MULTI-BAND CAMERA ON SLIM TO INVESTIGATE Mg# OF LUNAR MANTLE MATERIALS.

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Introduction: **S**mart **L**ander for **I**nvestigating **M**oon (SLIM) project is on going in JAXA. The main objective of this project is to demonstrate various techniques for "pin-point landing" on the moon. Demonstration of SLIM landing technology enables exploration to "landing to where we want to land" from exploring "easy place to land" in gravity objects.

After landing, SLIM project is planning to observe around landing site using **M**ulti-**B**and **C**amera (MBC). The observational mission is positioned as extra success. MBC will observe olivine and estimate Mg# of it. We started manufacturing the engineering model. At next summer, we will examine whether the performance satisfied requirements and collect data for calibration in the tests.

Design of SLIM: SLIM spacecraft (Project Mnager: S. Sakai, PI: S. Sawai) is a small lander. It is designed to achieve "pin-point landing" to 100 meter-order error circle (Fig.1). In order to "pin-point landing" of this level, SLIM mission will demonstrate new image-based onboard navigation system and autonomous landing along with several other new technologies (e.g. "tow stage" landing sequence, metal shock absorbers). The SLIM spacecraft weight is ~730 kg wet mass and ~200 kg class dry mass, both of which are more lightweight than previous lunar landers [e.g. 1]. Its main engine consists of 500N-class bipropellant thruster with N_2H_4 and MON3. The spacecraft will be launched with a Japanese rocket H-IIA in 2021 or 2022. Landing on (25.2ºE, 13.3ºS) located in the west of Mare Nectaris is planned.

Table 1. SLIM spacecraft characteristics

Item	Properties
Size	~2,700 × 1,700 × 2,400 [mm]
Weight	Dry : ~200 [kg] Wet : ~730 [kg]
Main Thrusters	500 N class two liquid type × 2
Sub Thrusters	20 N class two liquid type × 12
Main sensors	navigation cameras, landing radar system, laser range finder, IMU
Communication sys.	S-band
Launch	H-IIA rocket in 2021 or 2022

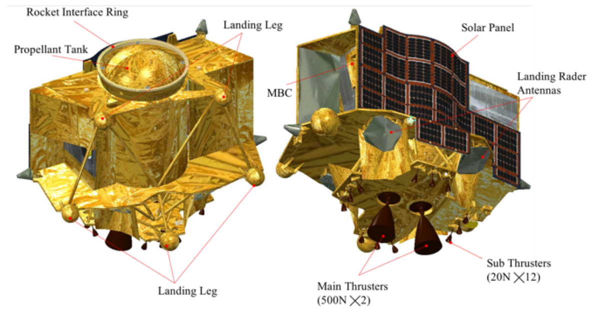

Fig.1) Design of SLIM

Design of MBC: MBC (Payload manager: M. Ohtake, Team leader: K. Saiki, Co-leader: H. Shiraishi, and Sub-leader: C. Honda) is a compact VIS-NIR camera composed of an imaging sensor (InGaAs), a filter-wheel with 10 band-pass filters, a telephoto optical system, and a movable mirror for panning and tilting (Fig.2). The sensor has sensitivity at wavelength from 700 to 1700 nm, which covers the characteristic absorption bands of lunar minerals. The housing of MBC is divided into a camera head unit (MBC-H) and an electric unit (MBC-E), which are connected with a harness cable. Table 2 summarizes the characteristics and performances of MBC.

The telephoto optical system can focus on an object from 1.5 to 30 m distance. The imaging sensor has 640 × 512 pixels with 20 µm pitch. The 4º field of view corresponds to the spatial sampling of 1.3 mm per pixel at 10 m from the lander. Using the movable mirror, observable scanning area is ~50º in azimuth and ~70º in elevation. This makes it possible to observe the size distribution of boulders around the lander. The observation wavelength of band pass filters were selected as 750, 920, 950, 970, 1000, 1050, 1100, 1250, 1550, and 1650 nm. The width of their bands is 30nm.

