
- ✓ Achieving target of "accurate maneuver and successful lunar orbiting";
- ✓ Acquiring full moon image map;
- ✓ Carrying out controlled impact on Moon.

Lunar Probe – Chang'e -2

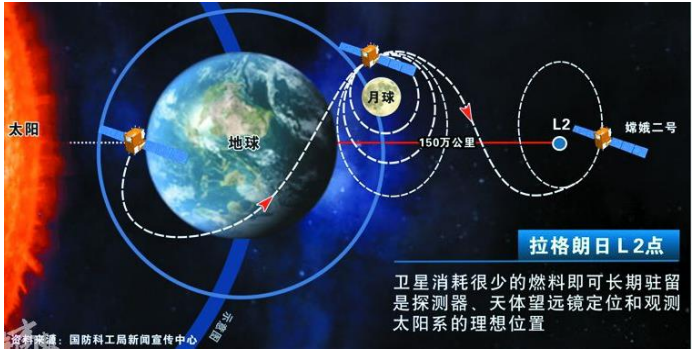
Chang'e-2 lunar probe:

- ✓ Launched on Oct. 1, 2010;
- ✓ Acquire full image of moon with 7m resolution and part image of moon with 1.5m resolution
- ✓ Several extended tests including circling the L2 point and Asteroid Toutatis exploration
- ✓ a high-definition image of Sinus Iridium





Full moon image

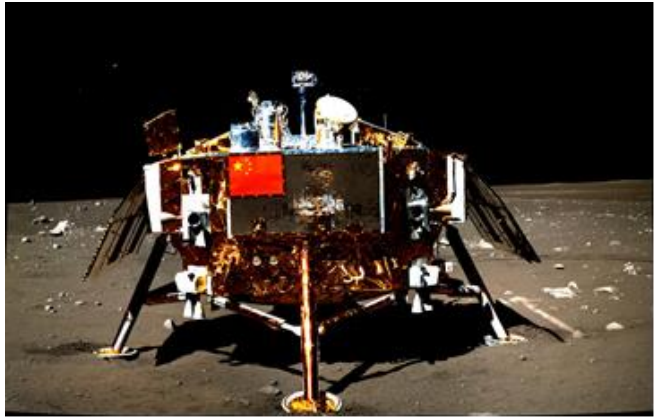


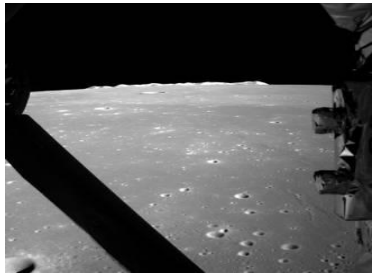
Extended test circling the Lagrangian Point L2

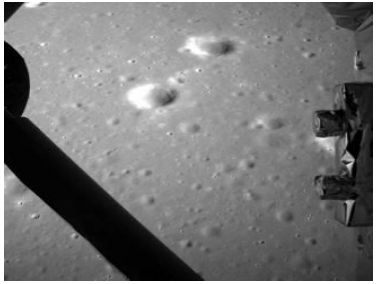
Lunar Landing – Chang'e-3

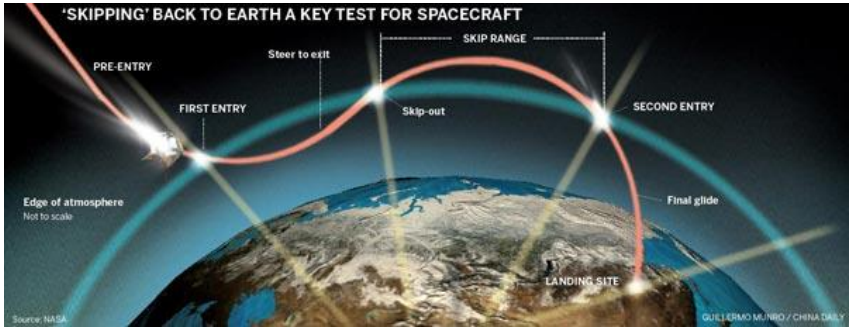
Chang'e-3

- ✓ Launched on Dec. 2, 2013
- ✓ Yutu lunar rover realized lunar soft landing
- ✓ Lunar based observatory
- ✓ Cross imaging of the lander and the rover
- ✓ Huge data generated by the lander and the rover



