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Ongoing and Upcoming Mission Highlights - DART

The Double Asteroid Redirection Test (DART): Navigating to Obliteration

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ABSTRACT

The Double Asteroid Redirection Test (DART) is NASA's demonstration of an asteroid deflection using a kinetic impactor. The spacecraft launched aboard a SpaceX's Falcon 9 on November 24th 2021, on a direct collision with the binary asteroid system Didymos planned for September 26th 2022. By impacting the small moon, Dimorphos, DART's objective was to alter the moon's orbit about the larger asteroid by several minutes. With post-impact observations, Earth-based and space-based telescopes were able to confirm an orbit's change of about 32 minutes.

The navigation of a ballistic mission is usually relatively simple. After the rocket launches it on its trajectory, the remaining task is to keep the spacecraft on the correct reference trajectory by using clean up maneuvers along the way, and meet final requirements. Other than heading to a violent demise, this mission had a number of unconventional aspects which gave the navigation team interesting challenges: a tight propellant budget for part of the mission, no reaction wheels which resulted in a noisy spacecraft with the Nav team having to rely heavily on Delta Differential One-way Ranging measurements to identify off line-of-sight delta-V, and critical operations in the last 30 days of the mission under a new thrusting control mode regime. Optical navigation was a critical element in the success of this mission, supporting testing of the SMARTNAV system and, especially, contributing to the determination of the spacecraft and target ephemerides for refined targeting maneuvers. By the end of the mission the team had processed hundreds of thousands of images.

This paper reports on the DART navigation from launch to impact, and details the challenges encountered along the way. The Navigation team had specific requirements during approach for the onboard autonomous system, called SMARTNAV, to take over in the last four hours and impact Dimorphos. We describe changes and adaptations made to the baseline mission timeline during flight operations, and we detail the challenges encountered in the last 30 days where a

late spacecraft control mode update became necessary to achieve better delivery and handoff to SMARTNAV. After strategic decisions in the final weeks of the missions, DART could have comfortably hit the larger asteroid, Didymos, which increased the probably of impact with its moon Dimorphos.

The presentation will give an overview of the mission, report on the overall navigation performance, and detail key moments of the approach phase leading to impact.

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The paper presented in this abstract has been carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

Comments:

If selected for presentation, we request that this come before the DART presentation/poster led by Justin Atchison. This current submission for presentation/paper gives an overview of the missions, and thus the background and context for the MDNav content.