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Introduction to Japanese exploration study to the moon

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ABSTRACT

The Japan Aerospace Exploration Agency (JAXA) views the lunar lander SELENE-2 as the successor to the SELENE mission. In this presentation, the mission objectives of SELENE-2 are shown together with the present design status of the spacecraft. JAXA launched the Kaguya (SELENE) lunar orbiter in September 2007, and the spacecraft observed the Moon and a couple of small satellites using 15 instruments. As the next step in lunar exploration, the lunar lander SELENE-2 is being considered. SELENE-2 will land on the lunar surface and perform in-situ scientific observations, environmental investigations, and research for future lunar utilization including human activity. At the same time, it will demonstrate key technologies for lunar and planetary exploration such as precise and safe landing, surface mobility, and overnight survival. The lander will carry laser altimeters, image sensors, and landing radars for precise and safe landing. Landing legs and a precisely controlled propulsion system will also be developed. A rover is being designed to be able to travel over a wide area and observe featured terrain using scientific instruments. Since some of the instruments require long-term observation on the lunar surface, technology for night survival over more than 2 weeks needs to be considered. The SELENE-2 technologies are expected to be one of the stepping stones towards future Japanese human activities on the moon and to expand the possibilities for deep space science.

1. Introduction

JAXA launched the Kaguya (SELENE) lunar orbiter from Tanegashima Space Center on September 2007. During the time Kaguya was in lunar orbit until it impacted into the southeast region of the Moon in June 2009, Kaguya made many contributions to science, obtaining scientific data about the origins and evolution of the Moon and developing technology for future lunar exploration [1].

As a next step, the SELENE-2 mission is set take over Japanese efforts at lunar exploration with a landing on the moon [2]. SELENE-2, the first Japanese lunar lander, is expected to bring major advances in both space technology and science. From a technological perspective, SELENE-2 offers a number of capabilities—precise and safe landing, surface mobility, and overnight stay on the moon surface—all of which are key technologies for future lunar exploration activities. The lander will attempt to achieve a precise and safe, soft landing by using laser altimeters, image sensors, and landing radars. From a scientific perspective, SELENE-2 will perform in-situ observation, environmental investigations, and research for future lunar exploration at the landing site. The launch is currently targeted for 2018.

To follow on from SELENE-2, work is already underway on robotic landers designated SELENE-X (where X starts from 3). Although the SELENE-X missions have not been completely defined as yet, several candidate missions such as sample return from the moon are being considered. This

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paper also introduces the current vision for SELENE-X missions leading to future human exploration of the moon.

2. The SELENE-2 mission

2.1. Why go to the moon?

It is important to discover new facts about the Earth, the Moon, and other planets in order to learn about where we came from. Planetary exploration in the past has provided us with a variety of facts, and current common knowledge consists of all such facts accumulated throughout history. From the viewpoint of learning our potential for expanding the sphere of human activities, we are still missing many facts about the mechanism of planetary formation, with little known about even the Moon, which is the nearest celestial body to Earth. In terms of technology, the Moon is a best test bed for demonstrating new technologies for planetary exploration. The near side of the Moon always faces Earth, making it easy for a lander to communicate with Earth. From a social viewpoint, the Moon, like the Sun, is very close to daily life. Lunar exploration is therefore a good example for education and outreach of science and technologies. Lunar exploration is also considered an area of international collaboration, with human exploration in particular requiring extensive collaboration.

2.2. Mission definition

SELENE-2 is the first Japanese lunar lander and since the purpose of the mission is lunar exploration, the mission objectives are as follows [3]:

I. Development and demonstration of key technologies for future exploration.
Safe and accurate landing technologies.
Surface mobility: rover.
Night survival technologies without using radio isotope energy.
II. In-situ observation and investigation for science and future lunar utilization.
Detailed and sub-surface geological observation.
Geophysics for discovering the interior structure of the moon.
Measure the moon environment for future utilization.
III. Contribution to international space exploration activity and meeting the public interest.
International payload.
Outreach or educational payload.
In order to achieve these objectives, a configuration consisting of a 1-ton class lander and a 100-kg class surface mobile robot (rover) is being considered. From among the Japanese launch vehicles, the H-2 A rocket is satisfactory for the SELENE-2 configuration.

2.3. Spacecraft configuration

The SELENE-2 consists of a lander and an orbiter. The lander carries a rover and mission payloads. In order to meet the mission requirements and to optimize the spacecraft design, some trade-offs are being considered. For example, whether to use direct lunar transfer orbit (LTO) insertion, geosynchronous transfer orbit (GTO), or another special launch orbit is under discussion. The selection depends on the launch vehicle performance, efficiency of the spacecraft propulsion system, launch window requirements, and other factors. The size of the orbiter is also a design factor. The smallest case is a spin-stabilized communication relay orbiter without a propulsion system like Kaguya's small satellites. In this case, a relatively large lander would descend to the surface, but this would require much fuel. By comparison, the biggest case is an orbiter of a few tons with a propulsion system for insertion into lunar orbit. This gives the smallest lander size and also minimizes the fuel required. In general, as the total spacecraft system becomes larger and the orbiter becomes bigger, a smaller lander becomes more advantageous for maximizing the mission payload. A tentative mass budget for the SELENE-2 spacecraft is shown in Table 1. The Japanese H2A rocket can carry a lander of around 1 t (dry weight) to the moon surface. This corresponds to a payload of a few hundred kilograms including a 100-kg rover. An artist's drawing of the SELENE-2 configuration is shown in Fig. 1.

Table 1
Tentative mass budget of the spacecraft (GTO launch case).

Orbiter	Bus system		600 kg
	Mission payload		100
	Fuel		2400
	Total		3100
Lander	Bus system		700
	Mission payload		200
	Rover	Bus system	80
		Mission payload	20
		Total	100
	Fuel		1700
	Total		2700
Total			5800

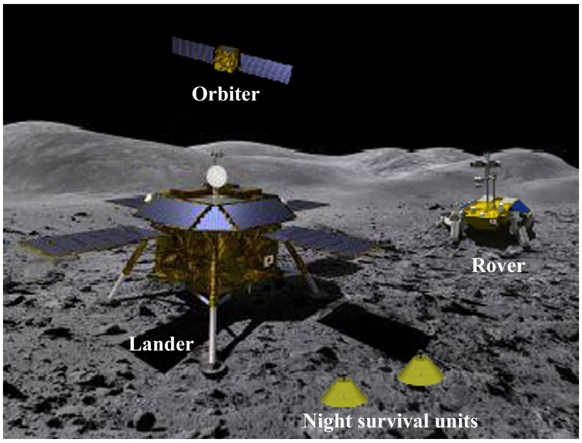

Fig. 1. Artist's drawing of the SELENE-2 configuration.