Double Asteroid Redirection Test (DART) Planetary Defense Mission: First Months in Flight and Readiness for Impact. E. Adams[1], E. Smith[2], Z. Fletcher[3], D. O'Shaughnessy[4], B. Tropf[5], K. Volland[6], L. Roufberg[7], P.Huang[8], J.John[9], E.Abel[10], G. Ottman[11], P.Harrington-Duff[12], J. Atchison[13], J. Bellerose[14], R. Harvey[15], E. Reynolds[16], A. Cheng[17], A.Rivkin[18], N. Chabot[19]

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Introduction: DART is a Class C mission that is managed by JHU/APL for the NASA Planetary Defense Coordination Office. It is the first space mission to demonstrate and measure asteroid kinetic deflection. DART's target, the binary asteroid system Didymos (65803), makes a close approach to Earth in the fall of 2022.

The DART spacecraft launched from the Vandenberg Space Force Base on November 24, 2021 atop a SpaceX Falcon 9 rocket. After a successful month of commissioning, the DART spacecraft has entered its cruise phase. Later this year, on September 26 2022, the DART spacecraft will impact the secondary member of the Didymos system, Dimorphos, and alter its binary orbit period with respect to the primary. Dimorphos is an ideal target because it is similarly sized to Near Earth Objects that are potentially hazardous to Earth. The spacecraft impacts at approximately 6.1 km/s and impart an orbit period change to Dimorphos that is measurable by Earth-based observers within weeks of impact [1, 2]. Approximately ten days prior to arrival, DART releases the Light Italian Cubesat for Imaging of Asteroids (LICIACube), a 6U CubeSat managed by the Italian Space Agency (ASI). LICIACube flies by the asteroid after the DART impact and image Dimorphos shape and resulting ejecta from the impact [3].

Payload: DART relies on Small-body Maneuvering Autonomous Real-Time Navigation (SMART Nav) to enable the impact with Dimorphos. This collection of firmware and software leverages heritage algorithms to enable the autonomous closed-loop guidance necessary to ensure the hypervelocity impact [4].

In the final hours of the mission, SMART Nav uses Didymos Reconnaissance and Asteroid Camera for Optical navigation (DRACO) images to determine the relative location of the target and autonomously commands maneuvers to impact Dimorphos. DRACO's telescope characteristics are described in Table-1. The camera also acquires OpNav images earlier in the mission [5].

Aperture	208 mm
F Number	f/12.6
Wavelength	400 nm – 1000 nm
FOV	0.29° full angle
IFOV	2.5 µrad, 4.9 µrad (binned)
PSD* (300 km)	1.0 m
PSD* (150 km)	0.5 m
PSD* (30 km)	0.1 m
SNR (30 days)	>7
SNR (final)	>100

Table-1 DRACO instrument characteristics.

The DRACO instrument successfully completed commissioning, opened its cover (see Fig-1), and successfully demonstrated the ability to continuously stream images to Earth. The first of the multiple optical calibrations was performed on M38 cluster. Additional tests are conducted periodically in cruise, including a test of SMARTNav with the Jovian Moons.

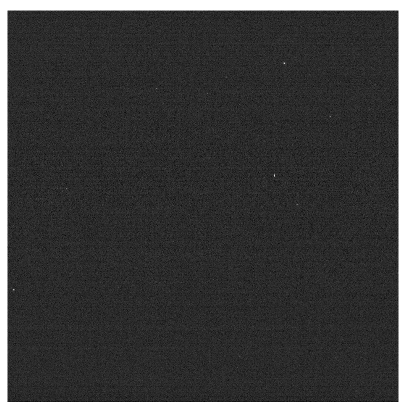

Figure-1 First light image for DRACO.

Technology Demonstrations: DART demonstrates a number of technologies as a part of its mission [6]. The DART spacecraft is the first demonstration of the NASA Evolutionary Xenon Thruster Commercial (NEXT-C) engine. NEXT-C engine is a gridded ion propulsion system, which electrically accelerates xenon to a high velocity. NEXT-C was successfully operated during commissioning, and is used for additional propulsion activities later in the mission.

To generate the necessary power for the ion propulsion system, DART relies on Roll-Out Solar Arrays (ROSA), which had previously only been flown on the International Space Station. The solar arrays autonomously deployed after spacecraft separation, and are performing nominally. In addition, DART carries the NASA Transformational Solar Array demonstration, which reflects additional sunlight onto a series of solar cells via reflective concentrators. During initial on-orbit characterization the transformational solar array produced unexpected, anomalously low cell voltages. The team is in the process of troubleshooting this technology demonstration.

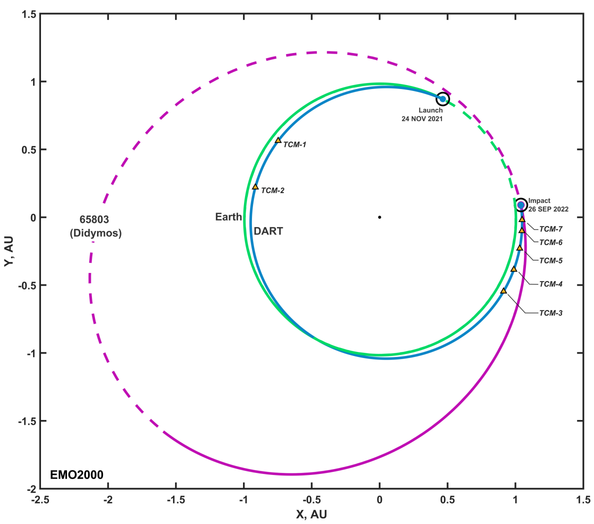

Figure-2 DART trajectory to Dimorphos

Approach and Terminal Phases: Spacecraft trajectory and mission design is showed in Fig- 2. The last thirty days prior to impact are packed with activities. DART acquires OpNav images every five hours enabling ground-based navigation to Didymos, and even more often in the last day prior to end of mission. The ground -based navigation ends approximately twelve hours prior to impact. Trajectory correction maneuvers are performed, and LICIACube will be released. DART will acquire multiple asteroid images to construct a light curve on the approach to Didymos that will help confirm the phasing of Dimorphos. The mission operations team will rehearse the transition and execution of the autonomous terminal phase (last four hours of the mission).

DART impact occurs at 0.076AU from Earth, with the solar phase angle of approximately 60°. As DART spacecraft closes in on its target, the images of Dimorphos and the impact site are streamed real- time to Earth.

During the impact period, Didymos is at roughly visual magnitude of 14-15 as viewed from Earth. At this brightness, ground-based telescopes as small as 1 meter in aperture are able to obtain useful data. A number of telescopes are under contract to perform these observations. The current orbit period of Dimorphos is 11.92 hours, providing two daily observation opportunities at each ground telescope. The placement of the large telescopes is such that all orbit phases are covered by at least one telescope per 24 hours. The mission ends once the data is analyzed and the Dimorphos period change is confirmed.

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References:

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