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Vision and Voyages for Deep Space Exploration*

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Abstract More than 50 years of space exploration has not only satisfied human curiosity and built up international cooperation, but also improved life on Earth. Space exploration is an open-ended process which started 50 years ago. It enables access to unknown terrains with robots and humans, thereby opening new frontiers. Progress of goal deep space exploration was reviewed. China's current deep space missions are also briefly introduced. Focused on the vision and voyages for China's deep space exploration in 5 or 10 years. Like the Chinese Lunar Exploration Program (CLEP), we embark on a journey to Mars. We will spend few decades on Mars with the robotic explorers. Unlike CLEP, scientists proposed to build Moon research station by 2030.

Key words Deep space exploration, Mars, Moon

Classified index V 4

1 Introduction

After more than 50 years since humans ventured into orbit for the very first time, space exploration has evolved in terms of destinations, duration, objectives and partnerships.

The United States, Russia, Europe, Japan, China, India and other countries and organizations have launched more than 200 space probes, visited seven planets and Pluto in the solar system, implemented the Moon, Mars, Venus, Titan, asteroids and comets landing detections, achieved sample return from the Moon, asteroids and comets particle, implemented six manned lunar landings and sent 12 astronauts to the Moon.

The challenges encountered on the way and the number of involved participants added to the level of complexity, but significantly increased the sustainability and the relevance to our common future on planet Earth. By 2030, there will be approximate 16 lunar explorations, 12 Mars missions. Missions to Mars are the ultimate challenge, which include the return of samples in 2025 and the close cooperation between robots and humans on the surface of the Red Planet in 2035 (Figure 1−3)[1−6].

2 China's Current Situation

The Chinese Lunar Exploration Program (CLEP) is an ongoing series of robotic Moon missions. The CLEP is divided into three main operational phases, with each mission serving as a technology demonstrator in preparation for future missions. Chang'E-1 and Chang'E-2 are lunar orbiters, and has now been completed effectively. Chang'E-3 is ongoing, and incorporates spacecraft capable of soft-landing on the

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Fig. 1 ESA artist's concept of a Moon village

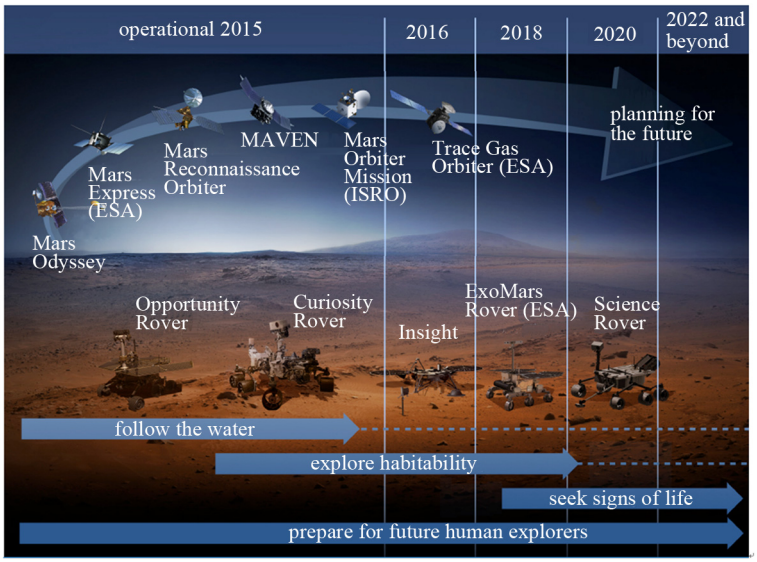

Fig. 2 On the red planet: robotic Mars missions

Moon and deploying lunar rovers. Chang'E-5 will entail a lunar sample return mission in 2018. More than 10 years of CLEP has not only achieved a series of progresses, but has also made favorable conditions for future deep space exploration.

3 Scientific Objectives

With emphasis on the Moon and Mars, the future deep space exploration will carry out terrestrial planets, giant planets, and small objects exploration. It will obtain many important research findings about the origin and evolution of the solar system, disastrous impact on the Earth by the Sun and small bodies, extraterrestrial life exploration and other research fields, and will also promote astronomy, space science and technology applications[7−8].

4 General Conception of Future Deep Space Exploration

By 2020, CLEP three phases will be comprehensively implemented: circling, landing and returning. China also proposes a series of Mars sample return, asteroids, Jovian system, interstellar exploration in the next 15 years (Figure 4)[9−11].

4.1 Moon

Chang'E-4 mission, phase two of China Lunar Exploration Program, represents China's first attempt to explore far side of lunar surface. Chang'E-4 mission

