TELESCOPIC CAMERA FOR PHAETHON (TCAP) AND MULTIBAND CAMERA FOR PHAETHON (MCAP) TO BE INSTALLED ON THE DESTINY+ SPACECRAFT. K. Ishibashi[1], S. Kameda[2], M. Kagitani[3], M. Yamada[1], O. Okudaira[1], T. Okamoto[1], T. Arai[1], F. Yoshida[1], T. Ishimaru[4], S. Sato[4], T. Takashima[4], T, Iwata[4], and T. Okada[4], [1]Chiba Institute of Technology, 2-17-1 Tsudanuma, Narashino-shi, Chiba 275-0016, Japan, [2]Rikkyo University, 3-34-1 Nishi-Ikebukuro, Toshima-ku, Tokyo 171-8501, Japan, [3]Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai, Miyagi 980-8577, Japan, [4]Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Chuo-ku, Sagamihara, Kanagawa 252-5210, Japan.

Introduction: An asteroid flyby mission DESTINY+ has been proposed in Japan [1]. DESTINY+ will be launched in 2022, and will flyby the asteroid 3200 Phaethon in 2026. Phaethon is known as a parent body of the Geminids meteor shower [e.g., 2], the size of which is approximately 5 km in diameter. Spatially resolved images of Phaethon will be taken by two onboard cameras, the Telescopic CAmera for Phaethon (TCAP) and the Multiband CAmera for Phaethon (MCAP), in order to understand the nature of a parent body of a meteor shower, which is an important source of dust delivered to the Earth. The relative flyby speed is as high as 33 km/s and the distance at the closest approach is approximately 500 km. Despite such a high flyby speed, the cameras are required to take unblurred images of Phaethon. We have carried out conceptual studies of the cameras, and conceptual designs of those cameras have been made.

Objectives of Camera Ovservation: Phaethon will be observed by the onboard cameras to understand the nature of a parent body of a meteor shower, and in particular constrain the dust ejection mechanisms from it. The specific objectives of the camera observation are taking images for (1) obtaining the light curve of Phaethon in order to estimate the rotational period, (2) measuring the outline shape of Phaeton, (3) making a 3D shape model of Phaethon, (4) observing the surface geological features of Phaethon including dust ejection features, and (5) observing the surface material distribution of Phaethon. The observations (1) to (4) will be conducted by TCAP, and (5) by MCAP.

Requirements for the Cameras: An asteroid-tracking function is desired for both the cameras in order to observe Phaethon in a wide range of solar phase angles during flyby. A strict weight limitation, however, requires having a tracking mirror on TCAP only and not MCAP. For the objectives mentioned above, TCAP requires a spatial resolution (a FOV per pixel) of ≤10 μrad/pixel, which corresponds to 10 m/pixel at 1000 km and 5 m/pixel at 500 km (i.e. at the closest approach), a field of view of ≥1 deg for imaging the full view of Phaethon even at the closest approach, and a signal to noise ratio (SNR) of ≥20 for observing the surface features clearly. We do not know what the dust ejection features on active asteroids look like; their shapes and scales are unknown. With the spatial resolution of ≤10 m/pixel, however, TCAP is able to identify at least the dust ejection features found on the comet Churyumov-Gerasimenko, which are pits ranging from 50 m to 300 m across [3]. MCAP requires bands of 400, 550, 700, and 850 nm as nominal bands, and 480 and 950 nm as optional bands with SNRs of 30, 50, 30, 30, 30, and 20, respectively, to measure the shapes and slopes of the spectra of Phaethon. A spatial resolution (a FOV per pixel) of ≤100 μrad/pixel, and a relatively wide field of view, ≥10 deg, is required for observing Phaethon even without tracking. MCAP requires simultaneous imaging for all bands in order to take multiband images of a high-speed moving target.

Telescopic CAamera for Phaethon (TCAP): TCAP is a telescopic panchromatic camera having a rotational mirror for asteroid tracking. The specifica-

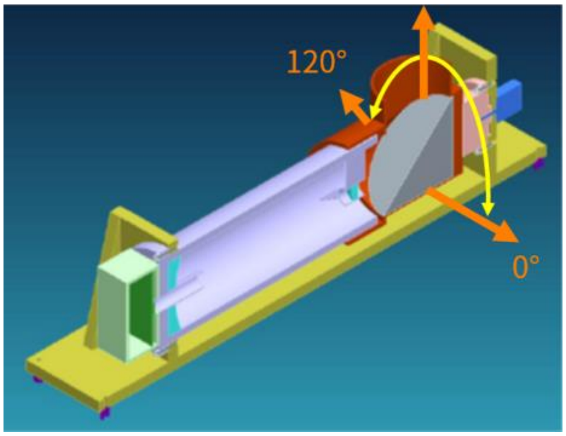

Figure 1. Schematic illustration of TCAP (cross-section).

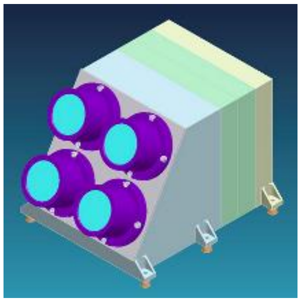

Figure 2. Schematic illustration of MCAP (4 bands).

