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DOUBLE ASTEROID REDIRECTION TEST (DART) MISSION DESIGN AND NAVIGATION FOR LOW ENERGY ESCAPE

Abstract

The NASA Double Asteroid Redirection Test (DART) mission is first mission to demonstrate asteroid kinetic deflection. The spacecraft will use terminal guidance to impact the smaller member of the Didymos binary asteroid system during its rare 2022 conjunction passes within 0.07 AU of Earth. Earth based observations of the change in light-curve then provide a measurement of the imparted change in period.

The mission design has evolved through three concepts. Initially DART was conceived as a monopropellant hydrazine bus that would achieve its heliocentric transfer predominantly from a dedicated launch vehicle. This approach has an asymmetry in the cost of the launch vehicle versus the cost of the spacecraft bus and operations.

Following a formal trade-study, the mission opted to utilize the commercial variant of the NASA Evolutionary Xenon Thruster (NEXT-C). In this instantiation, DART is launched as a ride-share with a geostationary satellite. Here, DART spirals away from Earth from a geostationary transfer orbit (GTO), conducts a flyby of a potentially hazardous asteroid, and impacts Didymos with the requisite arrival conditions. This approach offers cost savings and trajectory flexibility. However, for the selected flight system, the Earth escape requires 9 months. This duration dominates the xenon budget and limits the latest launch date, which is essential for maximizing schedule margin.

The current DART trajectory concept is still a ride-share with the NEXT-C engine. Now, the launch vehicle releases DART to a low energy Earth escape. This is achieved by partnering with missions with excess launch vehicle capacity, or by procuring an additional launch vehicle solid rocket booster. The launch vehicle ascent is optimized to deliver the primary satellite into its operational orbit, and then restart its upper stage to achieve a low energy escape. With the launch vehicle removing the need for an Earth escape spiral, the mission schedule has greater flexibility.

This paper will discuss the key studies associated with these transfers and focus on driving analysis associated with the baseline low energy escape case. For example, the selection of the escape energy drives the satellite checkout duration and orbit debris compliance. The escape direction is unconstrained on a unit sphere, so the spacecraft must be capable of recovering from inefficient directions. The navigation approach must account for sensitive regions in the trajectory and plan for both low-thrust and chemical phases of flight. These findings are relevant to other missions pursuing low-cost interplanetary ride-share.