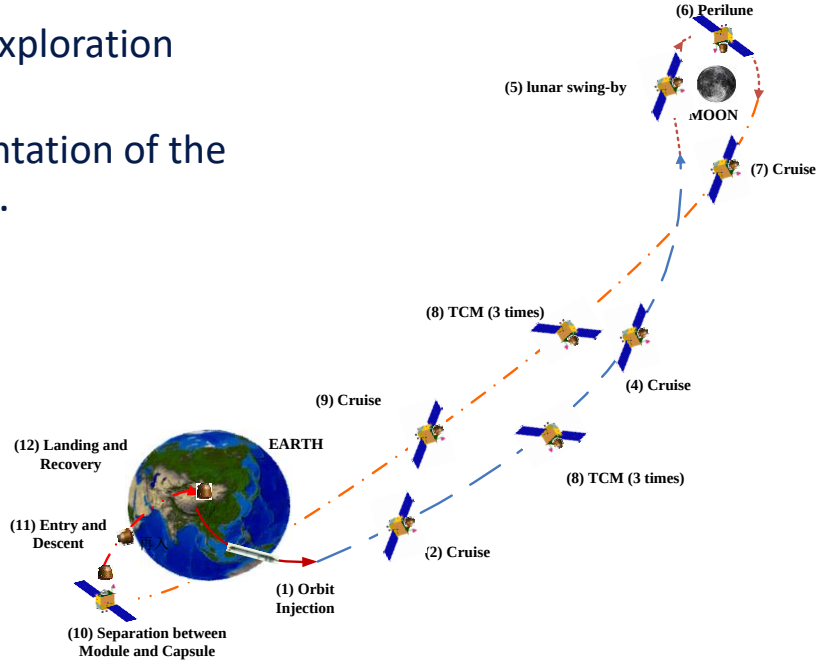




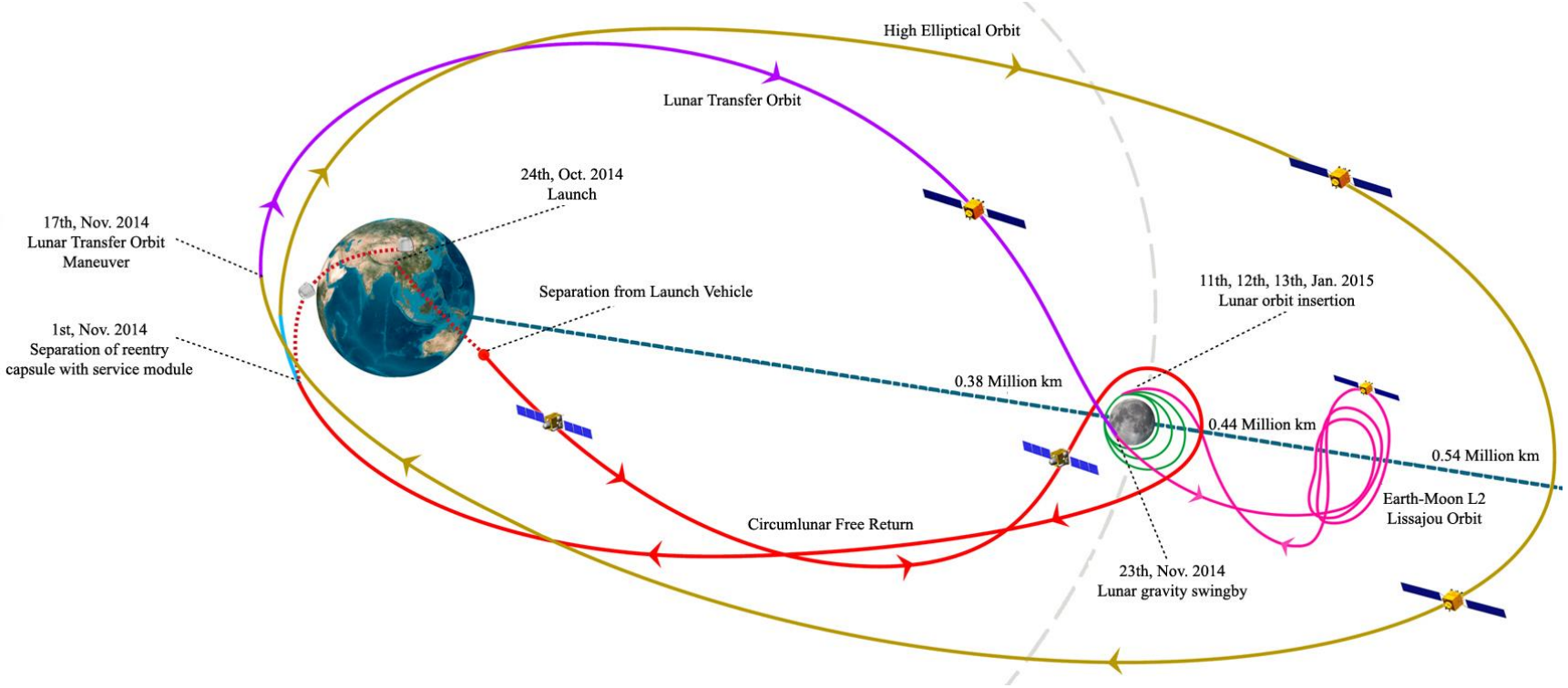


Chang'e-5T

- ✓ Launched on October 24, 2014;
- ✓ Reentry and Return Flight Demonstrator;
- ✓ Making China the third country recovering lunar exploration vehicle in the world;
- ✓ Laying a solid foundation for the smooth implementation of the lunar sampling and returning mission of Chang'e-5.



