**Positioning for Intercept: DART’s Approach and Terminal Phases**

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Asteroid impacts pose a well-established risk to humanity (Clemens M. Rumpf 2017). Numerous strategies for mitigating this risk have been proposed, including a kinetic deflector which uses the momentum of a spacecraft to alter the trajectory of a hazardous asteroid by colliding with the asteroid (Yamaguchi 2018). The Double Asteroid Redirect Test (DART) mission is funded by NASA’s Planetary Defense Coordination Office and will serve as the first flight demonstration of the kinetic impactor technique at realistic scales. DART is designed, built, and operated by the Johns Hopkins University - Applied Physics Laboratory.

The DART mission has selected the Didymos binary asteroid system to demonstrate the asteroid deflection. Didymos is ideal for this demonstration as the binary system provides better resolution on understanding the momentum delivered via the kinetic deflector (Stickle 2020). Understanding the momentum change in the asteroid is key to demonstrating the efficacy of the mitigation technique. Additionally, the ~160 m secondary member of the system, called Dimorphos, is ideally sized for demonstrating kinetic deflection.

The primary mission goal of DART is to intercept Dimorphos in late September 2022. This intercept will occur at ~6.6 km/s, and the resultant effect on the Didymos system will be observed by ground- and space-based assets (Adams 2019). Key to ensuring this intercept occurs as planned is the final 30 days of the mission, termed the Approach and Terminal Phases.

The Approach Phase for DART begins when the Didymos system can first be detected by the DART telescope, approximately 30 days prior to impact. This phase has three main objectives. The primary objective is for the spacecraft to use its telescope to obtain optical navigation imagery, and combined with ground-processing of these images, refine the trajectory to position DART for intercept with a series of trajectory correction maneuvers. The Approach Phase also provides an opportunity for a scientific investigation of the Didymos system to begin, as DART plans to take multiple lightcurve observations of the asteroid system. Finally, DART will also deploy a hosted CubeSat, the Light Italian Cubesat for Imaging of Asteroids (LICACube), provided by the Italian Space Agency (ASI). LICIACube will perform a close flyby of Didymos, and image the resulting ejecta plume that DART creates upon impact.

The Terminal Phase of the DART mission begins ~4 hrs from impact, when the navigation of the spacecraft transitions from ground-based to an onboard autonomous approach. DART uses the Small-body Maneuvering Autonomous Real-Time Navigation (SMART Nav) system to perform this final phase. In this phase, the attitude and trajectory control loops are closed with a continuous 1-Hz stream of imagery from the onboard telescope. SMART Nav initially guides to Didymos, until ~60 minutes from impact when it discerns and transitions to guiding spacecraft to Dimorphos. Trajectory changes are allowed until ~2 minutes from impact, at which point the use of thrusters is minimized to ensure that high-resolution imagery of Dimorphos can be captured. These images are streamed down to the ground using the spacecraft high-gain antenna throughout this period, providing investigators critical data on the surface topography of the impact site, thereby improving understanding of the resulting ejecta cloud and attendant momentum transfer.

# References

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