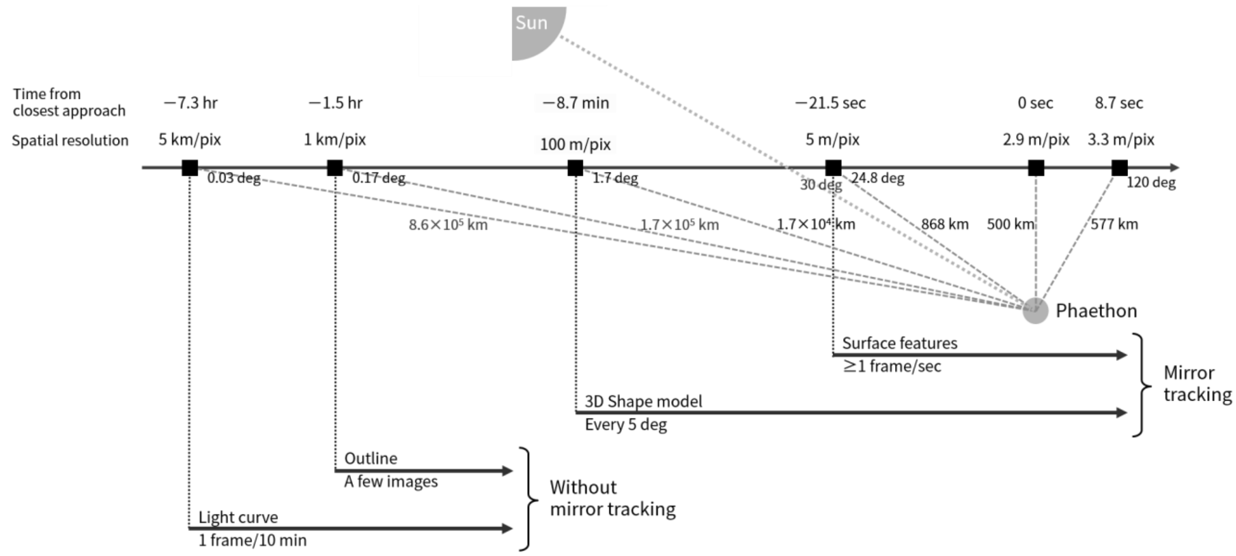

Figure 3. Flyby imaging sequence of TCAP. The direction of line of sight of TCAP is changed by the tracking mirror.

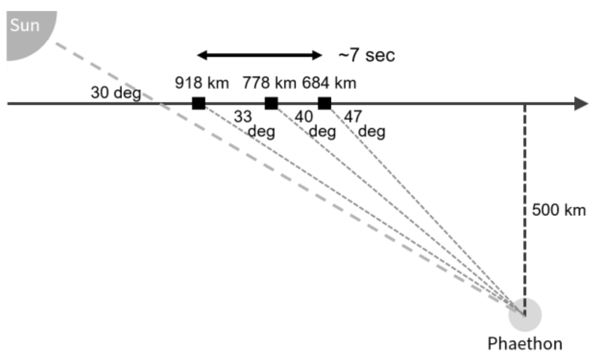

Figure 4. Flyby imaging sequence of MCAP. The line of sight of MCAP is fixed to the space craft with a tilt of 40 deg off the velocity voctor.

tions obtained by the conceptual study so far are as follows: The focal length, aperture, field of view, and FOV per pixel are 950 mm, φ120 mm, 1.1 deg × 0.82 deg, and 5.8 μrad/pixel, respectively. The schematic illustration of TCAP is shown in Figure 1. The rotational mirror can change the direction of the line of sight from 0 deg to 120 deg.

Multiband CAmera for Phaethon (MCAP): The focal length, aperture, field of view, and FOV per pixel are 55 mm, φ21.15 mm, 18.9 deg × 14.2 deg, and 100 μrad/pixel, respectively, for all bands. Since MCAP can not have a tracking mirror because of the weight limitation, the line of sight of MCAP is fixed to the spacecraft. The schematic illustration of MCAP is shown in Figure 2. MCAP has multiple optics and sensors for each band for simultaneous multiband imaging.

Flyby Imaging Sequence: The Flyby imaging Sequence of TCAP is shown in Figure 3. The imaging for the light curve observation starts 7.3 hours prior to the closest approach with a frame rate of 1 frame per 10 minutes, which also covers the outline shape observation. The observation for the 3D shape model starts 9 minutes prior to the closest approach. The observation of surface features on Phaethon is carried out from 20 seconds before to 10 seconds after the closest approach. Figure 4 shows the imaging sequence of MCAP. MCAP observation is carried out for 5 to 10 seconds at a distance less than 1000 km when Phaethon is in the field of view of MCAP.

Summary: The two onboard cameras for the DESTINY$^+$ mission for high spatial resolution imaging and multiband imaging of Phaethon have been studied, and their conceptual designs were obtained. In the next phase, we will refine the design of both the cameras and go into their detailed designs.

References: [1] Arai T. et al. (2018) *LPSC XLIX*, submitted. [2] Williams I. P. and Wu Z. (1993) *Mon. Not. R. Astron. Soc. 262*, 231-248. [3] Vincent J.-B. et al. (2015), *Nature 523*, 63-66.