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***Session: Ongoing and Upcoming Mission Highlights***

**DART Guidance, Navigation and Control: System Performance and Challenges**

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**ABSTRACT**

Double Asteroid Redirection Test (DART) is a technology demonstration for the kinetic impactor method of planetary defense against asteroids. The DART spacecraft was launched in November 2021 and successfully impacted the asteroid Dimorphos, the smaller of two bodies in the Didymos binary system, on September 26th, 2022. This impact marks the first time humanity has altered the course of a celestial body, and ongoing science investigations will reveal the efficacy of using kinetic deflectors for asteroid hazard mitigation. This data will inform future missions, which may protect the Earth against threatening asteroids. The mission also afforded the opportunity to demonstrate several new hardware components for the first time on a planetary mission including Roll-Out Solar Arrays (ROSA) and NASA's Evolutionary Xenon Thruster Commercial (NEXT-C). Additionally, DART used SMART Nav (Small-Body Maneuvering Autonomous Real Time Navigation), a novel autonomous terminal guidance system, to distinguish the two asteroids and automatically execute trajectory corrections in the final four hours to guide the spacecraft to intercept the target asteroid.

Much of the guidance, navigation, and control (GNC) system design was typical of a deep space mission, although DART presented unique challenges in development and flight that threatened mission success. DART used a 3-axis controlled system, with attitude and trajectory control accomplished via the use of hydrazine thrusters. Attitude estimation relied on a star tracker and IMU, as accuracy in attitude knowledge was essential to performing the terminal phase of the mission. GNC also was responsible for controlling the ROSA and high-gain antenna gimbals to ensure sufficient power and communication margins were maintained. While the GNC system design was somewhat typical for a deep space mission, there were numerous unique challenges the DART mission presented. Some problems resulted from the speed and cost with which the mission was developed. Prelaunch testing and analyses were streamlined to be commensurate with schedule and cost parameters. This led to some simplifications in modeling and analyses work. Just prior to launch, there were concerns raised about the dynamic loads that might result during ROSA deployment with an active attitude control system; these concerns threatened the timely launch of DART, but were mitigated with last-minute analyses.

Simplification in the pre-launch modeling led to some unanticipated control-structure interaction in flight that affected the solar array control loop, and required rapid mitigation to achieve the necessary solar array pointing. Finally, a major focus of pre-launch analysis and post-launch testing was to characterize star tracker performance under terminal phase conditions as errors from the star tracker strongly influenced the impact performance of SMART Nav. Numerous tests were conducted in flight, eventually uncovering a thermal alignment issue that was solved with some clever heater manipulation to stabilize the relative alignment between the star tracker and the Didymos Reconnaissance and Asteroid Camera for Opnav (DRACO). The GNC team's agility, dedication, and creativity led to rapid diagnosis and mitigation of these issues, and contributed to a spectacular impact with Dimorphos.

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***Comments:***