The simple over view of MBC operation is summarized (Fig.3). During cruise term, we are planning to take some images of the earth and the moon. After landing, the life time of MBC is only couple of days. We are going to make a panorama image using scan observational data, and survey the distribution of boulders around the landing site. Based on that information, then, we take multi-band images of boulders.

Scientific Objective of MBC: To make the best use of the pinpoint landing technique to the gravitational body to be demonstrated with SLIM, we plan to land where there is a high possibility that the mantle material is exposed based on "Kaguya" observation and estimate its Mg# (=Mg/(Mg+Fe) atomic ratio) [2]. The specification of MBC is designed to identify rock-forming mineral and rock texture around the lander. The wavelength of the band-pass filter is selected for identification of minerals such as: 920 nm, 950 nm, and 970 nm for pyroxene, 1000 nm, 1050 nm, and 1100 nm for olivine, 1250 nm for plagioclase, 1650 nm for spinel, and 750 nm and 1550 nm for continuum, respectively. 750, 950, 1000, 1050, 1250, and 1550 nm are important band to compare with previous data, such as Clementine UVVIS camera and Kaguya (SENENE) Multiband Imager [e.g. 3]. Fitting all bands with a spline function we try to detect subtle changes of peak position and shape of Fe^{2+} absorption due to change in Mg # of olivine.

References:[1] Aliberti M. (2015), Studies in Space Policy 11, 79-128., [2] Ohtake M. et al. (2019), LPSC XXXXX, submitted to this conference, [3] Ohtake M. et al. (2008), Earth Planets Space 60, 257–264.

Table 2. MBC characteristics and performance

Item	Properties
Instrument characteristics	
spectrometer	band pass filters
sensor	Vis-InGaAs imaging sensor
temperature	0ºC ~ 40ºC at the sensor
observable area	~50º in azimuth ~70º in elevation
Observation performance	
wavelength of band pass filters	750 nm, 920 nm, 950 nm, 970 nm, 1000 nm, 1050 nm, 1100 nm, 1250 nm,1550 nm, 1650 nm
band width	30 nm
field of view	4º
spatial sampling	1.3 mm/pixel at 10 m

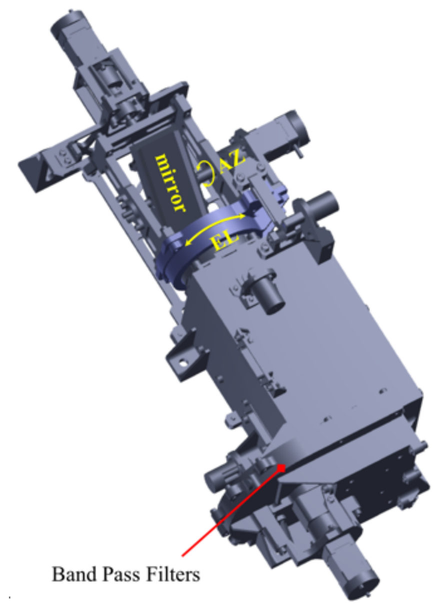

Fig.2) Design of MBC

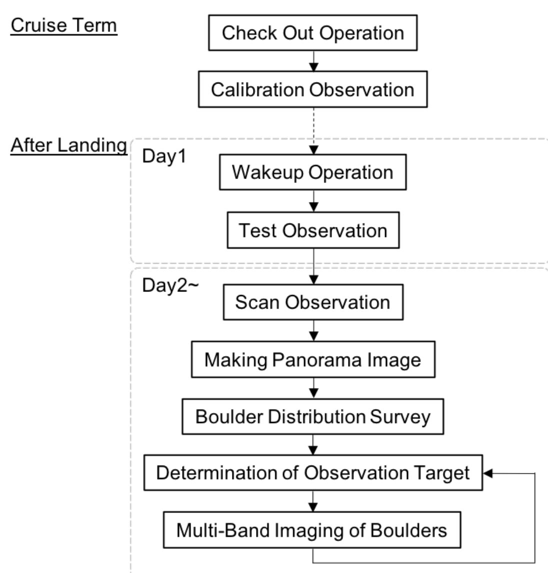

Fig.3) Over View of MBC Operation