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LISA PATHFINDER ATTITUDE AND ORBIT CONTROL SYSTEMS

Abstract

The LISA Pathfinder mission provides in-orbit validation of the critical technology necessary for the LISA mission. LISA (Laser Interferometer Space Antenna) aims at detecting gravitational waves generated by very massive objects such as black holes. Detecting gravitational waves will tell us more about the way space and time are interconnected. The Lisa Pathfinder mission consists of placing two test-masses in a nearly perfect gravitational free-fall, and of controlling and measuring their motion with unprecedented accuracy. This is achieved through state-of-the-art technology comprising inertial sensors, a laser metrology system, a drag-free control system and a precise micro-newton electric propulsion. The micro-propulsion coupled with extremely sensible inertial sensors is required for the spacecraft to fly in a purely gravitational orbit (drag-free spacecraft) around L1.

The operational mission is performed using the Science Spacecraft (SCM). However to achieve the operational orbit at L1, the SCM is attached to the propulsion module (PRM) to form the Lisa Pathfinder Composite Module (LCM). The PRM provides the propulsive capability to raise the LCM from the injection orbit to the operational orbit. The PRM is separated from the science spacecraft after entering the L1 Halo orbit, where the science experiment and technology demonstrations will take place. The Spacecraft Attitude and Orbit Control System (AOCS) is actually composed of three distinct systems to fulfil the needs of the whole mission:

- Composite AOCS, used to reach L1, aims at raising the Perigee through a succession of about 10 boosts performed with high thrust chemical propulsion. This phase ends up with a spin-stabilised separation of the SCM from the PRM during the cruise to L1.

- Micro-Propulsion AOCS takes over once the separation of the SCM has occurred and is based on the FEEP and Colloidals micro-propulsion systems. These systems control the spacecraft while on station and in between the science operation phases.

- Drag-Free Control System and the Disturbance Reduction System are the control systems that are used alternatively in Science mode.

The present article wishes to provide a comprehensive overview of the AOCS architecture, design and performance. It will focus in particular on the Composite AOCS and the Micro-Propulsion AOCS and will analyse the challenges of using micro-Newton electric propulsion system for AOCS operations.

LISA Pathfinder is currently in phase C/D and has already passed the Critical Design Review both at subsystem and system level. The spacecraft is planned to be launched in early 2011.