Chang'e-5T Extension

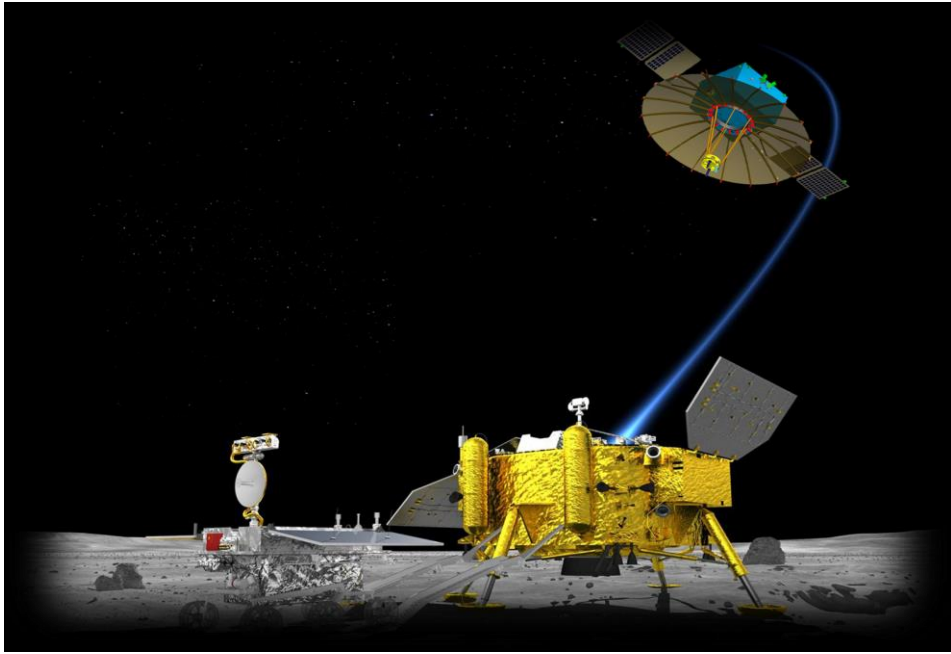


Orbital Mechanics

Chang’e-4 - Lunar Far-side Exploration

The Chang’e-4 Lunar Probe has landed softly on the far-side of the Moon for the first time and implemented in-situ and rover exploration, while all the data is sent back to Earth via a relay satellite.

