R&D Item

# 4. Exploration mission and systems for Lunar Lava Tubes

Progress until FY2024

## 1. Outline of the project

This R&D theme is to plan and design an exploration mission and develop an exploration system, aiming to realize robot exploration of lava tubes on the lunar surface after 2025.

In planning the exploration mission, we will consider the transportation means (rocket and lander) to the lunar surface, consider the method of inserting the system into the lava tube vertical hole, the exploration method, etc., and develop a plan to determine the system specifications to realize the plan. In addition, we will determine the specifications of the exploration system according to the mission plan, design the mechanical and electrical systems of the exploration system, and conduct space environment tests, etc., to realize an exploration system that can be used for lunar missions. The exploration system consists of an insertion capsule (container) and a small exploration robot. The exploration robot will be stored inside the insertion capsule, and the capsule will be loaded onto the lander, and the capsule will be inserted on site. It is expected that the capsule will unfold and become a station for relaying communications with the outside after releasing the robot. In order to realize these capsules and robots, we will work in cooperation with each research and development project based on the results of research and development and the results of preparatory studies in R&D theme 1, 2, and 3, to utilize the research results and conduct lunar environment tests of each technology, then consider space specifications and design them as exploration systems that can be used in the lunar environment.

## 2. Outcome so far

1. Planning of lunar lava tube exploration mission and transportation method

Assuming various possibilities for the method of reaching the vertical and horizontal holes of the lunar lava tube, we selected candidates for landers, mainly from the private sector, and considered the possibilities (in that, the launch rocket is considered to be attached to the lander). Regarding the operation method of the robot and communication system after reaching the vertical hole, we considered the selectable options, and proceeded with the study so that we can respond to future situations such as landers and budgets by planning multiple options for possible exploration mission methods.

2. Design of a control device that can be used in space environment and selection of electronic components compatible with space environment

In order to solidify the design by prototyping and testing exploration equipment capable of lunar exploration, we assumed the installation of the communication and control device of R&D theme 2, and proceeded with the implementation and evaluation of space environment tests of vibration, heat, and radiation of the control device. Regarding the control device, the hardware was completed and function confirmation and environmental tests were conducted. Regarding the development of the control circuit on the probe, we considered the installation of an evolved control device that is being researched and developed in R&D theme 2-1 and 2-2, and reflected it in the vehicle design. Prototyping of the evolved control device has been completed and operation tests have been conducted.

3. Specifications and design development of a small robot that functions in a space environment

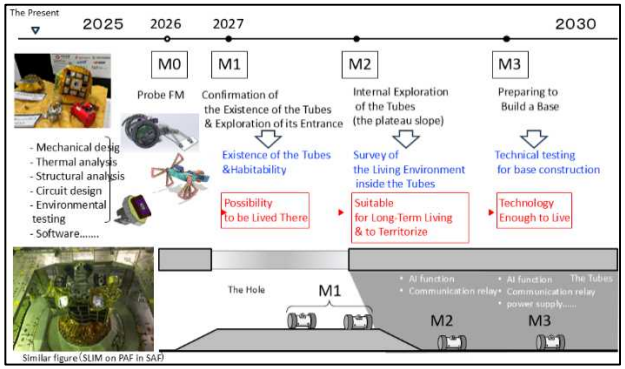
Initial considerations were conducted regarding the design of the Flight Model of the probe. Two types of aircraft designs are being carried out: an aircraft based on the prototype robot "RED" that is being mainly developed in this project, and an aircraft "LEV1 mini" that inherits the design of the small exploration robot LEV1 that was installed on SLIM, Japan's first successful lunar landing. In addition, for the newly proposed design, the basic policy is to install the proposed elements on a RED-based aircraft. In addition, for the design of the injection capsule for the small robot, we considered a design that takes into account the ability to transition to a facing posture that allows the exploration robot to be released after landing, and the ability to be deployed on the lunar surface, and carried out a prototype.

4. Design of specifications for the software installed in the small robot

In line with the contents of the mission considerations, the design of the software functions to be installed in the small robot and the ground software for operation and management were carried out based on the research results of research and development item 1. Parts of this were prototyped, and the specifications were examined by confirming them through simulations and experiments. Regarding the software to be installed, we have begun designing and developing the proposed modular, evolving functional architecture to operate as more practical software using the results of research in R&D theme 2-3 and 2-4.

## 3. Future plans

Eventually, for the small exploration robot, we will develop a flight model level aircraft, and for the insertion capsule, we will develop a prototype at the level of a ground test model.



Expected mission schedule