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NASA's Double Asteroid Redirection Test (DART) Phase C Trajectory Analysis

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NASA's Double Asteroid Redirection Test is designed to be the first mission to demonstrate asteroid kinetic deflection. The spacecraft will impact the smaller member of the binary asteroid system Didymos near perihelion in September-October 2022 (Figure 1). This conjunction represents a rare opportunity when Earth is near enough to Didymos (0.07 AU) for ground based observations of the impact event and the resultant change in light-curve data.

Throughout its development cycle, the mission has evaluated a variety of mission concepts to achieve this impact. DART is currently in Phase-C. The spacecraft design now incorporates a commercial variant of NASA's Evolutionary Xenon Thruster (NEXT-C). DART is the first flight demonstration of NEXT-C and will operate at a fixed power level of roughly 3.4 kW. DART uses NEXT-C to adjust its heliocentric trajectory to achieve an asteroid flyby and tailor the arrival geometry at Didymos. Monopropellant hydrazine thrusters are used to perform statistical correction maneuvers to target the asteroid flyby and Didymos impact, including autonomous terminal guidance in the final hours of operation.

The low thrust trajectory is designed with a set of boundary constraints at launch (energy and escape direction) and impact (geometry, lighting, and timing). There are also path constraints (fixed throttle thrusting and Sun-thruster angle keep-out-zones). The problem is formulated using collocation points, with an objective that minimizes the deterministic xenon required to achieve a feasible trajectory.

This paper will provide the most recent trajectory design for DART and describe the driving studies, including: flyby asteroid selection, propellant margins, launch window analysis, and trajectory recovery opportunities.

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Figure 1: Artist's depiction of the DART impact encounter. DART uses an ion engine to modify its trajectory towards the impact. A cubesat is deployed shortly prior to impact to achieve short-range post-impact imagery of the system. The impact and resultant binary system change is observed from Earth based telescopes.