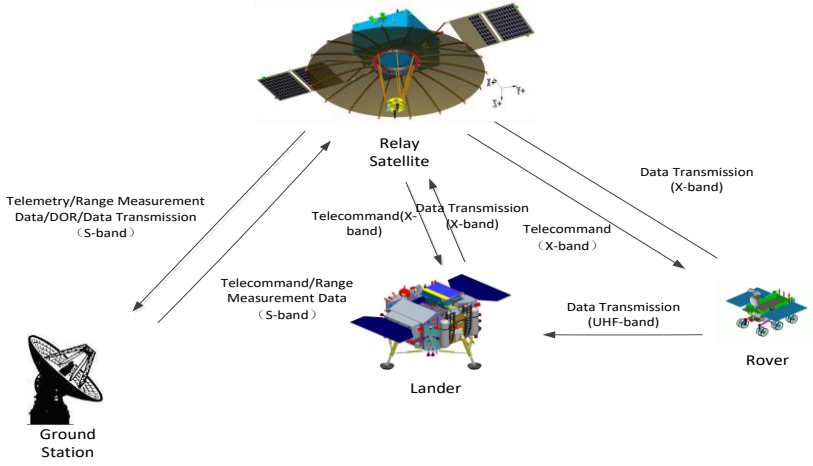
The lunar far-side is of great significance on geological evolution study, low-frequency cosmic radio survey, etc.. It has unique advantage than the lunar nearside.

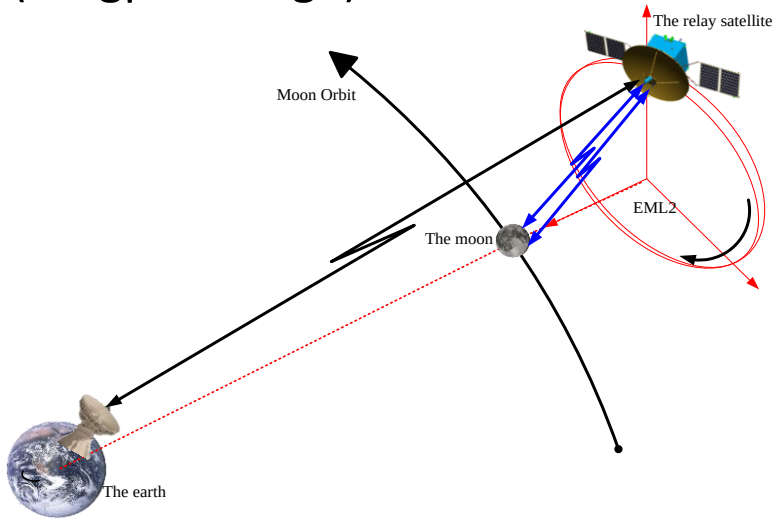


Chang'e-4 - Lunar Far-side Exploration

3.1 System Configuration

- ✓ Lander + rover combination structure;
- ✓ Data relay satellite for communication and control;
- ✓ Objective: landing on the far-side of the Moon;
- ✓ Two launches: probe + data reply satellite(Magpie Bridge)