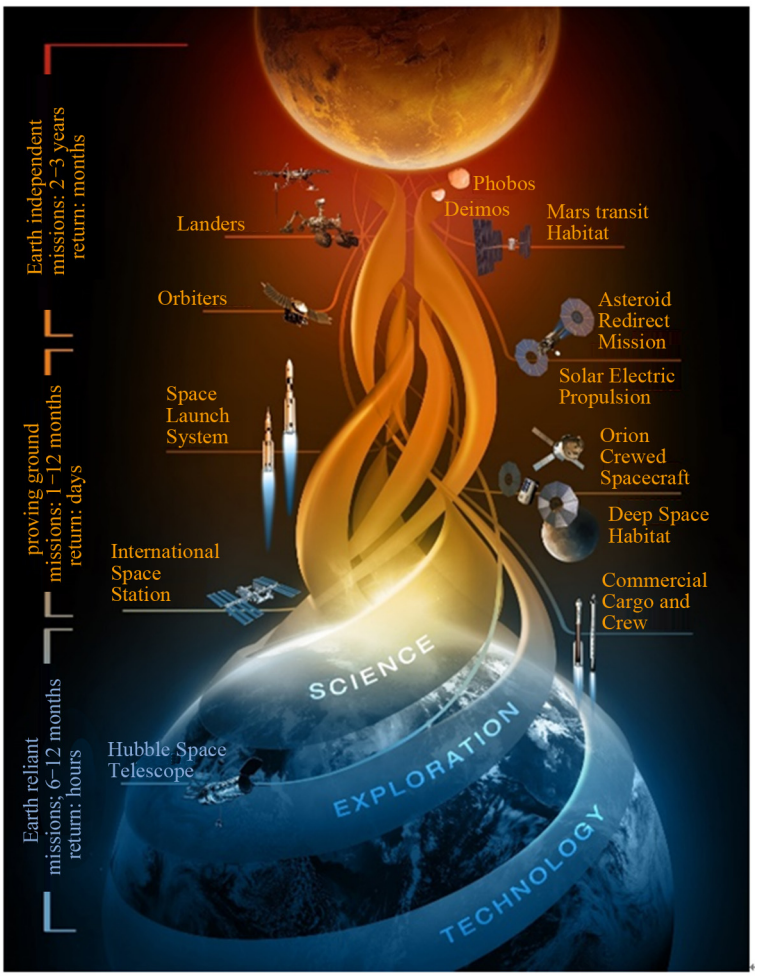

Fig. 3 NASA: three phases on the journey to Mars

includes lander, rover and a telecommunication relay, presently scheduled to launch in 2018.

The scientific objects of the future lunar exploration are space and astronomy, geology and structure, resources and environment. Proposed future lunar missions include robotic lunar missions and human lunar exploration. China is currently working on robotic missions to conduct scientific research and support future human surface missions. Robotic science missions would detect lunar south/north pole and collect sample and return to the Earth. So the robotic missions will continue well into the next decade to meet high-priority science objectives and to prepare for future human missions to the Moon. Human lunar exploration would include human orbiter lunar exploration, manned lunar-landing and manned lunar scientific station.

4.2 Mars

The Mars program consists of two missions to be launched in 2020 and 2030, respectively. The first phase is circling, landing, in-situ and rover exploration, and second phase is sample return.

Mars is the horizon goal for space pioneering; it is the next tangible frontier for expanding human presence. Our robotic mission will scout Mars' geological evolution and climate cycles, which were comparable to Earth's at one time and suitable for life, to detect Mars' space physical, atmospheric and meteorological characteristics, Martian surface environment; to research topography formation, Martian soil composition, structure, physical characteristics; to find valuable resources such as water ice just below the sur-

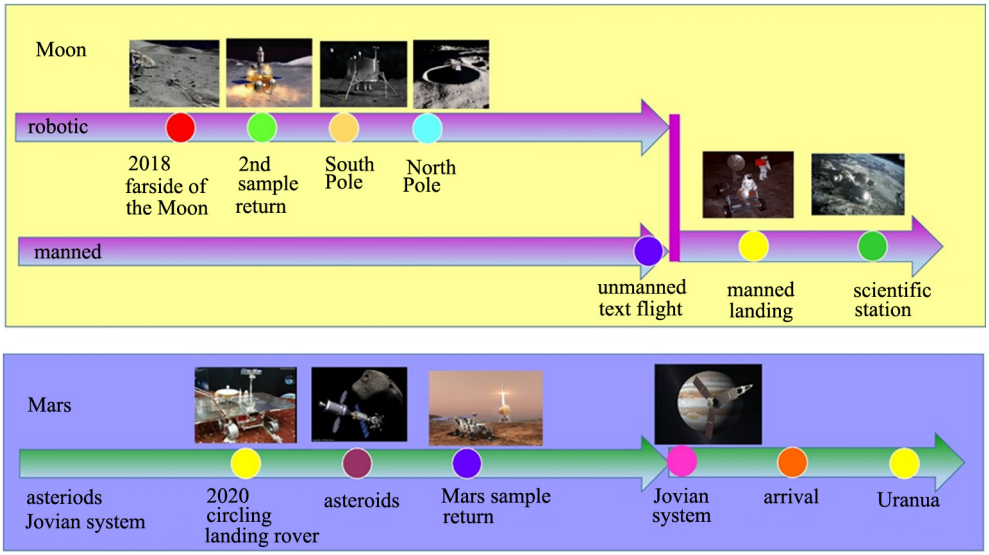

Fig. 4 Poposal for deep space exploration mission development route

face; to study the internal structure and the evolution of planetary systems, and comparative plane

4.3 Asteroid

By 2024, scientists suggested asteroid mission could focus on flying by, touchdown, sample return, with a serious of multi-purpose explorations, to detect the formation and evolution of asteroid, assess risks of impact on the Earth, and study the solar system origin, evolution and how life began on Earth.

4.4 Jovian system

By 2030, scientists proposed to carry out Jovian system orbiter exploration. To research the structure of Jupiter's magnetosphere, Europa space/surface environment and ice shell characteristics.

Arriving at Uranus is planned in 2048.

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