A Ground-based Optical Calibration Plan for DESTINY$^+$ on-board Cameras, TCAP and MCAP

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DESTINY$^+$ (Demonstration and Experiment of Space Technology for INterplanetary voYage with Phaethon fLyby and dUst Science) is a flyby mission to the asteroid (3200) Phaethon, planned to be launched in 2024 [1]. The two cameras will be installed at the spacecraft; one is a telescopic camera, TCAP (Telescopic Camera for Phaethon), and the other is a multi-band camera, MCAP (Multi-band Camera for Phaethon). The scientific goals using the cameras are (1) Obtaining the global shape of Phaethon; the contour and the light curve, (2) Obtaining the semi global features of Phaethon; Observation of the 3-D shape, (3) Obtaining the local features of Phaethon; topography of the surface such as dust ejection, (4) Observing the material distribution on Phaethon [2]. In order to achieve these goals the characteristics of the imaging data taken by the cameras should be correctly understood, and it is necessary to construct the way of the accurate optical calibration so as to extract scientifically valuable data from raw image data.

We listed the radiometric and geometric calibration tests for the optical systems and the image sensors of the cameras needed for achieving the goals. The measurement items of the optical calibration tests are followings: Dark current, bias, hot pixel, linearity, accuracy of conversion gain, dead pixel, flat field correction, sensitivity, point-spread function (PSF), distortion correction, confirming field of view (FOV), instantaneous field of view (IFOV), stray light. In addition to these common measurement items for a camera on spacecraft, full well capacities of the CMOS image sensors used in TCAP and MCAP, must be evaluated at different irradiation conditions because it is found that they depend on incident light flux and temperature of the sensors [3].

We first plan to conduct the following calibration tests using only the image sensors (or the image sensors equipped to the boards without the optical instruments such as lens). The dark current, bias, hot pixel, linearity, accuracy of conversion gain, dead pixel, full well capacity, and temperature dependencies on them will be evaluated. The calibration data of the Engineering Model (EM) and Proto Flight Model (PFM) of the cameras pertaining to the flat field, sensitivity, out-of-field stray light will be planned to be obtained by using the integrating sphere at JAXA/EORC and those pertaining to the PSF, distortion, FOV, IFOV, in-field stray light will be obtained by using the collimated light. These tests are basically conducted under atmospheric pressure at room temperature , which is around nominal temperature of the sensors during the flyby. On the other hand, computational simulations will be also planned to be performed in order to understand the temperature and ambient pressure dependencies on those calibration data. It will help for calibrations if the temperature of the sensors does not keep the nominal temperature. The detailed optical calibration methods and preliminary results of the characteristics of the sensors will be reported in the presentation.

References: [1] Arai, T. et al., (2021), LPSC 52, Abstract #1896. [2] Ishibashi, K. et al., (2021), LPSC 52, Abstract #1405. [3] Ishimaru, T. et al., (2019) Proceedings of the Space Sciences and Technology Conference 63, 3M06.

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