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SPIRAL CONING MANOEUVRE FOR IN-ORBIT LOW THRUST CHARACTERISATION IN CUBESATS

Abstract

Fundamental to the full characterisation of emerging propulsion systems for nanosatellites is the capability of measuring to a high degree of accuracy the spectrum thrust levels during in-orbit operations. These measurements are used to complement ground test performance data. Many new CubeSat missions use electric propulsion systems with thrust level production of few micro-Newtons. Whilst the resources for the direct measurement of extremely low levels of thrust exist for ground tests, complementary in-orbit characterisation techniques are limited. Additionally for extremely low thrust levels (few tens of μN) sensor technologies are, in the main, not compatible with nanosatellites due to the restrictive size and mass budgets of these platforms. In order to overcome the shortcomings of sensor technologies it is a common practice to perform thruster characterisation via attitude changes, applying torques by off setting the thrust vectors from the satellite centre of mass. This eases the assessment of low level thrust action over time by means of manoeuvres such as detumble, spin and despin, pointing performance, etc. However the effectiveness of these manoeuvres for thruster characterisation is drastically reduced when the external perturbations approach or exceed the thruster action on the satellite. This study presents an alternative method for in-orbit low thrust characterisation though the observed induced precession rate of a spinning CubeSat to enable the evaluation of particularly low thrust levels that are commonly out of reach by current methods. The alternative method consists of two stages. A first manoeuvre comprises the customary creation of a major axis spinner through the action of the highest level of thrust achievable by the propulsion system. This initial manoeuvre enables the direct estimation of thrust by measuring one-axis angular rotation and builds gyroscopic inertia that in turn reduces the CubeSat response to external environmental perturbations. A subsequent firing, this time using a lower level of thrust, sets an additional torque about the minor axis of inertia (normal to the former spinning axis) producing spiral coning on the CubeSat. In this way, the resulting precession rate after the second firing can be correlated to the causative low thrust. Computer simulations support the feasibility of the proposed alternative method for effective in-orbit low thrust characterisation. The resulting precession motion can be measured with the use of conventional commercial-off-the-shelf attitude determination resources in standard CubeSats.