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DYNAMIC CONTROL SYSTEM PERFORMANCE OF THE SPACE TECHNOLOGY-7 DISTURBANCE REDUCTION SYSTEM DURING THE LISA PATHFINDER EXTENDED MISSION

Abstract

The Space Technology-7 (ST-7) Disturbance Reduction System (DRS) is an experiment package aboard the European Space Agency (ESA) LISA Pathfinder spacecraft launched on December 3, 2015. DRS consists of four primary components: Colloidal MicroNewton Thrusters (CMNTs), an Integrated Avionics Unit (IAU), flight-software-implemented Command and Data Handling (C&DH), and Dynamic Control System (DCS). The CMNTs were designed to provide thrust from 5 to 30 μN with thrust controllability and resolution of 0.1 μN and thrust noise of 0.1 $\mu\text{N}/\sqrt{Hz}$ in the measurement band from 0.1–30 mHz. The IAU hosts the CDH and DCS flight software, as well as interfaces with both the CMNT electronics and the LISA Pathfinder spacecraft. During the portions of the mission where DRS is active, the DCS uses star tracker attitude data and capacitive or optically-measured position and attitude information from LISA Pathfinder and the LISA Technology Package (LTP) to control the attitude and position of the spacecraft and the two test masses inside the LTP. The primary DRS mission began after the completion of the nominal ESA LISA Pathfinder mission, ending on December 6, 2016, with the experiment meeting all of its Level 1 requirements. Following this, both the ESA LISA Pathfinder and NASA DRS teams began an extended mission.

The GSFC-developed DCS consisted of five spacecraft control modes and six test mass control modes, combined into six "DRS Mission Modes", used to implement the DRS mission. The Attitude Control and Zero-G Mission Mode were primarily used to control the spacecraft during initial handover and during many of the CMNT characterization experiments. The other Mission Modes, Drag Free Low Force, 18-DOF Transitional, and 18-DOF, were used to provide drag-free control of the spacecraft about the test masses. A thruster anomaly near the end of the DRS nominal mission necessitated changes in the way the system was run during the extended mission. This paper will discuss requirements and performance of the DCS spacecraft and test mass control modes during the extended mission of LISA Pathfinder. Flight data will be shown from the various flight experiments conducted during the extended mission. The DCS team also made parameter changes to some of the controllers, filters, and limits during the extended mission; the motivation and results of these changes will be shown and discussed.