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TRAJECTORY OPTIONS FOR THE DART MISSION

Abstract

The Double Asteroid Redirection Test (DART) will be the first space experiment to demonstrate asteroid impact hazard mitigation by using a kinetic impactor to deflect an asteroid. DART is the interceptor element of the Asteroid Impact Deflection Assessment mission (AIDA), a joint NASA-ESA mission which also includes the ESA Asteroid Impact Monitor (AIM) rendezvous mission. The primary goal of AIDA is to measure and characterize the deflection of an asteroid by a kinetic impactor. The results will have implications for planetary defense, human spaceflight, and Near-Earth Object science and resource utilization.

The mission design for the impactor, DART, is required to target the companion satellite in the Apollo binary asteroid system Didymos under conditions favorable for measuring asteroid deflection by ground-based observations. This study assesses the available trajectory options for DART, including risk mitigation activities such as backup launch options, opportunistic practice flybys, and second impact opportunities. In addition, we evaluate the possibility of launching both spacecraft with the same launch vehicle, and explore electric-propulsion options.

The baseline trajectory for DART is a simple Lambert arc departing Earth in December 2020, completing 1.5 heliocentric orbits prior to impacting Didymos on October 1, 2022. The launch date and energy are driven by the relative inclination of Earth and Didymos. This trajectory offers favorable arrival orientation and lighting, and has a declination of launch asymptote consistent with launch from the Wallops Flight Facility. Backup launch opportunities occur roughly every six months, consistent with the Earth-Didymos relative plane crossings.

The baseline trajectory meets all the constraints. At least one opportunistic flyby is available, the Near Earth Object 2004 FX31 in March 2021. This target can be easily accommodated by shifting the launch date and adding a deep-space-maneuver shortly after flyby. Doing so would represent an opportunity to test the terminal guidance algorithms, albeit without implementing the computed thrust commands. Additionally, opportunities exist for second impacts, in the event that the spacecraft doesn't successfully impact on the nominal date. These opportunities require a deep space maneuver to target a subsequent Earth flyby, which changes the period of the spacecraft to enable the second arrival one Didymos orbit later.

Given that both DART and AIM require a similarly inclined orbit, we explore options that enable both spacecraft to launch on the same vehicle. Finally, given DART's low launch energy, we explore options for electric propulsion, initiated from a geostationary transfer orbit.