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Small Spacecraft for Deep-Space Exploration (8)

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KEYNOTE: MARCO: FLIGHT RESULTS FROM THE FIRST INTERPLANETARY CUBESAT MISSION

Abstract

Launched May 5th, 2018, the MarCO spacecraft have demonstrated that small spacecraft (even CubeSats) can viably operate in the deep space environment. After successful reception of early telemetry and achieving commandability, both spacecraft transitioned to nominal mode to begin checkout operations. Subsequent passes demonstrated 62.5 - 8000 bps one-way and two-way communications, ranging, Delta-DOR tracking, and multiple spacecraft per aperture operations with the DSN. All four antennas (UHF, low gain, medium gain, and high gain) performed well and were characterized in flight. The spacecraft successfully performed multiple trajectory correction maneuvers to achieve its flyby of Mars, and autonomously oriented itself for imaging, solar-radiation-pressure reduction, and charging.

Early in the mission, the project partnered with both Morehead State University and SRI to perform in-flight tests of the UHF bent-pipe-relay designed for InSight. Goundstations broadcast a recorded InSight data stream to the MarCO spacecraft over UHF, each spacecraft received the data and packaged it for transmission, and then the vehicles downlinked the transmissions to the Goldstone and Canberra DSN stations. The successful in-flight data-flow test exercised much of the bent-pipe sequence required to support InSight at Mars.

The spacecraft also utilized on-board imaging to verify deployment of the HGA reflectarray. By choosing an advantageous angle, MarCO-B was able to simultaneously image the Earth and Moon at a distance of approximately 1 million kilometers. This unique vantage point exemplifies some of the use-cases of low-cost explorers, including providing observational capability that a larger explorer might not be able to provide on its own.

On November 26, 2018, the MarCO spacecraft successfully flew by Mars while relaying entry-descent-and-landing telemetry for the InSight vehicle. Both spacecraft performed beyond expectations and were able to provide a real-time link for the so-called "seven minutes of terror". In addition, once InSight safely landed, it transmitted its first image of the Martian surface through MarCO. Over the following weeks, images of Mars and Phobos, performance and health information of the spacecraft, and historical data were all downlinked.

Many lessons have been derived from the MarCO mission and the operation of the first two CubeSats to leave Earth orbit. From planetary protection to low cost ops, MarCO is paving the way to a new generation of explorers.