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A STABLE AND HIGHLY ACCURATE POINTING CUBESAT EARTH IMAGER FOR VLEO EARTH OBSERVATION

Abstract

The market for CubeSats offers a huge potential for Earth Observation (EO) satellites with a high revisit time. However, the development to sustain a higher spatial resolution better than 4 m is a challenge. It requires a stable EO platform to acquire accurate EO images from Very Low Earth Orbits (VLEO) in the altitude range 230 – 380 km. To obtain a pointing accuracy down to 1 degree and a high stability of the spacecraft, severe difficulties are present due to the nature of the atmosphere at these altitudes. The thermosphere is affected by the solar flux and magnetic indices which impose significant temperature and density fluctuations. The control of these issues, combined with free molecular flows, requires a complex model to predict any disturbance to be encountered.

A novel CubeSat design concept SHAPE (Stable Highly Accurate Pointing EO) can in principle yield an exceptionally stable satellite for high-resolution VLEO EO. SHAPE uses the principle of momentum conservation by integrating a large momentum wheel in the centre of the spacecraft composed of two 3-unit CubeSats. Its rotational speed is increased up to 7000 rpm to ensure that external disturbance torques are effectively counteracted. It was sized on the largest (aerodynamic) disturbance yielding a design torque of 0.014 Nm, 0.469 kg mass, 15 cm radius and 1 cm thickness. A resisto jet developed by the TU Delft is used to accelerate the wheel to its high speed. Additional power is delivered by a battery inside the wheel, adding required mass as well. To ensure stability, dedicated liquid dampers were designed to attenuate additional vibrations and residual nutation.

Momentum and reaction wheels are commonly used in satellites. Literature shows that SHAPE presents the first application of a substantial momentum wheel using a novel type of a magnetic bearing in a VLEO NanoSat. SHAPE provides with an innovative, out of the box, and simple solution, by tackling the problems of instability of EO from a VLEO spacecraft. Its costs are very competitive, roughly estimated 400 kEuro for the platform, including a dedicated optimised camera concept version of the ANT-2A Cubesat camera developed earlier by the TU Delft. However, a variety of cameras can be used, inexpensively and efficiently, with this platform using a standard plug play interface. The momentum wheel plays the dominant role in stabilising the platform, using a simple, trusted, reliable and efficient method.