Chang’e-5 Sampling and Returning

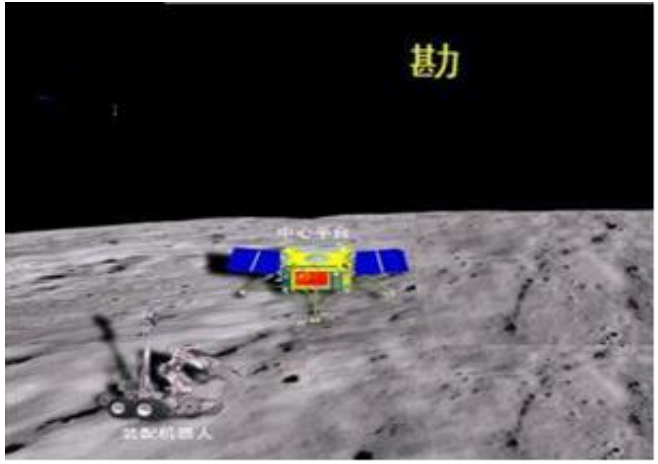
Chang’e-5 with LM-5 in 2020

- ✓ Lunar surface sampling, lunar surface ascending, lunar orbit rendezvous and docking, Moon-earth transfer, and high-speed earth reentry and sample return will be realized;
- ✓ Demonstrate necessary technologies for robotic exploration and/or manned lunar exploration;
- ✓ Chang’e-6 (Chang’e-5’s backup) might be used for South Polar Exploration.

2.2 Road Map (I) – Three steps

Explore lunar resources to built basic exploration capacities such as:

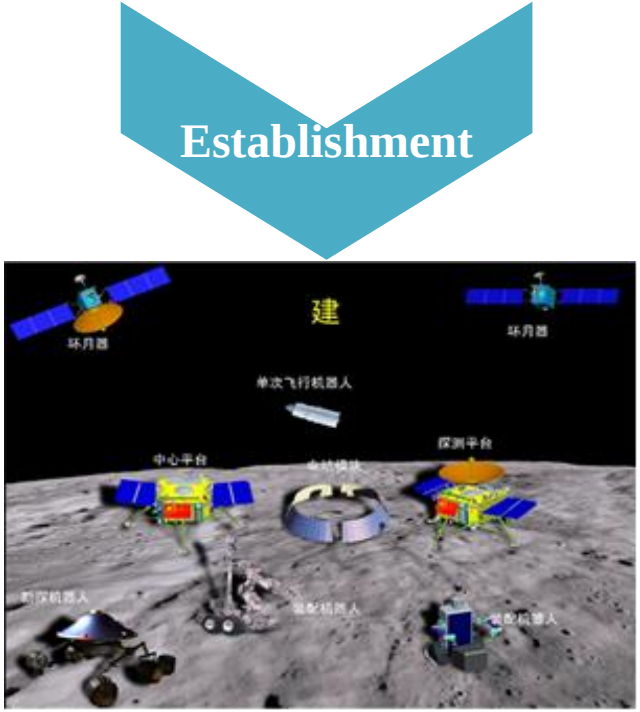
- ✓ High-speed network communication of the scientific research station;
- ✓ Robot exploration,
- ✓ low altitude flight,
- ✓ fixed position exploration,
- ✓ Internal structure exploration of the Moon and heat flux probe, lunar soil and gas resources explorations, and lunar surface biological experiments, etc.



2.2 Road Map (II) – Three steps

Establish basic platforms to completing the constructions of:

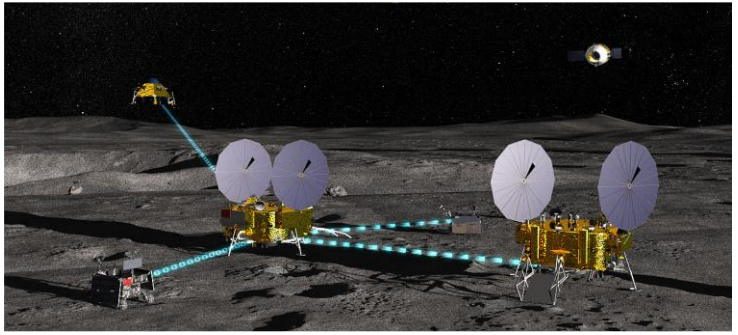
- ✓ central platform of scientific research station and power station,
- ✓ assembly robot and other basis platforms and facilities.
- ✓ Conducting lunar surface environment exploration, moon-based astro-observation and other scientific explorations.

