Accuracy Analysis of a Thrust Vector Ion Beam Scanner comprised of Retarding Potential Analyser

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The purpose of an ion propulsion system is to provide directional thrust, the direction however is rarely exactly along the thruster axis, manufacturing tolerances, structural parts or neutralizer positions change the ion acceleration direction away from the axis. Any error of the thrust vector not passing through the satellite centre of mass adds to a build-up of rotational momentum which needs to be annihilated by reaction wheels and ultimately by a propulsion system requiring propellant mass. In order to reduce the unwanted propellant mass for momentum wheel offloading it is mandatory to know the exact thrust vector of the thruster and adapt their mechanical interface to such an extent that their thrust vector is aligned to the satellites centre of mass.

Although the thrust of an ion propulsion system can be easily measured by a thrust balance the thrust vector deviation would require a highly complex multi-axis thrust balance. As an alternative ion beam characterization enables the use of plasma diagnostics to calculate the thrust vector of the ion thruster. Most thrust vector ion beam measurements are performed by a rotating boom equipped with faraday probes. Such a system however provides the current vector instead of the thrust vector. For thrust vector determination the angular kinetic energy spectrum and the charge stat needs to be measured and integrated over the hemisphere. Thales is currently integrating a thrust vector scanner based upon retarding potential analysers and an energy selective mass spectrometer capable of measuring the thrust vector.

A comprehensive error estimation for the calculated thrust vector is presented that includes the uncertainties of the mechanical and electronic equipment as well as numerical uncertainties of the data analysis and the uncertainty propagation.