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Author: Mr. Bryan Johnston-Lemke
Space Flight Laboratory, University of Toronto, Canada, bjlemke@utias-sfl.net

Mr. Karan Sarda
Space Flight Laboratory, University of Toronto, Canada, ksarda@utias-sfl.net
Mr. Cordell Grant
Space Flight Laboratory, University of Toronto, Canada, cgrant@utias-sfl.net
Dr. Robert Zee
Space Flight Laboratory, University of Toronto, Canada, rzee@utias-sfl.net

BRITE-CONSTELLATION: ON-ORBIT ATTITUDE PERFORMANCE OF A NANOSATELLITE TELESCOPE

Abstract

In the first quarter of 2013, the first two satellites of the internationally sponsored BRIght Target Explorer (BRITE) constellation were placed in orbit. The mission of the BRITE constellation, which is comprised of six 7kg nanosatellites, is to survey the variations in brightness of the most massive and luminous stars of the sky. These massive stars, despite being central parts of our most familiar constellations, are not well understood, yet through their life and particularly spectacular death as supernovae, are responsible for filling the interstellar medium with heavy elements, which are critical for the formation of planetary systems as well as the building blocks for organic life. The constellation will conduct differential photometry, in two colour bands, measuring the brightness variations on the milli-magnitude level, a precision at least 10 times better than what is currently achievable by ground based observations. Achieving this precision demands a level of pointing accuracy that pushes the envelope of nanosatellite performance.

The attitude subsystem of the BRITE satellites is among the most critical spacecraft systems in ensuring mission success. For massive stars, the period of light variations are on the scale of hours to months, therefore the satellites will perform 15-minute observations of multiple target star fields each orbit. Upon returning to a previously imaged target, the attitude system is required to hold the point-spread-function of the imaged stars to within 3 pixels of the original point locations, in order to trim out the pixel-to-pixel variations of the telescope detector. This stringent requirement implies a one arc-minute pointing control with long duration attitude stability and rapid reacquisition. Until recent advances in the miniaturization of attitude hardware, these requirements were insurmountable on a nanosatellite scale. Despite these advancements, a major challenge for the BRITE satellites was to characterize and tune these attitude components (reaction wheels and star trackers, in particular), as they operate at the edge of the required performance envelope. Further, novel attitude estimation and control techniques were applied, which were essential, given both the hardware compliment and their limitations. Perhaps the greatest challenges overcome by the developed algorithms was the lack of attitude rate gyros, and the relatively large time-lag and slow cadence forced by the sensors. This paper describes the attitude subsystem of this cutting-edge mission, with a focus on the challenges encountered during the design, as well as early on-orbit performance.