

## Development status of DESTINY<sup>+</sup> onboard cameras TCAP and MCAP

\*Ko Ishibashi<sup>1</sup>, Peng Hong<sup>1</sup>, Takaya Okamoto<sup>2</sup>, Takahiro Ishimaru<sup>2</sup>, Manabu Yamada<sup>1</sup>, Naoya Ozaki<sup>2</sup>, Takayuki Hosonuma<sup>3</sup>, Shunsuke Sato<sup>2</sup>, Osamu Okudaira<sup>1</sup>, Tomoko Arai<sup>1</sup>, Fumi Yoshida<sup>1,4</sup>, Masato Kagitani<sup>5</sup>, Shingo Kameda<sup>6</sup>, Takeshi Miyabara<sup>2</sup>, Masayuki Ohta<sup>2</sup>, Takeshi Takashima<sup>2</sup>

1. Chiba Institute of Technology, 2. Japan Aerospace Exploration Agency, 3. The University of Tokyo, 4. University of Occupational and Environmental Health, 5. Tohoku University, 6. Rikkyo University

DESTINY<sup>+</sup> (Demonstration and Experiment of Space Technology for INterplanetary voYage with Phaethon fly-by and dUst Science) is a mission proposed for JAXA/ISAS Epsilon class small program, scheduled to be launched in 2024 [1]. The flyby target of the DESTINY<sup>+</sup> mission is the near-Earth asteroid (3200) Phaethon, which is known as an active asteroid and a parent body of the Geminid meteor shower. The size of (3200) Phaethon is 5 to 6 km in diameter. The spacecraft will flyby (3200) Phaethon with a distance of  $500 \pm 50$  km at the closest approach and relative speeds of  $\sim 35$  km/s. In this mission, spatially resolved images of (3200) Phaethon will be taken by two onboard cameras, the Telescopic CAmera for Phaethon (TCAP) and the Multiband CAmera for Phaethon (MCAP). These observations would help understand the nature of a meteor shower's parent body, one of the sources of interplanetary dust particles that are thought to be an important transport medium of organic matter to the Earth.

TCAP is a panchromatic camera that observes the global shape, the semi-global features, and local surface features of (3200) Phaethon. To achieve those observations TCAP has a tracking mirror that can change the boresight of TCAP and can keep (3200) Phaethon in the field of view (FOV) of TCAP all the time during the flyby. The focal length, aperture, FOV, and IFOV (FOV per pixel) of TCAP are 790 mm,  $\phi$  114 mm,  $0.82 \text{ deg} \times 0.82 \text{ deg}$ , and  $7.0 \mu\text{rad/pixel}$ , respectively. TCAP also plays the role of the optical navigation camera for the flyby observation. The specifications above are required for both the scientific imaging and for achieving the flyby imaging sequence.

MCAP is a multiband camera, the wavelengths of which are 425, 550, 700, 850 nm. The focal length, aperture, FOV, and IFOV are 100 mm,  $\phi$  21 mm,  $6.5 \text{ deg} \times 6.5 \text{ deg}$ , and  $55 \mu\text{rad/pixel}$ , respectively, for all the bands. MCAP has multiple optical systems and sensors to take all band images simultaneously. We are considering a branching optical system for MCAP, which separates incident light into two imaging sensors using a dichroic prism. Thus, four bands can be covered with two branching optical systems. MCAP does not have a tracking mirror because of a strict weight limitation and will take images at the solar phase angles of around 10 deg, where the amount of the reflected light is enough to achieve high signal-to-noise ratios.

The observation for searching (3200) Phaethon will start 30 days before the encounter. We estimated the time of detection of (3200) Phaethon using the phase curve of (3200) Phaethon obtained by ground observation, and (3200) Phaethon will be detected by TCAP at least ten days before or earlier the encounter. The optical navigation using TCAP images to estimate relative trajectory will be conducted 5 to 2.5 days before the encounter. Then, the images of (3200) Phaethon will be taken around the closest approach for scientific objectives. Since the angular velocity at the closest approach is around 4 deg/s, which is too high to track by spacecraft attitude control only, the tracking mirror is required.

High pointing accuracy and pointing stability are required to keep the asteroid in the FOV of TCAP and image the asteroid without motion blur. We set the pointing accuracy requirement to  $\leq 0.05 \text{ deg}$  ( $1 \sigma$ ) and

$\leq 0.067$  deg ( $1 \sigma$ ) for the horizontal and vertical directions, respectively. The pointing stability requirement during 0.3 msec, the nominal exposure time of TCAP, is set to  $\leq 4 \times 10^{-4}$  deg/0.3 msec ( $1 \sigma$ ), which corresponds to 1 pixel. The main error sources in TCAP include the tracking mirror motion [2] and the alignment among the telescope's boresight, the rotational axis of the tracking mirror, and the direction of the mirror. We have been evaluating those errors, and the preliminary results show that the requirements are satisfied.

References: [1] Arai, T. et al. (2020) *LPS LII*, Abstract #1896. [2] Hong, P. et al. (2020) *LPS LII*, Abstract #1741.

Keywords: DESTINY+, (3200) Phaethon, Camera, Flyby imaging