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Double Asteroid Redirection Test: Technology and Engineering Challenges

Elena Adams, JHU/APL, USA, elena.adams@jhuapl.edu
Daniel O'Shaughnessy, JHU/APL, USA, daniel.oshaughnessy@jhuapl.edu
Michelle Chen, JHU/APL, USA, michelle.chen@jhuapl.edu
Jeremy John, JHU/APL, USA, jeremy.john@jhuapl.edu
Daniel Gallagher, JHU/APL, USA, daniel.gallagher@jhuapl.edu
David Carrelli, JHU/APL, USA, david.carrelli@jhuapl.edu
Cheryl L. B. Reed, JHU/APL, USA, cheryl.reed@jhuapl.edu

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ABSTRACT

The NASA Double Asteroid Redirection Test (DART) is a technology demonstration mission that will impact the binary near-Earth asteroid system, Didymos. Didymos is an ideal target to demonstrate the kinetic impactor technique, since the 780 m primary, Didymos A, is well characterized, and the 163 m secondary, Didymos B, is sufficiently small to allow measurement of the kinetic deflection. Didymos is also important as it is a member of Near Earth Objects; these asteroids are those that are most likely to pose a near-term threat to Earth. DART will launch in June 2021, leading to an autonomous intercept with Didymos B in October 2022, altering the orbit period of Didymos B with respect to Didymos A. The orbit period change of Didymos B will be measured and provide a better understanding of the momentum change possible via kinetic impact. The impact occurs when the Earth-Didymos range is sufficiently small to allow observation by Earth-based assets. The spacecraft will be guided to the impact by its on-board autonomous real-time system: Small-body Maneuvering Autonomous Real-Time Navigation (SMART Nav). In addition, DART will carry a 6U

CubeSat contribution provided by Agenzia Spaziale Italiana (ASI). The CubeSat will be deployed shortly (days or hours) before the DART impact, and will be placed on a trajectory that follows DART toward the Didymos system, thereby allowing observation of the impact. The CubeSat will autonomously acquire and track Didymos B throughout the impact, providing imagery of the impact and resulting ejecta plume. DART is currently in Phase C, with mission Critical Design Review (CDR) planned for summer 2019.

It is a substantial challenge to navigate the DART spacecraft to a hypervelocity impact with the Didymos secondary. The DART spacecraft will provide the first flight demonstration of the NASA Evolutionary Xenon Thruster Commercial (NEXT-C) ion propulsion system; this engine offers a wide range of launch opportunitiesthat achieve the desired Didymos arrival conditions, helping to provide the program schedule margin without changes to the vehicle design. The trajectory is designed to maximize the asteroid deflection (with an arrival velocity of 6 km/s relative to Didymos-B), while maintaining a proximity to Earth that allows both observation of the impact, and sufficient communication gain to recover imagery of the target upon the approach. Additionally, NEXT-C provides the DART mission numerous opportunities to fly by another asteroid, allowing characterization of SMART Nav performance many months prior to its use for the Didymos impact. The DART spacecraft will carry 22 m^2 solar arrays that generate ~3.5 kW of power for the NEXT-C engine, but the long arrays introduce substantial flexible body motion to the spacecraft. This motion must be managed carefully to maintain the DART narrow angle camera on the target asteroid, particularly while performing the necessary ΔV maneuvers required to ensure target intercept. SMART Nav targets Didymos A until late in the approach, as the size and orbit of Didymos B prevent resolution of the secondary by the narrow angle camera until ~1 hour prior to impact. Furthermore, shadowing of both primary and secondary set by arrival lighting, as well as rotational effects on the imagery will make it challenging to impact the center of Didymos B.