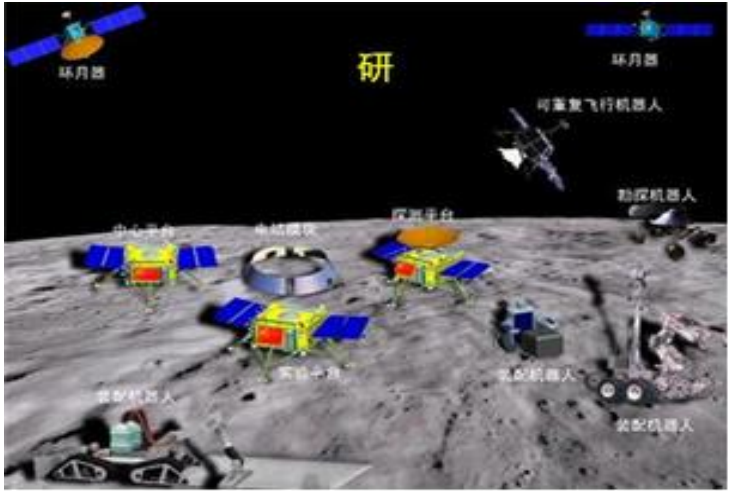


2.2 Road Map (III) – Three steps

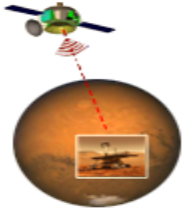
Research to Validate resource development and utilization technologies

- ✓ To finish the constructions of experiment platform, robot assembly, repeatable low altitude flying robot and other functional modules;
- ✓ To realize the overall operation of the scientific research station (Fig. upright);
- ✓ To carry out the climate change monitoring, lunar soil and gas resources utilization validation, and other scientific researches and technical tests.

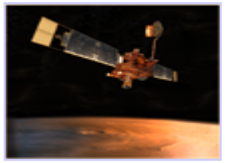




… and Deep Space Exploration

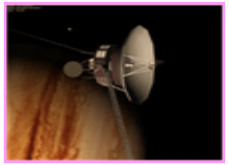


Mars Mission



Asteroid study

Mars sampling



Jupiter and its system study

2020

2021
Mars arrival

2024

2028

Around 2030

2036
Jupiter arrival

2048
Uranus

Mars Sample Return

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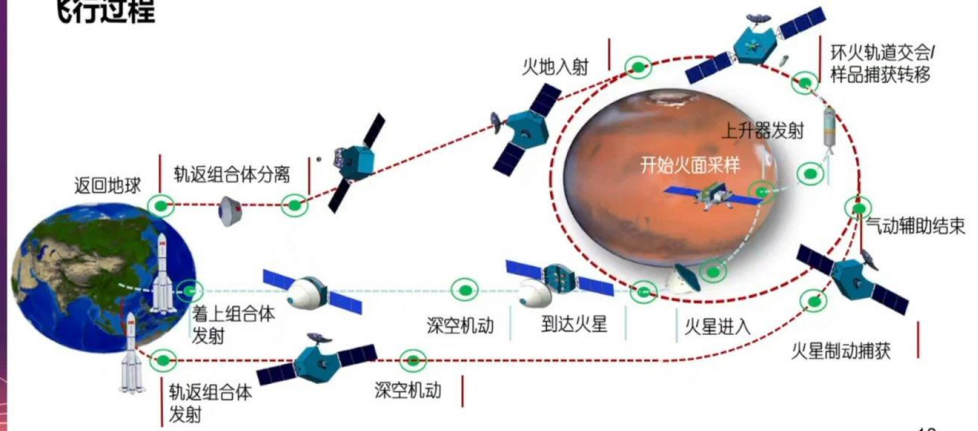
孙泽洲
“天问一号”总设计师

