Ground test plan of the Tracking Mirror on TCAP onboard DESTINY^{+}

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Demonstration and Experiment of Space Technology for Interplanetary voYage with Phaethon fLyby and dUst Science (DESTINY^{+}) mission will conduct a flyby-observation at asteroid Phaethon. This observation requires a tracking mirror for the Telescopic CAmera for Phaethon (TCAP) because of its higher relative angular velocity than previous small body flyby missions, which provides a difficulty to track the target only by spacecraft's attitude control. The tracking mirror should keep Phaethon's sunlit area in the field of view during the closest approach to the asteroid and obtain images without motion-blur during the exposure. Based on the science requirements, we have determined the pointing accuracy and pointing stability requirements for the tracking mirror through the error distribution analysis, including the spacecraft system and TCAP. The tracking mirror is a one-axis system composed of a step motor with a micro-stepping driver, reducer (Harmonic Drive), mirror, zero-point detection system, and mechanical stopper. We have manufactured a breadboard model of the actuator (BBM) and have evaluated its rotational performances to establish experimental methods for correctly evaluating the tracking mirror. We have shown that the pointing accuracies, pointing stabilities, and angular reproducibility of the BBM generally meet the requirements for the tracking mirror. In order to evaluate the tracking mirror's performances under mechanical configurations closer to the flight model, we plan to manufacture another breadboard model (BBM3) before the development of the engineering model (EM). Compared to BBM, the mechanical design and components of BBM3 will be almost identical to EM. A mass dummy equivalent to the mass of the mirror will be installed to the BBM3, and vibration tests will be conducted to evaluate the mechanical vibration characteristics. A prototype of the zero-point detection mechanism is also planned to be developed and evaluated. The zero-point can be determined by measuring the change in intensity of light emitted from LED diffracted through the slit with a photosensor. In addition to the zero-point, slits are installed every 45° between 0° and 180° for reference angle measurement. Pointing accuracies and stabilities of BBM3 will be measured by several methods depending on the test phases to ensure the robustness of the tests: (1) a calibrated polygon mirror along with an autocollimator to measure the static pointing accuracies, angular reproducibility, and zero-point accuracy, (2) a calibrated high-precision encoder for the evaluation of pointing accuracies over a wide range of angles, (3) the zero-point detection mechanism to measure angles discretely, which can detect angles at every 45 degrees based on the photocurrent and number of motor steps, (4) a laser-doppler velocimeter to measure pointing stabilities, and (5) a resolver to detect actuator's angle after the installation of the mirror. Based on these ground tests, the tracking performances of the TCAP tracking mirror will be extensively measured to ensure the successful flyby observation of Phaethon. We will also report the ground tests for EM and end-to-end tracking tests including TCAP optics by feeding back the target positions calculated by the captured images.

Keywords: DESTINY+, camera, tracking mirror

