ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (1) (1)

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DYNAMIC CONTROL SYSTEM MODE PERFORMANCE OF THE SPACE TECHNOLOGY-7 DISTURBANCE REDUCTION SYSTEM

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 three 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 $\mu\text{N}/\sqrt{\text{Hz}}$ in the measurement band from 0.1–30 mHz. The IAU hosts the C&DH 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.

After completion of the nominal ESA LISA Pathfinder mission, the DRS experiment was commissioned followed by its nominal mission. DRS operations extended over the next five months, interspersed with stationkeeping, anomaly resolution, and periods where control has handed back to LISA Pathfinder for them to conduct trending experiments. The primary DRS mission ended 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 a six-month extended mission.

The GSFC-developed DCS consisted of five spacecraft 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. This paper will discuss requirements and performance of these DCS spacecraft and test mass control modes. Flight data will be shown from each mode throughout the mission, both from nominal operations and during various flight experiments. The DCS team also made some changes to various controller, filter, and limit parameters during operations; the motivation and results of these changes will be shown and discussed.