三 火星采样返回任务及挑战

飞行过程



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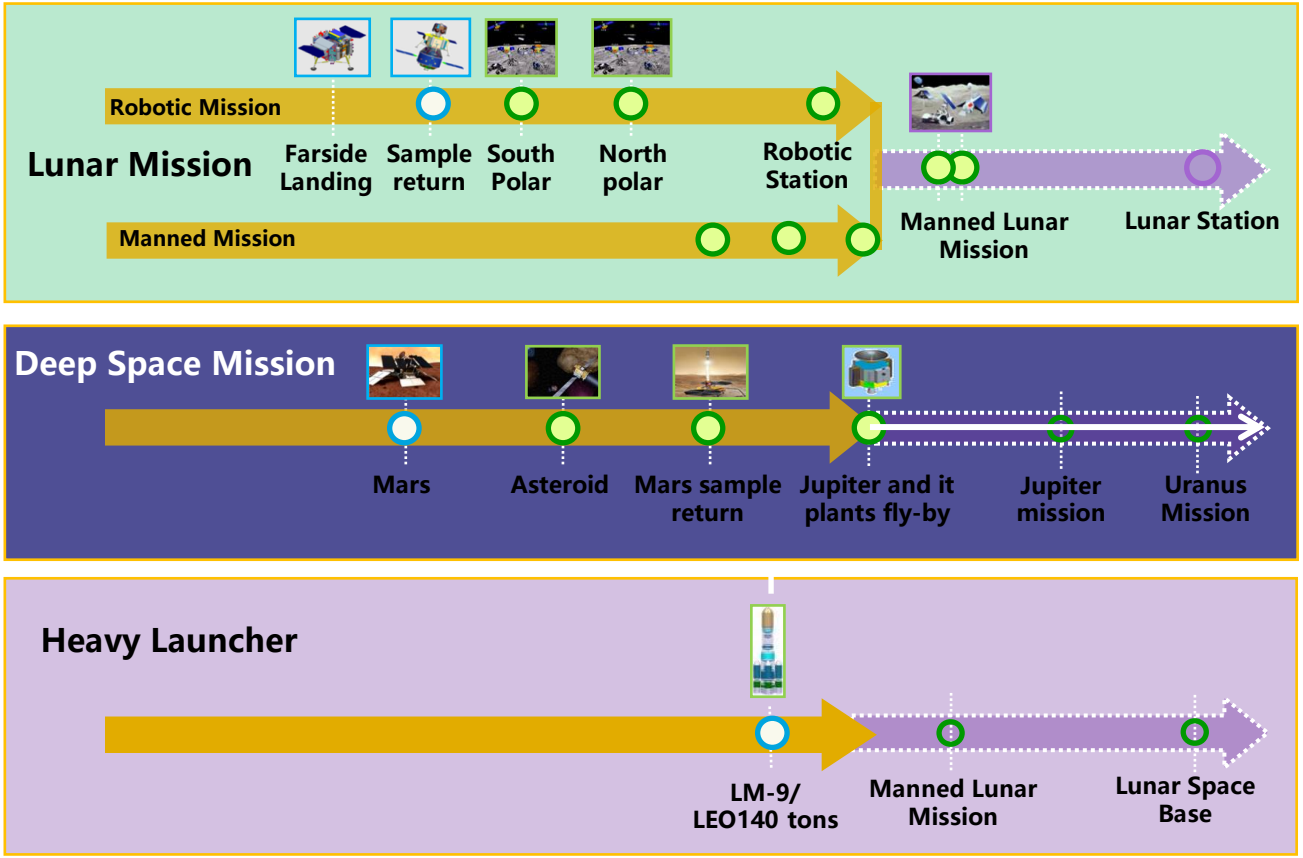
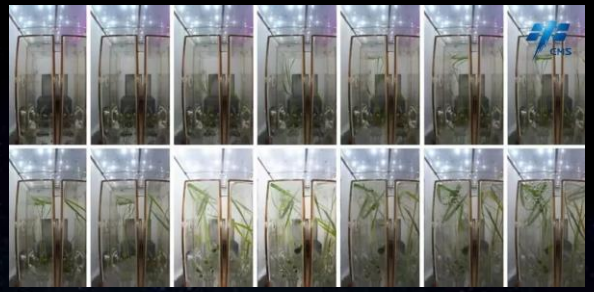
Looking to the Future…





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Any questions?