Paper ID: 26175
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SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (1) (3)

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EUROPEAN COLD GAS MICRO PROPULSION SYSTEM REACHED TRL-9 ON BOARD GAIA S/C. DISCUSSION ON IN FLIGHT PERFORMANCE AND SYSTEM FLEXIBLY AND CAPABILITIES, FOR BEING IMPLEMENTED IN OTHER MISSIONS REQUIRING ULTRA-FINE SATELLITE POSITIONING AND ATT

Abstract

An innovative European Cold Gas Micro Propulsion System (MPS), developed by TAS-I under Astrium and ESA/ESTEC coordination, was launched into space in December 2013 on board the European Space Agency's "billion-star surveyor" GAIA telescope. GAIA is a five-years mission aimed to produce precise 3D measurements of Milky Way stars' positions and motion, with unprecedented accuracy. GAIA operates at a spin rate of 4 revolutions per day, sweeping its two telescopes across the entire sky and focusing them onto the largest digital camera ever flown in space, with approximately a billion pixels. In order to meet the GAIA unprecedented scientific objectives, very challenging requirements were given to all the avionics subsystems. In particular,in order to limit the blur in the stars' images, the GAIA pointing requirements in terms of Relative Pointing Error are as tight as RPE AL=5 mas , RPE AC= 10 mas. RPE is in fact the stability of the telescope line of sight over the 4.4s period taken by a star to cross one of the 106 single CCDs constituting the GAIA Focal Plane). A thrust control capability obtainable only using Cold Gas technology is instrumental to accurately control the scanning law of the S/C (spin) and to compensate in real-time the environmental disturbances, mainly due to solar pressure (causing the precession motion. The MPS is therefore key to keep the pointing performance required by GAIA, providing a low disturbance propulsion (in absence of micro-vibrations, usually induced by reaction wheels) for fine attitude control. MPS requirements are impressive for a propulsion system, combining a large thrust dynamic range of 1 - 1000uN with 1 uN resolution, 0.1 uN thrust steps commandability and 300 ms time response to thrust change command. Novel thruster technologies and new thrust generation and regulation concepts were developed for GAIA, then validated by extensive qualification and acceptance ground testing, and today successfully confirmed in flight. In this paper the in-flight performance of the GAIA MPS will be discussed, being the S/C successfully placed in L2 since December 2013 and the MPS currently supporting the scientific equipment commissioning, contributing to achieve the expected performance. Each MPS micro-thruster is composed of a piezo valve, able to perform plunger sub-micrometric displacements, and of an upstream propellant mass flow sensor acting as a feedback. The electronics unit receives telecommands containing the desired instantaneous thrust level and properly manages the piezo valve driving voltage, achieving a closed loop control of the thrust. This is done for each thruster separately, for a branch of 6 thrusters in simultaneous operation, with thrust level commanding rates up to 8 Hz. Following the successful GAIA qualification and acceptance campaign, the cold gas micropropulsion activities are now led by SELEX ES, which is currently developing the MPS for European scientific programs such as Lisa Pathfinder (ESA) and Microscope (CNES/ONERA/ESA. In the frame of Euclid (ESA) Phase B, improvements of GAIA performances in terms of thrust range (up to 2 mN), time response (down to 200 ms) and resolution (down to 0.2 uN) have been studied and forecasted to be implemented. This paper will finally discuss the Cold Gas Micro-Propulsion flexibility and capability, for being implemented in a variety of other missions. The MPS cold gas thrusters system offers scaling up/down capabilities related to mass flow sensor calibration, nozzle throat geometry, inlet operating pres-

sure. In addition, the thrust control algorithm is part of the MPE S/W and may be modified/optimized both on ground and in flight. These features allow to widely tune the MPS dynamic range and other key performances for a worldwide Micro-Propulsion market requiring ultra-fine satellite positioning and attitude control (in the Science, Remote Sensing and Telecom domain, as well as in the small satellites area).